MEDIATION IMPACT OF MANUFACTURING STRATEGIES ON EXTERNAL ENVIRONMENTAL FACTORS AND MANUFACTURING PERFORMANCE

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ABSTRAK

Persaingan global yang semakin sengit telah mendedahkan firma di seluruh dunia, termasuklah pengilang di Malaysia, dengan pelbagai cabaran yang baru. Persekitaran yang mencabar ini telah mendorong para pengilang untuk menguna pakai strategi pembuatan tertentu yang terbukti berkesan seperti pelaksanaan teknik pengilangan *lean*, penambahan teknologi pengilangan dan penggunaan fleksibiliti yang strategik. Dalam hal pengilang *lean* di Malaysia, tidak banyak kajian yang telah dilakukan untuk mengenal pasti formula yang terbaik bagi mengatasi cabaran yang semakin banyak dalam persekitaran perniagaan. Dalam kajian ini, ketiga-tiga strategi yang dikenal pasti, iaitu teknik pengilangan *lean*, teknologi pengilangan dan fleksibiliti yang strategik, telah diteliti secara mendalam sebagai faktor yang bersepadu yang boleh memberikan kesan yang positif terhadap prestasi pengilang. Kerangka kajian ini menyelidik kesan pendekatan bersepadu dan strategi terhadap prestasi pengilang *lean di Malaysia*. Data dikutip menerusi kaedah tinjauan dengan soal selidik berstruktur diedarkan kepada pengilang *lean* di Semenanjung Malaysia. Model persamaan berstruktur (SEM) digunakan untuk menguji pelbagai model perantaraan. Hasil kajian memperlihatkan ketiga-tiga strategi memberikan impak yang signifikan dan bertindak sebagai perantara antara faktor persekitaran luaran dengan prestasi pengilang. Dapatan kajian turut menekankan beberapa hubungan 'quasiparodixical' yang menarik. Pengilang *lean* di Malaysia memilih pendekatan yang lebih berhati-hati dalam pelaksanaan teknologi pengilangan. Mereka lebih cenderung untuk menggunakan teknologi pengilangan dalam keadaan persekitaran perniagaan yang lebih stabil dan menganggap fleksibiliti yang strategik sebagai tidak membantu meningkatkan prestasi. Kajian ini menghasilkan model ramalan yang kukuh untuk menjelaskan kesan perantara strategi pengilangan terhadap faktor persekitaran luar dan prestasi pengilangan yang bermanfaat untuk membantu pengurusan syarikat sebegini. Batasan utama kajian ini ialah jumlah bilangan responden yang kecil. Penyelidikan akan datang perlu menggunakan dimensi yang lebih luas untuk mengukur prestasi, termasuklah menambah strategi pembuatan yang lain sebagai sebahagian daripada kerangka kajian serta membesarkan skop kajian untuk meningkatkan generalisasi hasil penyelidikan.

Kata kunci: Malaysia, pengilangan *lean*, teknologi, fleksibiliti yang strategik

ABSTRACT

The growing global competition has presented firms around the world, including manufacturers in Malaysia, with unprecedented challenges to ensure survival. Such a challenging environment should propel these manufacturers to adapt certain, well-proven manufacturing strategies, such as lean manufacturing, the inclusion of manufacturing technology and the appliance of a strategic level of flexibility. With respect to Malaysia insufficient research has been done on what are the winning formulae to overcome the mounting challenges in the business environment. In this study, all three identified strategies – lean, manufacturing technology and strategic flexibility – were investigated in depth as integrated factors that could positively improve manufacturing performance. The research framework examined the impact of such an integrated and strategic approach on the performance of Malaysian manufacturers. Data was collected using survey method, through the distribution of structured questionnaires to lean manufacturers in Peninsula Malaysia. Structural equation modeling (SEM) was used to test multiple mediator models the results of which indicated that all three strategies had a significant impact and mediated the relationship between external environmental factors and manufacturing performance. The results from this study also emphasized several interesting quasi-paradoxical relationships that implied that Malaysian lean manufacturers preferred a cautious approach towards manufacturing technology implementation, preferring to incorporate technology in a more stable business environment and viewed strategic flexibility as unfavorable toward performance improvement. This study produced a strong predictive model that explained the mediation impact of manufacturing strategies on external environmental factors and manufacturing performance that would be useful to those managing such companies. The main limitation found in this research was the small number of respondents. Future research should focus on a wider dimension for performance measurement, include additional manufacturing strategies as part of the research framework and enlarge the scope of this study in order to increase the generalizability of the research outcome.

Key words: Malaysia, lean manufacturing, technology, strategic flexibility

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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF ABBREVIATIONS

AMOS – Analysis of a Moment Structure

AMT - Advance Manufacturing Technology

ASEAN- Association of Southeast Asian Nation

CAD – Computer Aided Design

CAE – Computer Aided Engineering

EEF – External Environmental Performance

FMC – Flexible Manufacturing Cells

FMM – Federation of Malaysian Manufacturers

FMS – Flexible Manufacturing System

IEPT – Information exchange and Planning Technology

HVAT – High Volume Auto Technology

IMS – Integrative Managerial System

JIT – Just In Time

LAN – Local Area Network

LM – Lean Manufacturing

MATRADE – Malaysia External Trade Development Corporation

MFP – Multi Factor Productivity

MIDA – Malaysia Investment Development Authority

MITI- Ministry of International Trade and Industry

MP – Manufacturing Performance

MT – Manufacturing Technology

MNC – Multi National Corporation

NC – Numerical Control Machine

PDT – Product Design Technology

PLS- Partial Least Square

ROE – Return on Equity

SF – Strategic Flexibility

SDS – System Device Station

SEM – Structural Equation Modelling

SPC – Statistical Process Control

TPM – Total Productive/Preventive Maintenance

TPS – Toyota Production System

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.0 Background of Study

Malaysia's development has been largely fuelled by export-led growth. However, globalization has increasingly intensified competition and has sharpened the distinction between victors and losers. As a nation, Malaysia is an open economy, which depends heavily on external trade to achieve its economic growth (Al-Yousif, 1999; Choong, Zulkornain & Khim-Shen, 2003; Yusoff, 2005; Liang, Abdul Ghani, Jusoh & Chin, 2011; Talib, 2012). Given the openness of its economy, the negative wealth effects of the global crisis on demand and world trade have resulted in a decline in Malaysia's industrial production and manufacturing exports. Due to a relatively small population, Malaysia's domestic market is insufficient to finance additional growth for its economy. Consequently, international trade has been crucial in the development of the Malaysian economy, and foreign trade has been a significant and substantially increasing portion of the nation's gross domestic product (GDP) over the last three decades (Talib, 2012). The findings from a study by Hamid (2010) suggest that trade is an important variable in promoting economic growth for Malaysia; hence, its exposure to international instability is inevitable. Due to such heavy dependence on external trade, Malaysia's economy can be considered sensitive to any external shocks that could range from economic crises to intensifying global competition.

In the context of this research, the focus remains on the manufacturing sector for several reasons. Firstly, manufacturing has emerged as a leading sector in Malaysia in terms of adopting new operating and quality practices, and these practices are driven primarily by competitive rather than regulatory forces. Secondly, the industry is heterogeneous in terms of sub-sectors and product/process complexity. Thirdly, manufacturing is a very important sector in Malaysia. According to the Tenth Malaysia Plan 2011-2015, the manufacturing sector contributed 26.7% to Malaysia's gross domestic product in 2012. Exports from the sector constituted 80.5% of total merchandise exports. The electrical and electronics (E&E) industry is the largest single contributor with 26.1% of manufacturing output, and the largest employer at 40.0% of total manufacturing labor.

Due to such an important role, the manufacturing sector remains as the major and crucial indicator of the Malaysian economy. Thus, increasing global competition with customers demanding higher product quality, greater product selection, and superior customer service amid rising input costs have led many Malaysian manufacturing companies to adapt, adopt and develop various operational strategies in order to minimize wastage and defects, to improve product quality, and to sustain profitability and overall performance. Manufacturers face an unprecedented force from foreign products, new product introduction by competitors, rapid technological innovation and shorter product life cycle and changes in customer demands (Gouvea Da Costa, Platts & Fleury, 2006; De Toni & Tonchia, 2005; Vokurka & O'Leary-Kelly, 2000). To cope with these uncertain environments, manufacturers must continuously examine their strategies, practices, capabilities and identify the impact between these elements and their performance (Ketokivi & Shroeder, 2004; Germain, Claycomb & Droge, 2008). In searching for a new manufacturing paradigm, existing prominent manufacturing practices, such as lean manufacturing, have been chosen by some Malaysian manufacturers to mitigate external environmental factors, such as global competition, escalating raw material cost, supply chain variability, intensifying complex and hostile business environment.

However, implementing strategies takes a lot more than just adopting a system or a proven strategy. Manufacturing strategy has been broadly defined and approached, providing various positive alternatives for manufacturers, but, at the same time, making the process more complicated and complex. In the current competitive environment, complemented by the advancements in technology, trade agreements and an open market; manufacturing strategy has continued to receive significant and serious attention from researchers. The consensus is that if manufacturers fail to recognize the relationship between manufacturing strategy and their business environment, and how it impacts their performance, they will be saddled with a noncompetitive production system that will be costly, rigid and out of date (Ketokivi & Schroeder, 2004; Schroeder, Bates & Junttila, 2002; Rosenzweig, Roth & Dean, 2003; Ward & Duray, 2000; Swamidass & Newell, 1987). Such a predicament will be fatal for manufactures, preventing them from becoming dynamic enough to respond to any challenge surrounding their operation (Hibbard, Hogan & Smith, 2003).

1.1 Problem Statement

Malaysian manufacturing performance is closely linked to the economic health of the country. Serving as the biggest provider of over 1 million jobs nationwide and contributing toward more than 80% of total merchandise exports, the performance of the manufacturing sector needs to be improved and sustained in the long-term to ensure the buoyancy of the Malaysian economy. This study explores the possible remedies for the adverse impact of these external factors on the performance of Malaysian manufacturers through the facilitation of favorable manufacturing strategies.

For years, the manufacturing performance of Malaysian manufacturers has been shown to be closely linked to external environmental factors, such as dynamism and hostility on the global stage. The Asian economic crisis in 1997 caused a severe trade deficit in Malaysia, and, even after recovering from the hit, Malaysia faced tough competition from other ASEAN countries with similar manufacturing export specialization. Customer demand has become more sophisticated with mounting pressure to produce value added products at the lowest cost possible. Globalization not only provides borderless prospects but also presents Malaysian manufacturers with various perils, a phenomenon that is not limited to Malaysia but affects manufacturers around the world. The ever expanding global marketplace not only presents opportunities but also poses threats, driving manufacturers to continuously search for ways to maintain their competitiveness (Zhang & Sharifi, 2000; Choy, Lee, Lau & Choy, 2005).

Scholars observing these challenges have suggested that the adoption of world class practices, such as lean manufacturing, might help manufacturers sustain their performance despite such environmental factors. However lean scholars (Furlan, Vinelli & Pont, 2011a, 2011b) have suggested that lean when viewed as a strategy should be implemented in synergy with and complementary to other strategies in order to reap the full benefit. Such an approach has been duly emphasized by strategy scholars (namely Garcia & Alvarado, 2013; Dangayach & Deshmukh, 2006; Ashmos, Duchon & McDaniel, 2000) who unanimously supported the proposition that multiple strategies implementation would overcome the need for manufacturers to have to make a trade-off between crucial strategies, such as between cost and variety.

1.2 Research Questions

In context with the previously presented research background and problem statement, the foremost interest of this research is on "what is the impact of external environmental factors on Malaysia's manufacturing performance and do manufacturing strategies mediate the relationship?"

Based on this conception, the following four research questions were put together to guide this study:

RQ1 – Do external environmental factors have an impact on the performance of Malaysian manufacturers?

RQ2 – Do external environmental factors have an impact on the implementation of manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility?

RQ3 – Do manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility, have an impact on the Malaysian manufacturing performance?

RQ4 – Do manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility, mediate the relationship between external environmental factors and Malaysian manufacturing performance?

In this study, the researcher is interested in statistically testing the relationship among the variables (i.e. external environmental factors, manufacturing performance, lean manufacturing, manufacturing technology and strategic flexibility). It is hoped that through this, the study will be able to answer all the preceding research questions. These four general research questions have been particularized into several hypotheses that guide the researcher in going deeper into the phenomena under investigation.

1.3 Research Objectives

The intent of this research is to understand the impact of external environmental factors on the performance of Malaysian manufacturers, which is followed by the aim to examine the mediation impact of certain manufacturing strategies – lean manufacturing, manufacturing technology and strategic flexibility.

In the context of the Malaysian manufacturing sector, this research investigates (1) the impact of external environmental factors on Malaysian manufacturing performance; (2) the impact of external environmental factors on the implementation of manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility; (3) the impact of manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility, on Malaysian manufacturing performance; and (4) the mediation impact of manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility, on the relationship between the external environmental factors and Malaysian manufacturing performance.

Manufacturers from three sub sectors, electrical and electronic, automotive and aeronautical were selected based on how most reported previous works focusing on lean originated from this group of manufacturers. Due to that, deduction from published works focusing on lean as the subject matter was used as the basis of the decision to focus on these three sub sectors, which suggested that most lean implementers originated from electrical and electronic, automotive and aeronautical subsectors. Such deduction was necessary because lean manufacturers in Malaysia are not listed in any government directories such as FMM or even in government websites such as MATRADE or MITI, preventing the researcher from being able to directly identify the targeted respondents.

The information obtained from Malaysian lean manufacturers is used to probe the aforementioned research objectives to gain a better and deeper understanding of the subject being investigated. In this quantitative study, participants of the study were given structured questionnaires that probed their responses toward all the studied variables.

1.4 Significance of the Research

Specifically, this study attempts to analyze the linkage between external environmental factors and manufacturing performance with the presence of manufacturing strategies, i.e. lean manufacturing, manufacturing technology and strategic flexibility, in the context of Malaysian lean manufacturers. Most of the previous research on Malaysian manufacturers, particularly those that practice lean, focused on the content of the lean practices, such as on human resource factors (Puvanaswaran *et al.,* 2009; Puvaneswaran, Megat, Thang, Muhamad & Hamouda, 2008; Rozhan & Rohayu, 2008), the implementation and management issues (Wong, Wong & Ali, 2009; Nordin, Deros & Wahab, 2011; Nordin, Deros, Wahab & Rahman, 2012), as well as on process improvement strategies (Loi, 2004; Rosnah, 2004; Mohamad, Muhamad & Abdullah, 2008; Wong *et al.,* 2009). However, there has been a lack of emphasis on the practice of lean manufacturing, its impact on performance, complementary manufacturing strategies and its relation to the contingent external environmental factors. After an extensive literature review, the researcher is satisfied that these variables had yet to be tested in the same research framework either globally or within the context of Malaysia. Therefore, it is hoped that this study will add to the existing body of knowledge and theories of Malaysian manufacturers in respect of how their performance is linked to their environment as well as their implementation of other strategies to enhance their performance.

Consequently, this research intends to contribute to the understanding of manufacturing performance of Malaysian lean manufacturers. Most lean manufacturers choose to measure their performance using operational performance measurement, consistent with the practice of manufacturing strategy research, which often uses a single dimension for performance measurement. In this research, however, a focus on the multidimensional manufacturing performance is imperative. As explicitly emphasized previously by Ketokivi and Schroeder (2004), in order to study manufacturing strategy, there are three components that must be explicitly measured – goals, practices and multidimensional performance.

Various scholars, for example, Yang, Hong and Modi (2011), Brown, Squire and Blackmon (2007), Ketokivi and Schroeder (2004), also suggested the use of multidimensional measures for studying the practices-performance relationship. Moreover by including both financial and nonfinancial performance measures, this study is able to encompass a more comprehensive impact on manufacturing performance, which a single dimensional measurement is not able to accommodate. Correspondingly, this approach also provides the concept of a proposed measurement that is in tandem with the manufacturer's strategic objectives. By adopting a strategic type of measurement system, manufacturers acquire an accurate evaluation of their strategic objectives and their achievement. This approach might help firms avoid from focusing on the operational performance measurement system, which might not be translated into the actual strategic outcome of the firms.

More importantly, also in relation to the body of knowledge, this research will contribute significantly to the theoretical and body of knowledge through the process of investigating the impact of external environmental factors on the Malaysian lean manufacturers through the framework of the contingency theory. The contingency theory of organizations has a rich tradition in management research, and has received much empirical support in the literature (Donaldson, 2001). In principle, the contingency theory argues that organizational performance is a result of the organization's degree of suitability or fit, in terms of organizational characteristics, such as its strategy, and to some contingencies reflecting the situation of the organization, such as the environmental conditions of the operation. However, this theory focuses on the fit between the external environment, which is referred to as external contingency and often downplays the significance of strategic choice, which includes technological core, competitive business strategy and contemporary business practices (Ketokivi, 2006). This study not only delves deeper than the aforementioned conventional contingency theory but also examines the importance of internal contingencies in the context of performance by way of protecting the company from external threats.

In addition, the complementarity theory will also be put to use to supplement the lack of emphasis on internal contingencies by the contingency theory. Milgrom and Roberts (1990, 1995) described how several practices tend to be adopted together because they are complementary or mutually supportive of each other. Other scholars (Ichniowski, Shaw & Prennushi, 1997; Battisti, Colombo & Rabiosi, 2004; Bocquet, Brossard & Sabatier, 2007; Furlan *et al.*, 2011) also noted that strategies and practices are more effective when a firm adopts them as a set instead of piecemeal or as standalone implementation. Based on these arguments, it is highly expected that several manufacturing strategies when implemented together will have greater impact on the performance. It is also very common in strategy studies to examine multiple strategies together. Previous scholars (Kotha & Orne, 1989; Murray, 1988; Wright, 1987; Miller, 1992; Ashmos *et al.*, 2000) noted that studies have shown that combined multiple strategic actions may either be consistent or complementary or better in terms of performance.

In this study the projected idea of multiple strategies is put to the test in the context of Malaysian lean manufacturers. In terms of the body of knowledge, this research provides empirical corollaries through statistical means, from the concept of multiple mediations (represented by the three manufacturing strategies) in a single model. Such an empirical approach has received major scrutiny and attention from communication researchers, such as Afifi, Kamel and Khalil (2008), Ledbetter (2009), as well as Southwell and Torres (2006). However, the concept is relatively young in other social science subfields, especially that which focuses on strategies. While in most studies, correlated variables continue to be individually tested in simple mediation models using the renowned Baron and Kenny approach, there is a major flaw that this method is unable to address. The main issue when such variables are tested separately is that it causes estimation bias when there is inter correlation among them. Such an observation has also been supported by scholars, including Preacher and Hayes (2008) as well as Hayes (2009). In addition, the inclusion of multiple pathways to an outcome means that different theories can be pitted against each other in a single model. For example Theory 1 might propose variable M_1 functions as a mediator of X's effect on Y, whereas Theory 2 might propose M_2 as the other mediator. This advantage proves useful in such a case as this research, since more than one theory is used to explain the mediators as well as the interaction between all the other variables.

From the practical and managerial perspective, this study provides several alternatives in the field of operational management, especially in the area of operational excellence. The utilization of the contingency and complementarity theories in this framework should provide manufacturers, especially lean implementers, with another perspective and option that could strengthen their resistance and operational stance against threats from the external environment. Managers are not free to choose what strategy to use, every strategy linked decision chosen has to be within the capability of the organization itself. They also have to be able to choose what strategy best suits their company that is contingent to the demands of their task environment. As accentuated by Ketokivi (2006), external contingencies are essential parts in determining the feasibility of specific strategies. Therefore, it is hoped that this study will be able to provide managers and industrialists with a platform for a deeper understanding and sturdier knowledge concerning the construction of a stronger operational core through spot-on strategic choices.

1.5 Scope of study

This research is contextualized in a developing country, Malaysia, and focuses on the manufacturing sector due to its huge impact on the nation's economy. The group of manufacturers involved in the study includes manufacturers from several different industries that practice lean manufacturing. The chosen industries are based on the previous history of lean related theme studies conducted in Malaysia. These industries include automobiles, aerospace and electrical and electronic (E&E). The manufacturers include the assemblers as well as part producers from each of these industries.

1.6 Definition of Key Terms:

Several key terms used in this study are defined as follows, to further clarify and explain the terms used:

a) Manufacturing Performance (MP)

Manufacturing performance is defined as multiple achievements that can be measured by financial and nonfinancial indicators. Both elements are consolidated in measuring manufacturing performance in order to give a complete and unabridged quantification of the performance measurement made throughout the study.

b) External Environmental Factors (EEF)

The external environmental factors are defined as factors that exist in the business environment in which a firm operates that pose various and different challenges to the firms. In the context of this research, the business environment refers to the external environmental factors. Such factors include a huge variety of elements, all of which interact and continually change and are often measured through two elements – dynamism and hostility.

c) Manufacturing Strategy (MS)

This study takes the content approach of defining what constitutes manufacturing strategy. Manufacturing strategies are defined from three different perspectives using the work of Dangayach and Deshmukh (2001) as its operationalization platform. The three perspectives include manufacturing capabilities, strategic choice and best practices as manufacturing strategies. Manufacturing capability as a strategy includes strategic capability (strategic flexibility in this instance); strategic choices, such as manufacturing technology; and best practices, such as lean manufacturing.

d) Lean Manufacturing (LM)

An integrated manufacturing practice that includes techniques, activities and processes that are carried out in order to achieve better performance through the elimination of waste. In the perspective of this research, lean manufacturing is operationalized as the set of techniques that include supplier feedback, just in time (JIT), supplier development, customer involvement, pull production, flow production, flow production, set up time reduction effort, total preventive or productive maintenance (TPM), statistical process control (SPC) and employee involvement.

e) Manufacturing Technology (MT)

Manufacturing technology herein is also known as advanced manufacturing technologies, which consist of a group of computer based technologies that include computer aided design, computer aided manufacturing, manufacturing resource planning, robotics, group technology, flexible system, automated material handling system, computer numerically controlled machine tools, bar coding or other automated identification techniques, as well as any additional or advance technology when compared to previous manufacturing technologies (Lewis & Boyer, 2002; Stock & McDermott, 2001; Abd Rahman & Bennet, 2009). In the context of this research, this wide range group is segregated into four different types, which include information exchange and planning technology (IEPT), product design technology, high volume auto technology (HVAT) and low volume flexible technology (LVAT).

f) Strategic Flexibility (SF)

Strategic flexibility is regarded as the competitive priority approach (D'Souza & William, 2000; Nakane & Hall, 1991; De Meyer, Nakane & Miller, 1989), which allows firms to enhance their ability to react fast in synchronizing functional areas to any threatening changes (Rose, Kumar & Ibrahim, 2008; Swamidass & Newell, 1987). It differs primarily from operational flexibility due to different levels of practice and performance, in as much as, at the business level, operational flexibility measures the variation of practices within an organization and strategic flexibility measures the effect obtained on its performance. In order to achieve strategic flexibility, a firm must first achieve operational flexibility.

1.7 Organization of Thesis

The thesis is divided into several chapters. The first chapter introduces the research, while the second chapter comprises the review of the literature pertaining to manufacturing performance, manufacturing strategies and external environmental factors. The three manufacturing strategies reviewed are lean manufacturing, strategic flexibility and manufacturing technology. Based on the extensive literature review, the theoretical framework and related theories used in the research are presented in Chapter 2. In Chapter 3, a thorough explanation of the research methodology used in this research is mapped out as well as the postulated hypotheses that are tested. This is followed by Chapter 4, which comprises the analytical steps taken in this study complete with the outcome. The results include demographic information as well as the statistical results derived from the collected data. Finally, the thesis ends with Chapter 5, which discusses and concludes the outcome of this research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter aims to explain the route taken to investigate manufacturing strategies implemented by Malaysian manufacturers in order for them to achieve excellence in manufacturing performance while responding to the multifaceted challenges that form the influential external environmental factors surrounding their operations. It presents a review of the relevant literature leading to the development of the conceptual framework for this research. The focus of this review is on manufacturing performance; selected manufacturing strategies, such as lean manufacturing, manufacturing technology, and strategic flexibilities; and external environmental factors, which include hostility and dynamism. Previous empirical findings related to each variable are also be presented. This is then followed by the theoretical underpinning that forms the foundation of this research. Concluding this chapter, the theoretical framework and hypotheses for this study are then established.

2.1 Background of the Study

When the government of Malaysia introduced the Government Transformation Plan (GTP) in early 2011, a framework was established under the flagship, which aimed to lift the Malaysian economy toward higher ground, as outlined in the 10th Malaysia Plan. In the plan, several problems pertaining to the economic growth were identified, among which were the fall in direct investment, fall in productivity rates, inefficient use of resources, outflow of talent and lack of skilled labor. To overcome these problems, ten big ideas were generated and identified as key economic enablers, which were intended to serve as the mechanism for raising the nation's GDP by 6% per annum over the period of 5 years starting from 2011 and lasting until 2015. In order to realize this, the government of Malaysia introduced various strategies and identified key enablers in an attempt to raise Malaysia higher in its ability to compete globally.

Why globally? This was due to the fact that Malaysia relies heavily on its foreign trade. Being a small country with a population of only about 28 million, the local market is too small to be able to support the nation's economic growth on its own. Consequently, Malaysia's international trade has been playing a crucial role in the development of the nation and accounts for a significant portion of its GDP. The percentage of international trade to GDP in 1980 was 113.0%, and reached a peak of 220.4% in 2000, before reducing to 167.2% in 2011 (Talib, 2012). One of the major contributors was the share of merchandise trade, which stood at 84.5%, as compared to 15.5% for the service trade. Of this international trade, 50% was conducted with Malaysia's traditional trading partners – China, Japan, the USA and Thailand. Such a heavy connection to the global trading partners suggested that trade is an important variable in Malaysia's economic indicators and its exposure to international economic instability is inevitable (Talib, 2012; Abd Rahman & Talib, 2011; Hamid, 2010).

2.2 Malaysian Manufacturing Landscape

From the economists' perspective, there are three sources that contribute to the economic growth of a nation – inflation rate, employment growth, and productivity growth (Mohd Isa, 2005). Relating to the productivity of a nation, the manufacturing sector has always been an area of interest for various researchers due to its significant contribution toward a nation's economic growth. Regardless of the operating countries, manufacturing performance is always tied up with the economic element of countries. Here, manufacturing can be defined as the physical or chemical transformation of materials or components into new products, where the work can be performed by power driven machines or by hand, it can be performed in a factory or in the worker's home, and the products can be sold either wholesale or retail (Department of Statistics, 2011).

Meanwhile, in Malaysia, the manufacturing sector is the second largest contributor to the GDP at 26.2%; in addition, it is the main source of employment with a total employment rate of 28.4%, and remains as the main sector for contributing toward the economic growth of Malaysia (Malaysia Productivity Corporation, 2011; Federation of Malaysian Manufacturers, 2010; Islam & Karim, 2010). These facts show how pertinent the manufacturing sector is to the overall economic health of Malaysia. This sector continues to propel the economy forward through synergistic relationships with others, such as trading, financial, transportation, and services sectors. Therefore, it is without any doubt that the manufacturing sector is one of the most important drivers of the growth of the Malaysian economy, which, to date, employs more than one million workers nationwide (Annual Manufacturing Report, 2010).

Historically, when the first census was conducted by the Department of Statistics in 1959, the Malaysian manufacturing sector contributed RM 1,218 million of gross output value, which was dwarfed by the time the latest census was conducted in 2008, in which the value had increased to RM 742.9 billion (MPC, 2008). The largest industry sub-sector in Malaysia was electrical and electronics (22.6%), followed by food, beverages, and tobacco (16%), chemicals (14.3%), fabrication of metal (12%), plastics (9.3%), and the rest was in other industry sub-sectors. The last survey data collected by the Department of Statistics in 2009 showed that there were 32,535 manufacturing facilities throughout Malaysia with a gross output of RM 817.7 billion. All these figures emphasize the significant contribution of the manufacturing sector toward the growth of the nation's economy, how far it has developed over time, and how significant it has become as the pulse of the nation's economy. The following graph (Figure 2.1) shows a profile of the Malaysian manufacturing sector based on industry. This profile was derived from manufacturers registered with the Federation of Malaysia Manufacturers (FMM) for the year 2010. From the profile, it can be clearly seen that the largest number of manufacturing facilities are chemical plants, including those in the petroleum based industries. This is followed in second place by the electrical and electronic segment, and then the third largest sub-industry is food, beverages, and tobacco. The same trend can be seen for the export of manufacturing products, in which electrical and electronic products remain as the highest exported items amounting to more than RM 130 billion at the end of September 2011, which is 41.2% of total manufactured export, followed by chemical products (RM 38.9 billion), and other manufactured goods (MITI, 2010).

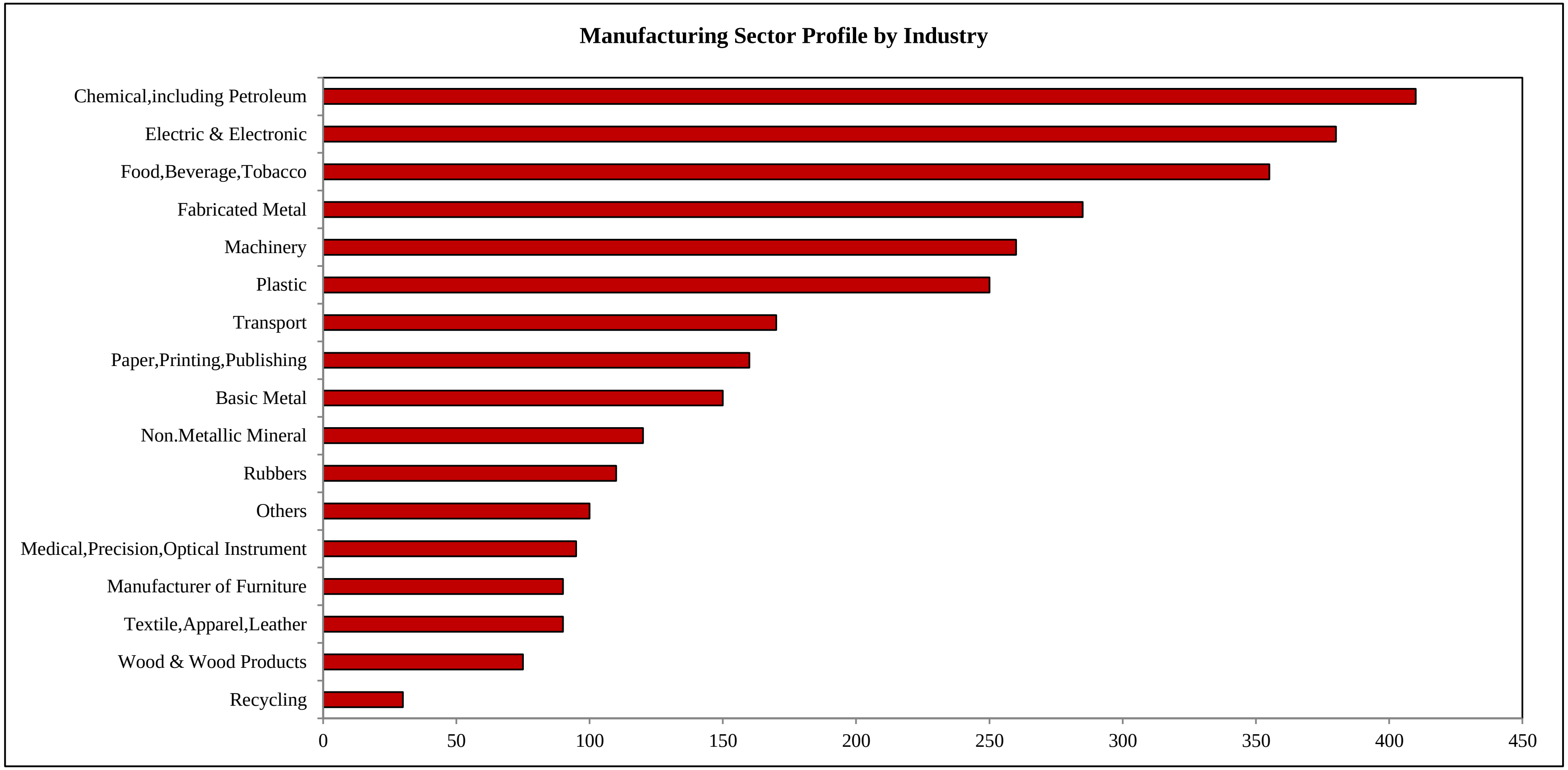


Figure 2.1
Malaysian Manufacturing Sector Profile by Industry
Source: FMM, 2010

2.3 Performance of Malaysian Manufacturing Sector

However due to globalization and the increased demand for better products by customers, manufacturers nowadays face intense multifaceted pressure to perform. The influx of foreign products, new product introduction by competitors, shorter product lifecycle, rapid technology updates, and changes in customer demand have forced manufacturers to re-examine their current strategy and achievements (De Toni & Tonchia, 1998; Anand & Ward, 2004; Verdu-Jover, Lloréns-Montes & Garcia-Morales, 2006). With such a dynamic environment as in Malaysia, manufacturers also face a high level of uncertainty caused by these ongoing changes. The electronics industry, which had been shown earlier as Malaysia's chief export earner since 1974, and the leading contributor of employment, has experienced a performance downturn since 1997. Unlike the experience of Korea and Taiwan where their locally owned firms have driven the catch-up process (Amsden, 1989; Amsden & Chu, 2003; Rasiah & Lin, 2005), multinational corporations (MNC) dominated electronics production and exports in Malaysia (Rasiah, 2010). Thus, any threat to these overseas corporations would undeniably affect their plants located in Malaysia and any form of recovery plans would be more complicated due to the characteristics of MNCs itself. A similar effect can be observed in the supply chain of these manufacturers due to their global links to their suppliers and vice versa.

Malaysia is a small country with a small local market, thus heavy dependence on export performance is unavoidable. This means that any changes in the global economy will have a more focal and significant impact on the local manufacturers. The downslide of manufacturing performance in Malaysia was in tandem with the decline in the global market shares of exports. In 2009 alone, the Productivity Report posted a massive drop of 8.6% in terms of total manufacturing productivity due to a deterioration of the electrical and electronic product cluster, which contracted to a share of about 22.8%. Since manufacturing constitutes the largest single component of Malaysia's economy, without doubt, sluggish manufacturing performance will also affect the nation's overall economy. Due to such a relationship, pertinent past research on this matter was reviewed to obtain a clearer picture.

Several scholars investigated performance trend and challenges face by Malaysia's manufacturers. Liang *et al.* (2011) conducted a study on the trade performance of Malaysia and its major trading partners. They identified Japan, the US, ASEAN countries and the EU as major trading partners, which accounted for more than 70% of Malaysia's total trade flow from 1970 to 2007. Apart from that there was also growing trade between Malaysia and East Asian countries, such as Hong Kong and Taiwan. This study showed that Malaysia recorded a trade deficit in 1997 due to the financial crisis that gripped Asia beginning July 1997. As the crisis spread, Malaysia saw slumping currencies, as well as a devalued stock market and other asset prices. Another notable scholar, Mahmood (2010) conducted a research focused on Malaysian manufacturing trends, challenges and prospects. He further affirmed that while the manufacturing sector is a dominant factor in Malaysia's growth it is highly dependent on the buoyancy of external factors. This study also pointed out the similarity of manufacturing export specialization between Malaysia and other ASEAN countries, thus adding to the competitive pressure on Malaysian manufacturers. The paper summed up the importance of the ability of Malaysian manufacturers to respond to global market change and add more value than their competitors in order to remain competitive.

Scholars from the Department of Statistics Malaysia, namely, Hassan and Talib (2011), also pointed out in their study how Malaysia is highly depended on external trade where demand is very strong and has become a key factor for inducing economic growth. Their research showed that almost two thirds of the growth (value added) was geared by external demand compared to one third of domestic final demand inducement, and, as a result, the Malaysian economy can be considered to be sensitive to external shocks. Their findings were supported by Liang and Jusoh (2012) who further reiterated empirically how much Malaysia depends on foreign trade, and, thus, how the economic performance is sensitive to the changes in the global environment. He suggested that there should be further action in terms of formulation of appropriate measures to boost exports through relevant policies.

Although it has been sufficiently proven that Malaysian manufacturers need to be able to compete globally in order to survive, sustaining the momentum requires a greater, deeper and long-term understanding coupled with a strategic perspective and concentration of effort in order to achieve it.

2.3.1 Definition and Conceptualization of Manufacturing Performance

Performance is the outcome of a singular activity or collection of activities by quantifying action and it can be defined as measuring the efficiency and effectiveness of action toward achieving predetermined objectives (Neely, Gregory & Platts, 2005; Wheelen & Hunger, 2011). In choosing what type of measurement is to be used to measure performance, the basics have to be considered. Given the extensiveness and multi-dimensionality of manufacturer's performance evaluation, measuring is not an easy task. There are many facets of the performance measurement system and this measurement should be done in the context of the organization itself (Gomes, Yasin & Lisboa, 2004). The paradigm of performance measurement should be compatible with the characteristics of the production system, the criteria of management adopted, and also coherent with the strategies of the firm (Hronec, 1993; Wisner & Fawcett, 1991). However, it is important to choose the right measurement for manufacturing performance in order to accurately assess the outcome of the manufacturing functions. Theoretically, financial measurement would be the direct approach to measure the performance of manufacturers, however due to the confidentiality issue, access restriction, and different accounting practices, it has been deemed to be less suitable and inaccurate in capturing actual manufacturing accomplishment (Wheelen & Hunger, 2011). Nevertheless, although financial performance measurement was very popular in the 1980s, it has evolved over time and nonfinancial performance measurement has become more crucial in recent years. Various researchers have pointed out that nonfinancial measurement is just as valid and reliable as financial measurement (Yusuff, 2004; Jusoh, Ibrahim & Zainuddin, 2008; Schmenner & Collins, 2007). Narrowing down the performance measurement to nonfinancial measurement does not make this tool less complicated. In discussing the nonfinancial measurement of performance, there are several different approaches. Some organizations prefer to measure their performance at the task level, operational level, and strategic level. As mentioned before, the measurement should be in the context of the organization itself. Operational measurement is used when the organization focuses on the internal capability; hence quality performance, ability to meet lead time (dependability), operational cost, and flexibility are used as measurement tools (Leachman, Pegels & Shin, 2005). As depicted in Table 2.1 below, there are many ways to measure the performance of manufacturers. While some still prefer the use of financial measurement (Chen & Cheng, 2007; Gomes, Yasin & Lisbao, 2011; Jusoh 2008), some parties argue that financial measurement focuses more on short-term achievement and that it is a hindrance to the long-term strategic approach (Chen & Cheng, 2007; Chenhall & Langfield-Smith, 2007; Berry, Christiansen, Bruun & Ward, 2007). However, in terms of measuring the performance of an implemented strategy, the objectives used in the formulation of the strategy, such as sales objectives and market share (Papke-Shields & Malhotra, 2001; Anand &Ward, 2004), should be utilized. The preferential use of these tools are becoming more regular and common among manufacturers due to the inability of operational measurement to translate the impact of overall manufacturing activities toward business performance.

Table 2.1
Previous Research Conducted on Manufacturing Performance

Author	Year	Financial Measure	Nonfinancial Measure	Content
Papke-Shields & Malhotra	2001		Sales growth Market share	The alignment of business strategy and manufacturing performance.
Anand & Ward	2004		Market share Sales growth	This research was done to study the impact of environmental dynamism on manufacturing performance.
Yusuff	2004	Annual sales Annual expenses Annual lost Annual profit	Market share Product variety New technology Research and development	This study assessed the implementation of best practices by electronic and electrical manufacturers in Malaysia and the impact toward their performance. Both types of measure were used to better capture overall performance.
Chen & Cheng	2007		Customer complaint On time delivery Equipment effectiveness Cost of quality	Manufacturing performance was developed based on traditional cost where the accounting system was deemed inadequate in capturing the relevant manufacturing performance. NFP were said to provide a critical link between strategy, internal organization, and technology.

Table 2.1 (Continued)

Author	Year	Financial Measure	Nonfinancial Measure	Content
Jusoh *et al.*	2008	Classification of PMS dimensions Highly used: Financial measure Operating income Sales growth Sales revenue	Classification of PMS dimensions. High to moderate: Customer satisfaction, Customer loyalty Low: Innovation measure, e.g. number of new patents, number of new products	Malaysian manufacturers prefer to use financial measures, operating income, sales revenue, and sales growth as performance indicators. Innovative measurement is still in its infancy stage, but growing as more manufacturers prefer multi-dimension measures to assess performance.
Brown *et al.*	2007		Supply chain, Technology investment, Growth initiative production level, New product development	Strategic measurement is used to measure the impact of implemented strategies and practice on performance.

Table 2.1 (Continued)

Author	Year	Financial Measure	Nonfinancial Measure	Content
Dossi & Patelli	2010	Sales Revenue	(Customer perspective):	Importance placed on strategic PMS to properly and adequately measure strategy implementation effectiveness. For multinational corporations (MNC), use of multiple performance measures is much better due to difference in exchange rate. Adoption of both NFP and FP measures will enable better determination of the overall performance of variously located plants.
		Operating income	Sales volume trend	
		Contribution margin	Market share	
		Net income	Customer satisfaction	
		Cash flow	Market coverage indicator	
		Networking capital	New customer rate	
		Return on investment	Customer loyalty rate	
		Return on Equity	Trade part satisfaction	
		Residual income	(Internal process):	
		Economic value added	Process productivity rate	
			Product/Service quality	
			Process quality	
			Product cycle time	
			Flexibility rate	
			Internal customer satisfaction	

Table 2.1 (Continued)

Author	Year	Financial Measure	Nonfinancial Measure	Content
Gomes *et al.*	2011	Financial	Product quality and customer satisfaction Process efficiency Product & process innovation Competitive environment Quality independence of management HRM Social responsibility	Manufacturers emphasize more on NFP as it is regarded to be more consistent with the ability to capture the complexity of manufacturing operations. Suggested future considerations on more innovative measurement, such as innovation capabilities as well as social responsibility.

It is important to realize how implemented manufacturing practices and strategies impact the customers instead of focusing on the internal achievement as with operational measures. Ketokivi and Castaner (2004) clearly indicated the importance of strategy in unifying various functions inside a manufacturing facility, thus minimizing the sole pursuit of lower level goals at the expense of overall performance. An internal operational achievement that is not translated into overall business performance would be detrimental to any business strategy. This indicates the importance of measuring performance from the strategic point of view. Among the strategic measurement dimensions usually used by the manufacturers are market share (Schemmener, 1993; Papke-Shields & Malhotra, 2001; Anand & Ward, 2004), sales growth (Swamidass & Newell, 1987; Papke-Shields & Malhotra, 2001; Anand & Ward, 2004; Camison & Villar-Lopez, 2010), quality performance (Gomes *et al*., 2004; Brown *et al*., 2007), and product/process innovation (Schmenner, 1993; Gomes *et al., 2*004; Ling-yee & Ogunmokun, 2008).

Instead of relying on a single dimensional measure of manufacturing performance, a multidimensional approach that includes both nonfinancial measures and financial measures is more appropriate, especially when measuring practices and performance (Fullerton & Wempe, 2009; Abdel-Maksoud, Dugdale & Luther, 2005; Ketokivi & Shroeder, 2004; Bozarth & Edwards, 1997). New parameters of measurement are being included, such as innovation indicators, in order to correctly measure the performance in the realm of business reality in which customer focus is crucial (Abdel-Maksoud *et al*., 2005). Successful manufacturing organizations must develop new products to meet market needs in a timely, cost-effective, and efficient manner, as sales revenue from new products is significant for the financial well-being of manufacturers (Larso, Doolen & Hacker, 2009; Gupta, 2003; Chang & Tang, 2001; Griffin, 1997).

2.4 External Environmental Factors (EEF) and Malaysian Manufacturers

Due to the heavy dependence on global trading partners and with the concept of an open market, Malaysian manufacturers cannot avoid being affected by changes in their surrounding environment. Various research has been conducted to confirm this relationship in the context of this country.

Talib (2012) investigated the interdependence of Malaysia's economy on other countries, especially its trading partners using business cycle analysis. In this study, the business cycle concept was studied using two dimensions of cyclical fluctuation – growth rate and growth cycle. Growth rate cycle assumes that the growth rate of an economic indicator is cyclical while growth cycle focuses more on estimating the long-term trend of economic time series. The main objective of this study was to provide evidence for the decoupling hypothesis, and whether Malaysia's economy is influenced by instability in the economies of other nations. One of the observations in this study was the fact that the period of financial instability in the international market also coincided with Malaysia's cyclical turns, for example, the evidence concerning the US 2007/2008 debt crisis in which the Malaysian economy was also impacted. However, another observation from the same study suggested that Malaysia's economic recession did not arise from the slower demand of advanced economies. Nevertheless, the scholar did note that his finding was only based on judgment rather than the appropriate use of statistical tools and suggested that future research should revisit the issue through the means of statistics.

Another research concerning Malaysia's trade performance in relation to its trade partners was conducted by Liang *et al.* (2011). Again, this researcher also pointed out that Malaysia's economy is too sensitive to external shocks. One cited incident was during the period from 2000 to 2005, when instability in the US economy played a relatively important role in inducing domestic production and value added strategies for Malaysia. The findings from this study pointed out that the financial recession of most Asian countries in 1997 affected Malaysia's overall export performance and also caused imports to drop, particularly in relation to the manufacturing sector. Thus, when there was an upswing in 2007, it was associated with the robust global economic recovery and the efforts of the government in sending out trade missions to open new markets.

In conclusion, this study showed an overall manufacturing led economy, which was deeply rooted within the overall changes in the global economy. However, this research focused on the financial oscillation, and did not elaborate deeper on the contingent effect pertaining to the financial crisis; rather it analyzed the financial impact, which it considered to be directly linked to the performance of the manufacturing sector.

2.4.1 Definition and Conceptualization of External Environmental Factors (EEF)

As mentioned before, the business environment in which a firm operates poses various and different challenges to the firms. In the context of this research, the business environment is referred to as the external environmental factors (EEF). Such factors can include a huge variety of elements, all of which interact and continually change. The factor can be classified into physical environment, political or legal environment, economics factor, social or socio-cultural factors, and technological factors (Waters, 2006). Byars, Rue and Zahra (1996) explained the external factor's impact on a firm through the following Figure 2.2.

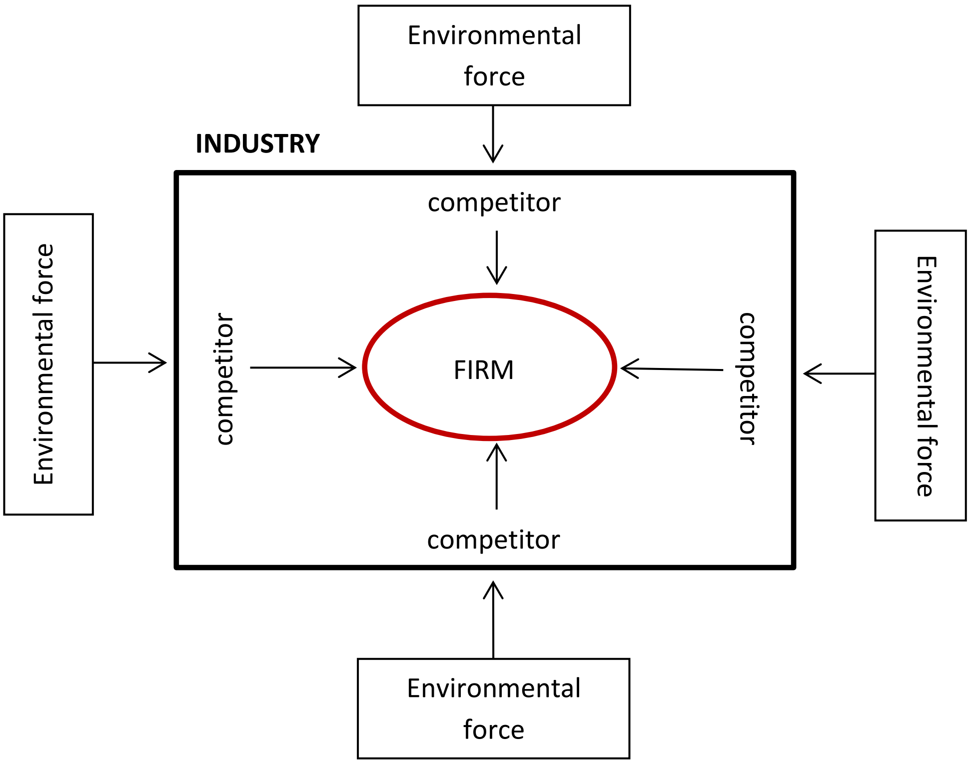


Figure 2.2
External Factors Impacting a Firm
Source: Byar *et al*, 1996

In this context, Byar *et al.* (1996) stated that environmental analysis identified external forces within the environment that could affect the industry as well as the firms within those industries. These forces are exemplified as political, legal, economic, social, and technological elements. This approach was similar to the famous five forces explained by Porter (1986). In his model, Porter described the five forces – threat from new competitor, customer bargaining power, supplier bargaining power, threat from substitute product or service, and competition – between existing competitors. Porter's model is further discussed later in this chapter.

Components of the external environmental factors include the physical environment, which is the natural and built environment in which the firm operates. In the context of the manufacturers, the physical environment would make them choose where to operate, for instance, near to supply sources or near to customers. To a certain extent, manufacturers could make such choices but the choices are often limited and firms have to accept the prevailing conditions (Waters, 2006).

Meanwhile, other components of the business environment comprise the influential political and legal factors. These factors are the laws and regulations that govern the operation of firms. Manufacturers, or any other type of organization for that matter, prefer regulations and political situations that are both ideal and stable to operate within (Wheelen & Hunger, 2010; Waters, 2006).

Lastly, other factors are economic environment, socio-cultural factors, and technological factors. These last three factors deal with the pricing of end products and how the general economy enables firms to achieve their financial objectives, defining the relationship between the firm and the society within which it exists, and explaining how the application of technology affects an organization, respectively. It is claimed that, to a large extent, the external environment (e.g. industry and customer characteristics) of any organization determines its adopted strategy (Lotayif, 2010; Murray, 1988). From the existing literature on the subject, the external environmental business factors have been shown to have a significant impact on manufacturing performance. Table 2.2 summarizes the relationship between the two variables.

Table 2.2

Summary of Environmental Factors on Performance

Author	Year & Scope	Environmental Factors	Content
Chi, Kilduff, Gargeya & Dyer.	2009 n=229; USA	Dynamism Complexity Diversity Hostility	Congruence between business environment and supply chain management and competitive priorities has a significant impact on business performance. Hostility and dynamism significantly impact all dimensions of business performance while diversity only has no impact on and complexity for certain dimensions of business performance.
Li	2000 n=72; China	Government regulation Dynamism	High performing manufacturers respond to changing business environment by adopting manufacturing flexibility while poor performers concentrate on cost efficiency alone.
Özsomer, Calantone & DiBenedetto	1997 n=192; Fortune 500 companies	Hostility Uncertainty	Uncertainty leads companies to be proactively innovative, while, in hostile environments, most companies would rather play safe in the face of a high risk involvement

Table 2.2 (Continued)

Author	Year & Scope	Environmental Factors	Content
Miller & Friesen	1983, n=52	Heterogeneity Dynamism Hostility	Significant, positively impacted.
Liao & Tu	2007 n=303; USA	Uncertainty	Under high uncertainty conditions, manufacturing system automation will have significant impact on manufacturing performance.
Jusoh	2010 n=120; Malaysia	Uncertainty	Level of uncertainty is significant with the choice and extent of performance measure used.
Swamidass & Newel	1987 n=23; USA	Uncertainty	Manufacturers cope with environmental uncertainty by increasing manufacturing flexibility and ensuring manager involvement in strategic decision making for better performance.

Miliken (1987) defined uncertainty as the lack of ability to make accurate predictions concerning the external environment factors that affect a firm. For the purpose of this study, environmental uncertainty is conceptualized as external environmental factors and is defined through its three elements, which are dynamism, heterogeneity, and hostility. This definition is conceptualized based on the earlier work by Miller (1987), Liao and Tu (2008), and Miller and Friesen (1983, 1984a).

Dynamism is defined as the amount of unpredictability in customer-changed production or service technologies and modes of competition in the industries. Heterogeneity is defined as the difference in competitive tactics, customer tastes, product line, and channels of distribution, etc., across the firm's respective market.

Lastly, hostility is defined as the environmental evidence shown by price, product, technological and distribution competition, regulatory restriction, shortage of labor or raw material and unfavorable demographic trends. In the context of this study, dynamism and hostility are the two dimensions used to measure uncertainty as external environmental factor, they are measured most in various environmental factor studies (Lumpkin & Dess, 2001; Moreno & Casillas, 2008; Wiklund & Shepherd, 2005).

2.5 Manufacturing Strategy

Manufacturing strategy is generally defined as the development of specific competitive strength based on the operation function and the use of manufacturing capabilities to achieve manufacturing goals (Amoako, 2003).

One of the pioneer researchers in manufacturing strategy (MS), Skinner (1996), defined MS as exploiting certain manufacturing functions as a competitive weapon. MS includes making decisions and plans affecting resources and policies directly relating to the sourcing, production and delivery of tangible products by positioning the company resources in a way that enhances its competitive position in the marketplace (Swink & Way, 1995). Industries choose to follow operation strategies, such as lean manufacturing (LM), agile manufacturing and six sigma, to achieve a better competitive advantage, achieve productivity improvement and emerge as top players in their field (Seth & Gupta, 2005; Tsang & Chan, 2000; Anand & Kodali, 2009). Therefore, it is without a doubt that the right manufacturing strategy is always an important driver in ensuring a company's higher performance. Researchers have chosen to define manufacturing strategy in accordance with the context of their approach. Below (Table 2.3) are some definitions of manufacturing strategy by several distinguished researchers in the field.

Table 2.3
Various Definitions of Manufacturing Strategy

Author	**Year**	**Definition**
Skinner	1969	The exploitation of certain manufacturing functions as a competitive weapon.
Schmenner	1979	Plan that describes how to produce and distribute products.

Table 2.3 (Continued)

Author	Year	Definition
Hayes & Wheelwright	1985	As a pattern of decisions made by manufacturing organizations and the degree to which they support the business strategy.
Swamidass & Newell	1987	The deployment and development of manufacturing capabilities in alignment with firm's goals and strategies, which, in turn, gives it a competitive advantage.
Hayes & Pisano	1994	Stating specified competitive advantage that is required and how to achieve it.
Swink & Way	1995	Decisions and planning concerning the firm's resources and policies that affect the functions in a firm in delivering products.
Brown	1999	Drivers for continuous improvement in competitiveness that enable it to satisfy multiple requirements.

2.5.1 Manufacturing Strategy – The Beginnings, Evolution and Progression

Professor Skinner was the first to use the term "operation strategy" through his renowned article published in the Harvard Business Review in 1969. He postulated that there were four types of manufacturing strategies:

i. Cost-based strategy – this approach uses a prediction by economic theory, where the optimum firm will operate at a scale where organization and technology will produce at the lowest average cost.
ii. Quality-based strategy – has the best quality for a given design.
iii. Flexibility-based strategy – be the most flexible in terms of schedule, product change, and product release.
iv. Speed-based strategy – offer the best customer service.

Using this framework, much later on, Rose *et al.*(2008) commented that cost-based strategy, as defined above, is more suitable for firms that practice mass production and where quality is not a major concern. As for flexible manufacturing, this strategy influences a firm's ability to fluctuate as necessary in terms of product, design, product mix, product material, and sequence, in order to meet various requirements by customers (Dangayach & Deshmukh, 2001).

After Skinner's typology, other renowned strategists, Miles and Snow (1978), came up with a different character typology of manufacturing strategies. They explained four types of manufacturing strategy as distinct characters according to the general strategic orientation of firms implementing them, as explained below:

i. Defenders – companies with a limited product line that focuses on improving the efficiency of their existing operation. The cost orientation makes them unlikely to innovate in new areas.

ii. Prospectors – companies with fairly broad product lines that focus on and market product innovation, emphasizing creativity over efficiency.

iii. Analyzers – companies that operate in at least two different product-market areas, one stable, the other variable. In the stable areas, efficiency is emphasized and in the variable areas, innovation is emphasized.

iv. Reactors – companies that lack a consistent strategy-structure-culture relationship. Often ineffective when facing environmental challenges and tend to adopt a piecemeal strategic approach.

This approach continues to be used by manufacturing strategy researchers to this very day, since dividing competition into these categories not only enables strategic managers to focus on monitoring a certain strategic orientation, but also helps develop scenarios for future industry development (Wheelen & Hunger, 2010). This work was then followed by Porter (1985) in which he introduced his four generic strategies. Porter's generic business strategies are generally summed up as follows:

i. Cost leadership strategy- aims to achieve overall cost leadership in the industry, which considers assets used, employee productivity, and discretionary expenses. For example: cost reduction from experience, tight cost and overhead control, cost minimization primary and supporting activities on firm's value chain, such as research, manufacturing, service, sale forces, and advertising (Porter, 1985; Dess, Lumpkin & Eisner, 2007; Hitt, Ireland & Hoskisson, 2003; Pamel, 2000).

ii. Differentiation strategy - offers unique products and services in various forms, such as prestige and brand image, technology leadership, engineering design, rapid product innovation, features, customer service, and dealer network (Porter, 1985; Dess *et al*., 2007; Hill and Jones, 2004).

iii. Focus strategy - can be categorized into cost and differentiation focus. It chooses a narrow competitive scope within an industry for the selection of a specific market group in order to provide better service. The cost focus is to create a cost advantage within a particular market, while the differentiation focus aims to differentiate the target market. The firm is able to utilize technology, research capability, managerial creativity, and talented workforce to serve unique market segment differentiation (Porter, 1985; Hill & Jones, 2004).

iv. Integrated strategy - overall low cost and differentiation strategy enables a firm to provide two types of value and lower prices for unique value to customers, such as automated and flexible manufacturing systems, and extended value chain by information technology (Porter, 1985; Dess *et al.*, 2007).

Over the years this typology has received numerous empirical supported evidences (Vorhies & Morgan, 2003; Shoham, Evangelista & Albaum, 2002; Cabello, Garcı´a & Jime´nez, 2000; Slater & Narver, 1993; Miller, 1992; Conant, Mokwa & Vanadarajan, 1990). Porter then followed his earlier work with the identification of the famous five forces to explain the forces of competitiveness.

The competitor model is summarized as follows:

i. Rivalry among existing organizations – originate from the desire of the firm to gain competitive advantage.
ii. Supplier of key inputs – reliant on suppliers, which cause firms to develop stable, long-term relationships with suppliers as a result of strategic alliances.
iii. Customers – customers having a strong influence in certain markets with preference toward competitive markets.
iv. Potential new entrants – new entrants bring extra capacity, typically adopt strategies of aggressive competition to build market share at the expense of existing firms.
v. Substitute – occur when customers can replace one product with another from organizations in different industries.

Porter's model carefully indicates how the hurdle of gaining competitive advantage depends on the performance of competitors and that when competition is weak, it is relatively easy to gain competitive advantage and vice versa (Waters, 2006). From an extensive review of the literature, it is easily concluded that within the manufacturing strategy framework, the models of Miles and Snow (1978) and Porter (1980; 1985) are the most popular frameworks in terms of classifying the various ways in which firms compete (Miller, 1992; Oltra & Flor, 2010).

However, while Porter's generic strategies model has been amply supported empirically (Kabadayi, Eyuboglu & Thomas, 2007; Langfield-Smith, 2005;

Wai-Kwong, Priem & Cycyota, 2001; Homburg, Krohmer & Workman, 1999; Lee & Miller, 1996), it has also received criticism due to its limitations and simplicity (Mintzberg, 1988). Over the years the classical strategic typology introduced by Porter began to receive criticism as it was said to be too generic and deemed inadequate to be used by firms as a competitive weapon nowadays. Below is a summary of the arguments and criticisms concerning Porter's Theory of Generic Strategies.

Table 2.4
Arguments Concerning Porter's Theory of Generic Strategies

Criticism	**Author (Year)**
Number of strategies are not limited to these strategies only: Cost leadership Differentiation Supply chain Training	Allen, Helms, Takeda & White (2007)
Dichotomous nature: Generic strategies are not dichotomous in usage, as a number of businesses that adopt both cost leadership and differentiation strategies have not ended up being stuck in the middle (as suggested by Porter). In fact they are some of the world's most successful firms.	Murray (1988)
Theoretical shortcomings: Generic strategies are too general. Strategic approach is too simplified.	Christman, Hofer & Boulton (1988); Hill (1988); Miller (1992) Day & Wensley (1988); Matthur (1992); Morrison & Roth (1992); Spender (1993)
Fit with reality: Generic strategies do not fit empirical reality.Generic strategies model is based on an invalid epistemological approach.Generic strategies do not consider the evolution of the competitive environment.	Gurau (2007); Dawes & Sharp (1996) Aktouf, Chenoufi & Holford (2005) Downes (1997)

Table 2.4 (Continued)

Critism	Author(Year)
Limited applicability:	
Generic strategies are not applicable for small firms.	Lee, Lim, Tan & Wee (2001)
Generic strategies are not applicable for fragmented markets.	Borch & Brastad (2003); Pitelis & Taylor (1996)
Generic strategies are not applicable for retailers.	Botten & McManus (1999); Gupta (1995)
Generic strategies are not alternative solutions, but can profitably coexist in the strategic approach of a firm.	Kaya, Alpkan & Aytekin (2003); Kotha & Swamidass (2000); Wagner & Digma (1997); Miller & Dess (1993); Miller (1992); Wright, Kroll, Tu & Helms (1991); Murray (1988); Wright (1987); Miller & and Friesen (1986)
Alternative theoretical approaches:	
The strategic analysis should apply a resource-based approach.	Juga (1999); Kay (1993)
The strategic process is flexible and emergent, being based on trial and error.	Botten & McManus (1999)
Generic strategies do not consider the necessity for collaborative strategies.	Brandenburger & Nalebuff (1995); Moore (1996)

Source: Adapted from Gurau, 2007

Over the years, manufacturing strategy studies have received wide attention from both academicians and industrialists. The emergence of various challenges from the business environment has drawn more attention to this topic. However the traditional typology has also evolved with more researchers going for content classification of manufacturing strategy.

Dangayach and Deshmukh (2001) reviewed and classified more than 30 years of research performed on manufacturing strategy to capture its overall constitution. Starting from the earliest work by Skinner in 1969, until the year 2000, 260 published research papers were reviewed and classified according to the methodology used and contribution to the total area of manufacturing strategy. The outcome was a complete summary of the manufacturing strategy body of work, which indicated that manufacturing strategy is actually an issue approached through three different priorities:

i. Manufacturing strategy as manufacturing capabilities – Skinner (1969; 1974) started this route by dividing manufacturing strategy into five different priorities: cost, flexibility, quality, delivery dependability, and delivery speed. An approach seconded by Neely (1993), Slack (1994), Wheelright (1984), and Gerwin (1987).
ii. Manufacturing strategy as strategic choice – Skinner (1969) proposed plant, equipment, production planning, and production design, etc., as the key choice areas in manufacturing strategy. This approach was further elaborated upon by Wheelwright and Hayes (1985), and Hill (1987) with the addition of structural and infrastructural issues.
iii. Best practices – this approach has received more attention in recent research. Hayes and Wheelwright (1985) coined the concept, which was later adopted and developed by Schonberger (1986).

Based on this classification work, 97%, which is 200 out of the total 206 reviewed, approach manufacturing strategy from the three platforms above.

The approach above is called a content approach of manufacturing strategy, with the second approach being the process approach. The latter includes elements such as design, development, and implementation of manufacturing strategy. In a comparison of the two approaches, the content approach has received more attention from researchers due to its large scope since it covers a larger paradigm on maturing strategy as a whole. However, the process approach is also gaining more attention since it focuses on strategy deployment throughout the company (Voss, 2005).

In the context of this thesis, the content approach has been chosen as the research framework for the whole study for the reason that it facilitates a wider and more complete strategic outlook of a firm that chooses to compete through manufacturing. Manufacturing practices have a significant impact on manufacturing performance (Dale & Lightburn, 1992; Karim, Smith & Halgamuge, 2008a; Karim, Smith, Halgamuge & Islam, 2008b; Lai, 2003). Various scholars have reported positive relationship between manufacturing practices and performance (Anderson, Rungtusanthan, Schroeder & Devaraj, 1995; Filippini, 1997; Flynn, Schroeder & Sakakibara, 1995; Flynn & Flynn, 1996; Forza & Filippini, 1998; Hendricks & Singhal, 2001; Ibusuki & Kaminski, 2007), and that manufacturing practices adapted or adopted by manufacturers are context specific (Davies & Kochhar, 2000; Bayo-Moriones, Bello-Pintado & Merino-Dı´az de Cerio, 2008). This line of work has received continuing attention and there is evidence that some practices are widely adoptable, whilst others are only effective in specific contexts (Sousa & Voss, 2001).

There is also a growing view that manufacturers must view manufacturing practices as bundles or packages and not just single and individual practices (Shah & Ward, 2003; Cua, McKone & Schroeder, 2001). It is important to understand which practices are necessarily complementary, and which are not, which practices are universal and which are contingent (Voss, 2005).

The context of best practices is becoming an increasing source of interest due to the failure of many practices to materialize into benefits (Davies & Kochhar, 2000; Shah & Ward, 2003; Voss, 2005). Many best practice debates ignore the issues of why practices are successful and instead concentrate on which best practices will provide a competitive edge (Ketokivi & Schroeder, 2004). Much of the fundamental understanding underpinning practices is often ignored. Evidence through empirical validation has indicated that best practices are not chosen in a systematic manner nor are they measured properly. There did not appear to be any investigation of the context of best practice. This could be the reason why so many 'best practices' resulted in failure to transfer into an effective implementation. The adoption of best practices is not sufficient to emulate the success of top manufacturers since practices have to be adapted to the environment in which the company is operating (Camp, 1989; Whittle, Smith, Tranfield & Foster, 1992; Young, 1992; Galbraith, 1977). However, the crucial argument is that companies that have adopted best practices achieve high performance in operational areas (Voss, 1995; Brown *et al.*, 2007). Contingent to that, it has been suggested that by implementing these practices at the operational level, the performance of the overall organization will also be improved (Davies & Kochhar, 2000; Schroeder & Flynn, 2001).

Various manufacturing practices have been discussed in a broad spectrum of the literature. However, manufacturing practice research on the strategic content relating to the importance of content choices and integration of implementation has only recently began to be integrate with another important concern of manufacturing strategy (Brown *et al.*,2007; Brown & Blackmon, 2005; Brown, 2000; Ketokivi & Schroeder, 2004).

2.5.2 Importance of Manufacturing Strategies to Malaysian Manufacturers

The link of manufacturing strategies to performance has been discussed by various scholars. The manufacturing strategy determines how manufacturing resources and capabilities are deployed based on the process, content and implementation (Hayes & Wheelwright, 1985; Brown & Blackmon, 2005). With the progress made from the seminal work of Skinner (1985), Hayes & Wheelwright (1985) and Hill (1985), the conventional manufacturing strategy paradigm has been changing and evolving. Core manufacturing concepts, such as manufacturing practices, capabilities and world class manufacturing process, have been challenged and improved. Scholars have suggested that while the conventional manufacturing paradigm is still useful (Drucker, 1990), there is a lack of (1) cohesive theory based effort by researchers (Leong, Synder & Ward, 1990), (2) insufficient survey based empirical work (Brown & Blackmon, 2005), and (3) proper integration with the concept and theories developed in other disciplines (Brown & Blackmon, 2005). Therefore, while the conventional strategies can still be of use, manufacturers continue to find and explore other paradigms of manufacturing strategies that are best suited to them. Malaysian manufacturers have undergone the same journey and experience. Vinayan, Jayashree and Marthandan (2012) in his study on Malaysian manufacturing industries tried to determine the elements that represent competitive advantage. Their study showed that in order to maintain competitive advantage, four major components – the ability to respond as an organization, the ability to compete at a low cost, having and effective supply chain management and the ability to differentiate and innovate product – are needed. An earlier study by Yusuff (2004) tried to determine the best manufacturing practices among Malaysian electrical and electronic firms. This research suggested that the implementation of world class practices was satisfactory in the areas of management commitment, internal and external customer service policies and supplier relationship and development programs. The research of other scholars on the manufacturing strategies of Malaysian manufacturers was less comprehensive and more focused on singular or individual paradigms, such as supplier selection and strategies on manufacturing performance (Ndubisi, Jantan, Hing & Ayub, 2005), purchasing strategies and manufacturing performance (Thrulogachantar & Zailani, 2011), instead of the complementarity approach taken by this study.

Beyond the importance of a robust manufacturing sector to economic health, there are three primary reasons why Malaysia needs to focus on manufacturing strategy:

1. Other countries, such as the US (Ezell &Atkinson, 2011), the UK (Technology Strategy Board, 2012) and even Malta (Malta Science & Technology Board, 2011) have strategies to support their manufacturers, and,

by lacking similar strategies, Malaysia is forcing the manufacturers to compete at a disadvantage.

2. Systemic market failures mean that through the absence of manufacturing policies, Malaysian manufacturers will underperform in terms of innovation, productivity, job growth, and trade performance.

3. If the country loses the complex, high-value-added manufacturing sector, it is unlikely to get it back, even if the ringgit declines dramatically.

2.5.2.1 Strategic Perspective of Lean Manufacturing

The industrial environment faced by Malaysian manufacturers is characterized by, among others, rivalry among competitors, speed of change as well as instability of demand. Everything seems to indicate that markets for industrial output will continue with the specific needs of customers, such as quicker and more regular deliveries (Marin-Garcia, Maria-Sabater & Bonavia, 2009; Peng, Schroeder & Shah, 2008; Ketokivi & Schroeder, 2004; Devaraj, Hollingworth & Schroeder, 2004). In such circumstances, manufacturers have no other choice but to shield themselves with strategic operation priorities in their production. At the operation level, two different blocks to strategic approaches have been identified – differentiation and cost priority. Manufacturers that emphasize the latter give priority to the efficient management of cost through reduction of operating cost, or reduction of investment and inventory (Marin-Garcia & Bonavia, 2011; Avella, Fernandez & Vazquez, 2001; Ketokivi & Schroeder, 2004; Hayes & Wheelwright, 1985). However, companies that emphasize on differentiation will see quality of operation such as error free product, quality, delivery and flexibility as priority (Lewis & Boyes, 2002; Avella *et al*., 2001; Devaraj *et al.,* 2004; Hayes & Wheelwright, 1985). However, it seems impossible for manufacturers to satisfy all these priorities without a certain trade off to make it work. A trade off means that increasing one chosen capability might decreases the other (Porter, 1996; Slack, 1998; Skinner, 1974). Currently, manufacturers prefer to focus on a few priorities at any given moment, and, once satisfied, move on to others without losing the developed, accumulated priorities (Gonzalez Benito & Suarez Gonzalez, 2007 (as cited in Marin Garcia & Bonavia, 2011); De Toni & Tonchia, 2002). This approach is the basis of such practice that shapes the system of advanced manufacturing of which lean is a part. Various scholars have stated that the application of this practice would be beneficial to the implementers. Lean manufacturing has received notable approval among researchers, as being able to improve productivity through a reduction of waste (Callen, Fader & Kinsky, 2000; Callen, 2010), added value to product (Suzaki, 1993), and basically improving the majority of operational keys, such as the reduction of lead time, better inventory level as well as unit cost (Callen *et al*., 2000; White & Prybutok, 2001; Marin-Garcia *et al*., 2009), which, in turn, allow improvement against competitors. Regardless of whether the manufacturers make highly differentiated products with a few models or use repetitive configurations, or vary in terms of the industry in which they operate, lean has proven to be superior and beneficial (Flynn, Schroeder & Flynn, 1999; Hayes & Pisano, 1994; Sweeney, 1991).

The lean strategic approach is based on the assessment of lean as a strategy to improve performance (Ahmed, Montagno & Firenze, 1996) showing that organizations achieve higher performance through the management of their manufacturing strategy. Such an outlook indicates that the complementary aspect between strategy and performance is crucial when pursuing long-term benefit (Steward & Raman, 2007; Liker, 2006; Bhasin & Burchner, 2006; Lewis, 2000). It has been recognized that a strategic approach is necessary in explaining how the practice of lean helps improve performance (Takeuchi, Osono & Shimizu, 2008; Towill & Christopher, 2007; Berry *et al*., 2007). These aforementioned scholars summed up the claim that lean as a strategy can bring significant competitive advantage when it is exploited in the long-term for the development of specific capabilities of the organization.

2.5.2.2 Strategic Perspective of Manufacturing technology

It has been suggested that firms that adopt manufacturing technology would not reap the appropriate amount of benefit from its implementation unless they adopt it together with a strategic planning approach (Stock & McDermott, 2001; Saberi & Yusuff, 2011). Manufacturing technology can be strategically used to achieve a sustainable competitive edge and enables manufacturers to acquire a superior performance position (McIvor, 2008; Kristianto, Ajmal, Tenkorang & Hussain, 2012). The strategic implementation of manufacturing technology allows manufacturers to respond to demand uncertainty and increases their competitive advantage (Goyal & Netessine, 2007; Gerwin, 1993). Strategic technology choice enables the company to not only focus on the implementation of the technology but also on how effective the investment is toward the performance of the manufacturers. From a strategic perspective, manufacturing technology acts as a tool used by firms to adapt and react to the increasingly volatile and complex business environment (Sonntag, 2003; Orr & Sohal, 1999). Olesen (1990) reported that two out of six strategic characteristics of the most successful companies are the willingness and ability to acquire technology and take technology risks. These strategic advantages are crucial factors that have been noticed and adopted successfully by Japanese manufacturers (Orr & Sohal, 1999). The acquisition of appropriate technology is very important to enable a competitive advantage to be gained (Burcher, Lee & Sohal, 2004; Gindy *et al.*, 2006; Rishel & Burns, 1997).

As mentioned before, the adoption of manufacturing technology is not an easy task. The existing contingency factors, such as industry type and product lifecycle, are among the factors that could affect the success of adoption and the result (Sonntag, 2003). There are even several industries that claim that the adoption of manufacturing technology is not beneficial for them (Orr & Waldron, 1997). However, contrary to this popular notion, the use of MT should significantly increase the competitive advantage of manufacturers (Abd Rahman & Bennet, 2009). Various studies have shown that investment in manufacturing technology is expected to contribute to the strategic performance of firms (Swamidass & Nair, 2004; Liu & Yang, 2008). Studies have also empirically proven that the adoption of manufacturing technology also helps increase the strategic flexibility within firms (Dangayach & Deshmukh, 2004; Narasimhan, Talluri & Das, 2004; Gerwin, 1993). In studying manufacturing technology, most of the research focused on the impact of technology on performance (Abd Rahman & Bennett, 2009; Swamidass & Nair, 2004; Small, Yasin & Czuchry, 2009). However, there is a lack of attention to a technology choosing guide to facilitate manufacturers to make smart choices in handling challenges from environmental factors. This proclamation is supported by various technology researchers (such as De Lima, Da Costa & Jannis, 2009; Sonntag, 2003; Sim, 2001). The strategic approach to manufacturing technology enables these manufacturers to gauge such investment concerning the outcome of demand realization, optimal behavior capacity as well as the financial benefits of it all. Such an approach takes a long-term, comprehensive view of business and technology issues (Elitan, 2012; Goyal & Netessine, 2007; Saberi & Yusoff, 2011). Strategic benefits, such as early market entrance, market leadership and the ability to customize products, and, ultimately, improved product flexibility within and outside of the plants, are extremely important for the growth and survival of manufacturers (Elitan, 2012; Mooradian *et al*., 2006). The relationship between manufacturing technology and performance from a strategic point is relatively complex (Kotha & Swamidass, 2000); however, the requirement for internal consistency within the manufacturing organization asserts the importance of the strategic approach to achieve superior performance. Ultimately, the implementation of such technology offers manufacturers the ability to produce at lower cost, while, at the same time, become operationally flexible to meet customer requirements, and, finally, meeting the potential of improving the overall business performance. In the context of strategic approaches, manufacturing technology is viewed as a tool that enables firms to increase their production capability to sustain long-term objectives. This capability deserves attention as it serves as an approach to deal with the uncertainty associated with the business environment as well as the risk of huge investment that is associated with the technology. While strategists have argued that the implementation of multiple strategies by manufacturers would be problematic instead of beneficial (Porter, 1996; Slack, 1993), manufacturing technology would instead reduce the need for tradeoff between strategies, especially between the cost and variety for manufacturers (Kotha & Swamidass, 2000). The ability to adopt multiple capabilities through the implementation of manufacturing technology has proven to be crucial when dealing with stiff competition and unexpected changes in the business environment (Garcia & Alvarado, 2013; Kotha & Swamidass, 2000; Dangayach & Deshmukh, 2006). In respect of the significant impact on performance of manufacturing technology, an ability of such has been proven to be the essence of the reasoning behind choosing the strategic perspective outlook of this strategy.

2.5.2.3 Strategic Perspective of Flexibility

Due to the intense competition in the manufacturing sector (Hilman & Mohamed, 2011) Malaysian manufacturers have realized the need to understand and implement flexibility from the strategic point of view. Strategic flexibility enables the manufacturers to better deal with the dynamic and changing environment and aids them in adopting a strong stance against the threats from competitors (Hilman & Mohamed, 2011; Larso *et al.*, 2009; Sanchez, 1995; Stanev *et al.*, 2008). Flexibility has started to occupy a centralized position in how manufacturing could be strategically developed to play an important part in acquiring competitor advantage (Slack, 2005; De Toni & Tonchia, 1998; Gupta & Goyal, 1989). Flexibility has been widely defined by different researchers, proving it to be a multifaceted concept. Sethi & Sethi (1990) identified at least 50 different definitions of flexibility as of the multitude of facets provided by Gupta and Goyal (1989), and De Toni and Tonchia (1998). However, consolidation of these ideas firmly points to the importance of flexibility as a 'tool' or prerequisite to effectively respond to changing market needs (Gerwin, 1993; Barnes-Schuster, Bassok & Anupindi, 2002; Bordoloi,Cooper & Matsuo, 1999) and how it enhances performance (Hilman & Mohamed, 2011; Das & Elango, 1995; Roitzsch, Hacker, Pietrzyk & Debitz, 2012). Strategic flexibility has been viewed by various scholars (namely Kestigian, 2005; Jacob, 2005; Raynour & Lennox, 2004) as a crucial factor for global companies in order to compete and survive in an open market, which is also a similar requirement and challenge for Malaysian manufacturers. Flexibility, while being important for increasing operation effectiveness, needs to be viewed from the long-term perspective, which is aiming to achieve the overall company goals.

2.5.3 Definition and Conceptualization of Lean Manufacturing

This section explains the conceptualization of the first mediator, which is lean manufacturing. The manufacturing practice being studied in this research is lean manufacturing among Malaysian manufacturers. Manufacturing leanness is a concept that unifies the various practices of lean by measuring different predetermined lean characteristics (Bayou & de Korvin, 2008; Soriano-Meier

& Forrester, 2002). There are many different definitions concerning the nature of lean manufacturing constructs (Shah & Ward, 2003; Shah & Ward, 2007; Papadopoulou & Ozbayrak, 2005; Singh, Garg, Sharma & Grewal, 2010). Leanness could be treated as a benchmark performance measurement (Cumbo, Kline & Bumgardner, 2006; Singh *et al.*, 2010). However, the overlapping of lean tools, lean definitions, and lean terms is something that has been troubling previous researchers for ages (Parker, 2003; Karlson & Ahlström, 1996; Anderson, Jonsson & Platforms, 2006). Although the implementation of lean varies from one organization to another, the basic core elements of lean always remain the same. Some companies choose to implement the full array of lean tools while others choose a piecemeal approach in which several tools deemed appropriate to their operation are chosen (Gurumurthy & Kodali, 2009; Doolen & Hacker, 2005). The principles of lean, however, remain constant, which are the elimination of waste through specifying value, identifying value stream, flow, pull, and perfection (Womack & Jones, 2003). For the purpose of this study, conceptualization is done based on the previous work by Shah and Ward (2003, 2007).

Literature review accentuated that the nature of lean definition are both too broad and prove to be difficult in discriminating the underlying component of lean (Shah & Ward, 2007; Hopp & Spearman, 2004; De Treville & Antonakis, 2006). This approach takes lean manufacturing as an integral social and technical system that manufacturers incorporate as part of their operation. The main focus is to reduce waste by concurrently decreasing variability from supplier, customer and their own internal process. Based on this perspective, nine elements are used to measure lean practices. This approach is chosen due to:

1. The scope of lean practices is not too broad that it generalize every organizational phenomenon
2. It showed evidence of clarity, communicability, consistency, parsimony, inclusivity and exclusivity as required by any good conceptual definition (Wacker, 2004).
3. This approach is holistic in nature as it is able to capture both, the internal and external practices to better align lean manufacturing with the original concept and develop appropriate measures for it.

Base on this conceptualization, the nine parameters used to define lean manufacturing practices are, supplier management, just-in-time delivery, supplier development, customer involvement, pull production, flow production, set-up time reduction efforts, total productive/total preventive maintenance, statistical process control, and employee involvement. These nine different latent constructs form the pillars of lean manufacturing. Among these nine pillars, the main focus is on customers, suppliers, and the internal operations of the lean manufacturing concept itself. The breakdown of these nine elements is as follows:

2.5.3.1 Supplier Management

Supply chain variability originates from the inability of the supplier to deliver the right quality, and the right quantity at the right time and place (Womack, Jones & Roos, 1990). Methods to avoid such variability in the lean supply chain include maintaining an involved and dependable supply chain, and by obtaining regular feedback on quality and performance, as well as providing training and development for supplier enhancement (Shah & Ward, 2007).

Lean manufacturing also improves material handling, inventory, quality, scheduling, personnel, and customer satisfaction (Taj, 2005). In addition, the philosophy also focuses on utilizing more effectively the available resources with the ultimate goal of satisfying most of the customers' requirements at minimum cost (Papadopoulou & Özbayrak, 2005). Lean management can help avoid decisions that result in undesirable trade-offs that negatively impact key stakeholders, such as employees, suppliers, customers, investors, or communities (Emiliani, 2006). Supplier involvement and development is key to lean manufacturing. By focusing on supplier development, the lean supply chain is ultimately enhanced (Fujimoto, 1999). By integrating the supply chain, a ripple effect or bullwhip-like effect could be eliminated. Japanese automobile manufacturers manage inventory, production, and the supply chain effectively, which helps with flexibility within the company (Liker & Wu, 2000). Supplier involvement and strong supplier-manufacturer partnerships within the Japanese automakers help them achieve a 30% man-hour advantage and four to five months of lead time advantage compared to the US automakers (Clark & Fujimoto, 1991). This is crucial for lean manufacturers since they have minimal inventories to cushion any slack in the supply chain.

2.5.3.2 Just-In-Time (JIT)

Voss and Robinson (1987) defined just-in-time (JIT) as a production methodology that aims to improve overall productivity through the elimination of waste, which leads to improved quality. The JIT philosophy was first developed in Japan by Toyota Motors. JIT also stresses cost reduction through the use of just-in-time production, which comprises pull systems, one-piece flow, levelling and *jidoka*(Womack & Jones, 1996; Liker, 2004; Shook, 2009; Wong & Wong, 2011). In terms of its development, Ohno (1988) identified the two pillars of TPS as automation and JIT production. The JIT philosophy is very closely associated with lean manufacturing, which aims to produce and deliver finished goods just-in-time to be sold, sub-assemblies just-in-time to be assembled to finished goods, fabricated parts just-in-time to go into assemblies, and purchased materials just-in-time to be transformed into fabricated parts (Vuppalapati, Ahire & Gupta, 1995; Wafa & Yasin, 1998). Additionally, JIT focuses on waste reduction and continuous improvement to achieve operational excellence (Moreira & Alves, 2006; Ansari & Modarress, 1990). Next, JIT is a disciplined approach for improving the overall productivity and eliminating waste. It provides for the cost-effective production and delivery of only the necessary quantity of parts at the right quality, at the right time and place, while using a minimum amount of facilities, equipment, materials, and human resources. A key philosophy of JIT is simplification (Voss & Robinson, 1987). The JIT approach to manufacturing must consist of the following building blocks: company-wide commitment, proper materials at the right time, supplier relationships, long-term contract, quality and personnel (Ansari & Modarress, 1990; Shannon, 1993).

Lastly, the JIT philosophy is the elimination of waste and respect for people (Hobbs, 1994; Payne, 1993; Wantuck, 1983). In a JIT system, the elimination of waste is achieved by adopting practices, such as total quality management, focused factory, reduced set-up times, flexible resources, group technology layout, pull production system, and effective use of technology (Gargeya & Thompson, 1994; Sohal, Ramsay & Samson, 1993; Suzaki, 1987).

Although application of the above practices seems to be appealing to a wide variety of manufacturing and service areas, unfortunately, since its beginning, an often narrow view of JIT, mainly inventory reduction and frequent deliveries, has been accepted and practiced by a large number of manufacturing organizations (Deshpande & Golhar, 1995; Handfield, 1993; Lawrence & Hottenstein, 1995; Golhar, Stamm & Smith, 1990; Moras & Dieck, 1992). Careful examination of the JIT philosophy clearly indicates that the application of JIT to reduce inventory and to deliver frequently is only a small fraction of the full potential benefits of a JIT system (Blackburn, 1991; Gilbert, 1994; Towner, 1994). JIT is a production and inventory control system in which materials are purchased and units are produced only as needed to meet actual customer demand (Garrison & Noreen, 2000). According to Foster and Horngren (1987), four main characteristics of JIT can be ordered. Firstly, the elimination of non-value creation activities relating to product or service; secondly, by focusing on high level quality and doing things right first time; thirdly, focusing on continuous improvement of efficiency of activities;

and, lastly, by identifying non-value creation activities, activities simplification, and increasing the number of examinations in the process.

2.5.3.3 Customer Involvement

Lean, as termed by Womack and Jones (2003), denotes a system that utilizes less in terms of all input, to create the same output as that created by a traditional mass production system, while contributing increased variety for the end customer (Panizzolo, 1998). It is an effective tool to better understand customer needs and improve quality (Chen, Lindeke & Wyrick, 2010). Lean pays particular attention to the requirements of customers and what value the customer is willing to accept and pay for. In the Japanese Toyota system, a huge workforce is maintained to deal with customer management (Chen *et al.*, 2010; Womack *et al*., 2007).

2.5.3.4 Pull Production

Delving deeper into the lean manufacturing concept reveals the pull system. Pull production utilizes the same basic concept as JIT, which means that raw materials or work-in-progress is delivered with the exact amount and "just-in-time" for when the downstream workstation needs it. JIT is a system that focuses on waste reduction and continuous improvement to achieve operational excellence (Moreira & Alves, 2006). The ideal of a pull system is that the materials will be available from the supplier (upstream stage) exactly when the customer (downstream stage) needs them. This means that all the inventories in the factory are always being processed, as opposed to waiting to be processed, and that the customers must usually plan ahead by anticipating what is their requirement based on the turnaround time from the supplier. Ohno (1988) obtained the idea of pull production using *kanban* while visiting a supermarket. In the supermarket system, the customer is the one that triggers the need for something to be put on shelf – thus creating a pull system. Within the pull system, *kanban* is a sub system that assists the handling of daily fluctuation of loads within an operational chain. According to Ramnath, Elanchezhian and Kesavan (2010), *kanban* is a Japanese word meaning signboard or billboard. The *kanban* system is a typical concurrent system with replicated components. It consists of many work centers, each producing component parts for other centers, and using or consuming parts from other centers. In other words, every work center is both a supplier and a client of component parts (Ling & Durnota, 1995).

The *kanban* system is viewed as the physical or visual information system. Successfully deployed *kanbans* deliver the right amount of material to the right place exactly when it is needed (Emiliani, 1998). An advantage of the *kanban* system is its ability to control production and its simplicity in production scheduling, reducing the burden on operators, easing the identification of parts by the *kanban* attached to the containers, and substantially reducing paper work (Gupta *et al.*, 1999).

2.5.3.5 Flow Production

It has been understood that smoothness and harmony in flow are fundamental to productivity and efficiency (Simons & Zokaei, 2005). One piece flow is basically a technique used to manufacture components in a cellular environment, such that no part will go to the next operation until the previous operation has been successfully completed (Emiliani, 2000). One-piece flow is defined as moving/making only what is needed, thus minimizing the WIP inventory (Kasul & Motwani, 1997). The goal of one-piece flow is to make one part at a time, correctly all the time, and to achieve this without unplanned interruptions or lengthy queue time (Emiliani, 2000). Tasks are reduced to their simplest components so that there are fewer opportunities for machine or operator error (Emiliani, 1998).

Another concept under flow production is standard work. Standard work emphasizes human motion and the elimination of waste. Focused around human movement, standardized work outlines efficient, safe work methods, and helps eliminate waste while maintaining quality (Kasul & Motwani, 1997). Standardized work explicitly exhibits the current best practice (minimal manpower and effort, highest quality, highest safety) in performing each job and communicates this at the workstation (Detty & Yingling, 2000). Standard work is a term used to systematize how a part is processed, and includes any man machine interactions and studies of human motion.

Manufacturing engineers break down each operation into small pieces, making certain that each worker is given all the tools to make the part quickly and with the highest quality. The process is documented in writing, with photographs and video, and examples of defective products nearby. This is done to eliminate errors that waste time and money and ensure reproducibility from operator to operator (Emiliani, 1998).

The next concept was revealed when a Toyota delegation visited the Focke-Wulf aircraft works in Germany, where they observed the 'productions *takt* time' concept, which was later developed into what we know as *takt* time (Holweg, 2007). *Takt* is the elapsed time between units of production output, when the production rate is synchronized to customer demand. Operating to a *takt* time means that all workstations operate at a constant rate synchronized to customer demand. The *takt* system describes a constant rate of flow (Simons & Zokaei, 2005) and also refers to the rate at which customers are buying products from the production line, i.e. the unit production rate that is needed to match customer requirements. It is calculated by dividing the total available time per day by the daily customer demand (Abdul Malek & Rajgopal, 2006).

In lean manufacturing, material handling systems must contribute to synchronizing the flow of materials (Domingo, Alvatrez, Peria & Calvo, 2007). Work balance refers to a situation where all the operators along the production line require the same length of time to perform their tasks. Operating a line to *takt* time is a prerequisite for effective work balance (Simons & Zokaei, 2005).

2.5.3.6 Set-up Time Reduction Efforts

Set-up time is defined as the time that passes between when the last good piece comes off the current run and when the first good piece comes off the next run, while running at the optimum rate. In other words, reducing the set-up time helps reduce the time between product changeovers (Shah & Ward, 2007). Lowering set-up time will help promote greater flexibility, especially for multiple products in the same production line (Monden, 1983; Koufteros, Vonderembe & Doll, 1998).

Eventually, all these reductions would ensure that customer's lead time is reduced. Lead time reduction in terms of set-up time, moving time, processing time, waiting time, and queuing time will enable a company to respond quickly to customer needs (Cheng & Podolsky, 1993).

2.5.3.7 Total Productive/Total Preventive Maintenance (TPM)

TPM basically focuses on maximizing equipment effectiveness through planned and preventive maintenance, and using maintenance optimization techniques (Shah & Ward, 2003). TPM is one of the lean manufacturing pillars in which it enables waste reduction by reducing the chances of idle down time during operation. TPM is intended to bring both production and maintenance functions together by a combination of good working practices, team working, and continuous improvement (Cooke, 2000; Ahuja & Khamba, 2008).

It is a system of maintenance that governs the entire life of the equipment in every division, including planning, manufacturing, maintenance, and others to improve the overall performance of this equipment. TPM addresses the entire production system over the entire lifecycle and builds a solid, shop floor based mechanism to prevent various losses and waste (Bamber & Dale, 2000). While top management commitment and leadership is essential for TPM success, it is not sufficient without delegating empowerment to production operators in order to establish a sense of ownership in their daily operating equipment (Tsang & Chan, 2000).

2.5.3.8 Statistical Process Control (SPC)

The key advantage of lean manufacturing is to establish the culture of continuous improvement where perfection becomes a goal (Yamamoto & Bellgran, 2010; Ahlstrom & Karlsson, 2000). One of the quality control tools championed by lean manufacturing is the usage of SPC for better control and monitoring of process and product quality. Strict quality assurance allows firms to predict output more accurately, with the operating requirement (Shah & Ward, 2007). SPC ensures that any defect in the product is prevented from flowing through to the next process. Improving quality is a major element in lean manufacturing. Quality is deemed crucial for customer satisfaction and is ranked among the top ten company competencies (Taj & Morosan, 2011; Shah & Ward, 2007). SPC allows quality control on production, starting from upstream to downstream to ensure the consistent quality of the product produced.

2.5.3.9 Employee Involvement

Lean manufacturing is reported as having a negative effect on employee outcome, work characteristics, product design, and organization's innovation capability (Lewis, 2000; Parker, 2003; Fucini & Fucini, 1990; Mehri, 2006). Employees have busy schedules and multiple responsibilities that will make it much harder to get workers to work together for formal discussions, and casual chats that may spark innovative changes (Chen *et al.*, 2010). However, those claims go totally against the basic core of lean manufacturing where the focus is on respect for people, which includes enhancing the involvement and capability of workers through employee training, employee participation, team work, fair compensation, and a new attitude toward suppliers (Sohal *et al*., 1993; Wantuck, 1983). Puvanasvaran *et al.* (2009) carried out research on composite manufacturers in Malaysia and showed how lean practices had improved the employees' problem solving capabilities in eliminating waste, which contributes to cost saving. Employee involvement is critical to lean manufacturing where workers are encouraged to make split-second decisions in production whenever any non-conformance is detected (Puvanaswaran *et al.*, 2009; Liker, 2004). According to Liker (2004), knowledge about lean manufacturing at the Toyota plants has gradually been accumulated by workers and managers over 20 years in their daily activities through the constant learning of new methods and variations of methods consolidated on the plant floor. Lean employees have the opportunity to use their initiative, creativity, and job specific knowledge and they are non-authoritarian in nature (Bamber & Dale, 2000). However, due to knowledge limitations among the workers themselves, work simplification and automation has been introduced to partly overcome this problem (Appelbaum, Bailey, Berg & Kalleberg, 2000; Liden, Wayne & Sparrow, 2000). The combination of these approaches would enable workers to participate easily toward achieving lean manufacturing goals. Employee empowerment is considered a way to encourage and increase decision making at the lower levels of an organization, which, consequently, enriches the work experience of the employees.

2.5.4 Lean and Manufacturing Performance

The objectives of lean manufacturing are improvement in productivity, attaining an adequate level of quality and reducing production time, cutting cost, and, finally, achieving the targeted performance (Forrester *et al.*, 2010). Various studies have been conducted globally on the effect of lean implementation on organizational and operational performance as a whole. These studies clearly indicated that the adoption of lean practices clearly leads toward an increase in performance (Fullerton, Huntsman, Wempe & Neeley, 2009; Shah & Ward, 2003; Wood *et al.*, 2004; Hanson & Voss, 1998).

Furthermore, the published literature suggested that the implementation of lean practices also positively influences operational flexibility (Ahmad, Schroeder & Sinha, 2003; Matsui, 2007) and significantly reduces manufacturing lead time (Shah & Ward, 2003; Ahmad, Mehra & Pletcher, 2004; Abdallah & Matsui, 2007). Shah and Ward (2003) found that the influence of lean practices contributes significantly to the operating performance of plants. Lean manufacturing practice superiority has been proven and continues to be rated as extremely effective (Papadopoulou & Ozbayrak, 2005) in ensuring that organizations derive enormous benefits for this transition (Wong *et al.*, 2009; Nordin *et al.*, 2010; Wong & Wong, 2011).

Additionally, lean manufacturing is also a learning system that encourages staff to perform better in technical operations, which, in turn, increases the performance process (Ballé & Régnier, 2007). The lean system increases worker utilization and reduces the workforce size, which usually leads to a reduction in manufacturing cost (Chen *et al.*, 2010). Successful standardization of work processes helps ensure a high quality product, proud workers, satisfied customers, workplace safety, and the strong performance of factory costs (Emiliani, 1998).

Lean manufacturing also helps to achieve process stability by combining men, machines, and materials to produce 100% quality products when they are needed to satisfy customer demand. This involves attaining demanding standards in equipment reliability, raw material, purchased parts quality, employee knowledge and skills, and production quality control (Detty & Yingling, 2000). Wong *et al*. (2009) stated that the highest benefits of lean are reduced cost, followed by productivity improvement and waste reduction. Detty and Yingling (2000) acknowledged that lean manufacturing contributes many benefits by reducing the changeover time and processing time in parts of the system, lowering warehouse inventories and exchange inventories, reducing assembly cell inventories, pre-assembly, finished goods inventory, and decreasing floor space requirements. Lean manufacturing provides the required changes in the work environment, which induces more efficient ways to manufacture goods, provides better physical structure and a generative manufacturing method that increases output, improves quality, and grows sales and profits without the need for constantly enlarging the production or support staff (Emiliani, 1998; Simons & Zokaei, 2005). Lean practices are generally shown to be associated with high performance in a number of studies of world-class manufacturing (Sakakibara, Flynn, Schroeder & Morris, 1997; Giffi, Roth & Seal, 1990). Overall, the review of related research indicates that the implementation of lean practices is frequently associated with improvements in operational performance measures (Shah & Ward, 2003).

2.5.5 Definition and Conceptualization of Strategic Flexibility

Research on manufacturing flexibility has established its footing in management for quite a while, covering the last 20 years. However, the scope of flexibility has since changed whereby the concept becomes clearer since better taxonomy has been developed. Past researchers have adequately covered the concept of operational flexibility. In this framework, flexibility is defined through three different approaches by De Toni and Tonchia (2002), which are:

i. as the characteristics of interface between a system and its external environmental turbulence, such as uncertainty;
ii. as the degree of adaptation, which includes the measurement mechanism, control, and regulation that aims to maintain homeostasis; and
iii. as the capability to adapt.

This definition is in tandem with earlier work by pioneering flexibility researchers, such as Slack (1983) and Mandelbaum (1978). Slack (1983), in his work, distinguished the difference between varied flexibility and response flexibility, and later included variety (product and process flexibility), volume flexibility, and delivery. As more researchers dwelled on the subject, other dimensions of flexibility were determined and explained. The different dimensions are summarized below:

Table 2.5
Different Dimensions of Operational Flexibility

Year	Author	Flexibility dimension
1987	Slack	Product; mix; volume; delivery
1990	Sethi & Sethi	Machine; market; material; handling; operation; process; routing; product; volume; expansion; program; product
1993	Gerwin	Mix; material; volume; product/modification; changeover; re-routing; sequencing
1996	Gupta & Somers	Volume; programming; process; product and production; market; machine; routing; material handling; market expansion
1999	Koste & Malhotra	Machine; labor; material; routing; operation; expansion; volume; mix; new product; modification
2000	D'Souza & William	Volume; process; variety; material handling

Flexibility is then considered as the resulting interaction of various dimensions (Slack, 1987; Upton, 1995; Dixon, Nanni & Vollman, 1990). These dimensions have since progressed and included more, such as quality, product, service, and cost flexibility. However, in the context of this study, operational flexibility can be replaced by a much newer concept, which is strategic flexibility. Strategic flexibility has received less attention from scholars due to its recent emergence. However, it is slowly becoming an important point of discussion as it is critical for realizing firm success (De Toni & Tonchia, 2002; Price *et al*., 1998; Narain, Yadav, Sarkis & Cordeiro, 2000).

As for the case of operational flexibility, a clear definition and classification has yet to be sorted out for strategic flexibility. However an appropriate approach that could facilitate this process is by considering the level at which it is being specified (Gerwin, 1987). Strategic flexibility is defined by how well a firm addresses and adapts its strategic decision to unexpected changes in the competitive environment (Hyun & Ahn, 1992; Narain *et al*., 2000). This level of flexibility is regarded as long-term flexibility, an opposite approach to operational flexibility, which is viewed as short-term flexibility (Boyle, Scherrer-Rathje, & Stuart, 2011).

This is just one approach taken in defining and classifying strategic flexibility. Various researchers have taken several unequivocal approaches toward this concept, as summarized in Table 2.6 below. Understanding the constituent dimensions of manufacturing flexibility and their interrelationships will be of value to those organizations whose competitive strength depends on the flexibility of their main functions (Oberoi, Khamba, Sushil & Kiran, 2007).

Strategic flexibility is based on the notion that firms that have greater variety could experience an economic advantage against those that have lower strategic flexibility (Liao, Hong & Rao, 2010). However, researchers have unanimously agreed that measuring flexibility is not an easy task and that it remains as one of the most difficult organizational tasks (Worren, Moore & Cardona, 2002; Narain *et al*., 2000; De Toni & Tonchia, 2005). However, due to its importance, strategic flexibility has been receiving more attention of late.

Table 2.6
Various Definitions of Strategic Flexibility

Year	Author	Definition	Dimension
1996	Lau	Firm's ability to respond to uncertainty by adjusting its objective	People Process Product Integrated system
1996	Bierly III & Chakrabarti	Firm's ability to change strategic decisions in response to either internal or external changes in the environment	Manufacturing Financial Marketing Knowledge
1999	Parker & Wirth	A long-term ability to change the internal system as needed easily	Expansion
2002	Worren *et al.*	Firm's ability to respond to changing market	Model variety Model introduction New product

Table 2.6 (Continued)

Year	Author	Definition	Dimension
2004	Lloréns-Montes, García-Morales & Verdú-Jover.	The capability that helps firms manage environmental uncertainty thus enhancing performance	Process flexibility Product flexibility Routine Volume Expansion
2005	Zhang	A set of organizational abilities to proactively respond quickly to a changing competitive environment and develop competitive advantage	Product Cross functional coordination
2007	Nadkarni & Narayanan	Ability to intentional change and adapt to environmental changes throughout changes in strategic action, asset deployment, and investment strategies	Resource deployment Competitive simplicity Shift in competitive action

2.5.6 Difference between Strategic Flexibility and Operational Flexibility

The subject of flexibility is closely linked with the uncertainty of the business environment (Narain *et al.*, 2000; Oberoi *et al.,* 2007). Slack (1987, 2005) published one of the earliest research findings, which clearly stated the need for flexibility in whatever form for companies to continue to be competitive in the changing business world. As explained earlier, operational and strategic flexibility differ greatly from one another. However, these two different levels of flexibility are linked with each other. De Toni and Tonchia (2005) perhaps best captured the link between operational and strategic flexibility. Their work explained the first nexus in terms of practice and performance, where, at the business level, operational flexibility measures the variation of practices within an organization and strategic flexibility measures the effect obtained on its performance. At the corporate level, the link between strategic flexibility and operational flexibility is determined by the business change resulting from the firm's competitiveness.

The main reason for linking this is due to the fact that strategic flexibility is achieved by attaining operational flexibility (De Toni & Tonchia, 2005). Strategic flexibility is regarded as the competitive priority approach (D'Souza & William, 2000; Nakane & Hall, 1991; De Meyer *et al.,* 1989); therefore, achieving it is clearly a survival issue.

2.5.7 Strategic Flexibility and Manufacturing Performance

Another element of strategic flexibility is that it is treated as a strategy for firms instead of a quantity that is simply measured (De Meyer *et al*., 1989; Nakane & Hall, 1991). This differs greatly from the operational approach in which its dimension is just a type of flexibility that would be used to achieve higher performance in certain performance dimensions (Hallgren & Olhager, 2009). The adoption of strategic flexibility as the manufacturing strategy will affect a firm's ability in dealing and handling fluctuations in the product, product mix, design, material, and sequence (Dangayach & Deshmukh, 2001). Strategic flexibility as a strategy will allow firms to enhance their ability to react fast in synchronizing functional areas to any unwarranted changes (Rose *et al.,* 2008; Swamidass & Newell, 1987).

2.5.8 Manufacturing Technology Definition and Conceptualization

Technology has a broad meaning to manufacturers. As discussed earlier, today's competitive environment has caused manufacturers to re-evaluate their strategies and practices. One aspect that manufacturers focus on is the ability of the current manufacturing technology (MT) on hand to meet these challenges in the turbulent environment (Sonntag, 2003). In the context of this research, MT is defined as advanced manufacturing technologies (AMT), which consist of a group of computer based technologies that includes computer aided design, computer aided manufacturing, manufacturing resource planning, robotics, group technology, flexible system, automated material handling system, computer numerically controlled machine tools, bar coding or other automated identification techniques as well as any additional or advanced technology when compared to previous manufacturing technologies (Lewis & Boyer, 2002; Stock & McDermott, 2001; Abd Rahman & Bennet, 2009).

The conceptualization was based on the earlier work by Kotha (1991), and Kotha and Swamidass (2000). In reference to their work four dimensions of manufacturing technology have been grouped as follows:

1. Information exchange and planning technology (IEPT) – this group consists of the technologies used for information exchange as a tool used in planning. It includes such technology as local area network (LAN), technology used for control of production, electric data interchange,

intercompany networks as well as inventory management software, such as MRP I and MRP II.

2. Product design technology (PDT) – which includes the technologies used for technical drawing, such as computer-aided design (CAD), computer-aided engineering (CAE) and automated drafting technologies.

3. High volume auto technology (HVAT) – this group consists of technology required in high volume manufacturing of discrete products. Among these technologies are computer-aided quality control tools used during inspection of incoming products, in process product as well as outgoing finished products. Other technologies in this group include robots (non-pick and place as well as pick and place) and automation protocols.

4. Low volume flexible technology – the technologies in this group comprise numerically controlled machines (NC), computer numerically controlled machine (CNC), flexible manufacturing cells (FMC), flexible manufacturing systems (FMS). This group of technology has been designated as enhancing flexibility in production and increasing its capability in coping with changes in product volume and product introduction.

Item numbers 3 and 4 are actually the split up of the dimensions of production technology as conceptualized in the earlier work by Kotha (1991). In addition, MT is a generic term for a group of manufacturing technologies that combine both scope and scale capabilities in a manufacturing environment. Manufacturing strategy has become more sophisticated. As a result, MT can play a crucial role in making it possible for firms to compete on “traditionally” contradictory competitive priorities simultaneously. Besides the work of Kotha (1991), and Kotha and Swamidass (2000), Wiarda (1987) also offered suggestions concerning what constituted MT. This approach suggested subgroups for the technologies within MT, which are (1) the traditional hardware technology, consisting of systems, devices, and station (SDS); and (2) group of technologies, often in software form, which perform integrative and managerial functions, namely integrative and managerial systems (IMS). SDS examples include automated identification station, automated inspection stations, automated material handling devices, computer aided design workstations, computerized numerical control machine tools, numerical control machine tools, programmable production controllers, robots and shop-floor control systems (Wiarda, 1987).

As for IMS, it includes computer aided manufacturing, computer-aided engineering, statistical process control, production planning/inventory management software, engineering data management, computer aided process planning, local area network, and group technology. Global and domestic (non-exporting) firms have different objectives for adopting MT as a means to effectively compete in their respective markets (e.g. flexibility, time-based competition).

Whatever the objectives may be, the adoption of any new technology involves uncertainty about achieving the objectives. In addition to the inherent human resistance to change and innovation, at least two other types of uncertainty are present when adopting manufacturing innovations: technological uncertainty (whether the adoption of the technology will be profitable) and strategic uncertainty (how the decisions of competing firms will adversely impact a decision to adopt new technology). Adopting MT involves both types of uncertainty. Reducing the technological and strategic uncertainty associated with MT adoption is critical to firms, both in the acquisition and implementation stages. Firms attempt to identify critical factors to reduce these uncertainties and support their strategic objectives. Thus, these factors provide a link between the firm's long-term competitive strategy and its technology. Kantrow (1980) calls such factors as the "strategy-technology connection".

Another research by Lai and Narayanan (1997) was performed on the electrical and electronic sector. It became an ideal case to investigate the two important aspects of technology transfer that had previously alluded researchers: the first one is the level of sophistication of the technology transferred and the extent of transfer. They wanted to identify what factors influence the choice of technology of MNCs in the electrical and electronic sector. In theory, the price factor plays an important role in determining technology-choice. Thus, in labor-abundant economies the price of labor, relative to the price of capital-abundant technologies, is deemed to be more "appropriate". The converse holds true in capital-abundant economies. The relevance of such arguments has been undermined by globalization of the production process. MNCs are no longer bound by factor prices in their home economics when making their technology choices. Indeed, they are free to locate all or parts of their production activities in different parts of the globe to reap the benefits of local comparative advantages.

Furthermore, in a dynamic environment, economies are seeking to change their traditional comparative advantages into new ones. Consequently, the quality of the product, which, in turn, is determined by the market niches for which the MNCs produce, plays a crucial part in determining technology-choice. It has been argued that once product quality is held constant, the range of substitutability between capital and labor is usually narrow. Relative prices are therefore not a primary determinant of technology decisions in many industries (Lai & Narayanan, 1997).

With a wide choice of technology to choose from, it is important that manufacturers choose the right one. The right choice of technology is the basic requirement of manufacturing strategy as it supports the firm's competitive priorities (Sonntag, 2003; Kotha & Swamidass, 2000). The right technology will enable firms to respond to changing customer and market demands, thus ensuring their survival (Joseph, McClure & Joseph, 1999; Sonntag, 2001; Hayes & Pisano, 1996).

As for Malaysia, the country's manufacturing demand for the latest technologies has been valued at RM20 billion every year (Business Times, 2006, p.45). The need for such technologies has caused the industries to record a staggering amount of machinery and equipment imports. MIDA reported that imports for such equipment have increased from €7.9 billion in 2005 to €8.6 billion in 2008. The main sources for these items are from Japan, USA, China, and Germany (Market Watch, 2010). The large amount of investment clearly indicates the crucial role of technology to manufacturers.

2.5.9 Manufacturing Technology and Manufacturing Performance

Although technology adoption provides a competitive advantage, the full benefits of new technologies are only realized when they are used together with new workplace organizations that include training. Technology adoption can increase productivity growth, in particular, multifactor productivity (MFP) growth. Black and Lynch (2004) used firm-level data to examine the effects of adoption of new workplace practices and computer use on productivity. They found that "changes in workplace practices, along with increasing diffusion of computers, may well have played a significant role in the recent rise in manufacturing productivity". Bartel, Ichniowsky & Shaw (2007), in a study of the valve manufacturing industry, found that the adoption of new manufacturing technology is associated with increased skill requirements and changes in human resource practices.

In other words, in order to successfully adopt new technologies and integrate them within their organizations, firms embracing new technology have to obtain new skills and/or to upgrade the skill level of their existing workforce because the attributes of new technology could be significantly different from old technologies. Training is often used to meet the challenge for two reasons. Firstly, training is less costly, especially when skill requirements are firm-specific (Baldwin & Johnson, 1996; Gander, 2003) and/or when labor reorganization is difficult due to reasons such as stringent labor market regulation. Secondly, training can change users' attitude toward adopting new technologies and increase their acceptance, which is important for the effective use of new technologies (Ouadahi, 2008).

Manufacturing technology is deemed crucial to overall performance because any disruption, such as machine break down, delay in receiving spare parts, lack of technical back up locally, will directly affect production. Due to its criticality, manufacturing technology implementation and adoption also have to be closely monitored, not only because it affects the operation of production, but because it is also tied to a large amount of investment.

Today, most organizations share almost the same manufacturing technology so owning MT does not guarantee success; rather, it is the management of the technology that will earn firms the upper hand (Oberoi *et al.*, 2007). The main problems and issues that are related to MT always concern the implementation part, therefore to measure the level of adoption, two dimensions must be considered, i.e. level of investment in MT and level of integration or adoption of the technologies themselves.

There are high and also low technologies that are used in manufacturing. High technology increases the firm's productivity and also its performance. The plants that have adopted a larger number of MT, such as robots, lasers, or computer-controlled machinery have higher subsequent growth rates and lower failure rates (Doms, Dunnes & Roberts, 1995). New technology is continually advancing and is likely to affect all aspects of firm performance; for example, research and development, design services, and the drivers of strategic planning. Its impact is seen not only on issues such as greater efficiency in production, but also on corporate structure, communication, and creativity. High technology firms have a more external orientated strategic outlook, leadership style, and culture ethos. The research findings suggest that this leads to greater overall performance (O'Regan, Sims & Ghobadian, 2005).

The benefits of MT have been widely reported in the literature and can be classified as having tangible or intangible benefits (Kaplan, 1986). The tangible benefits, which are easily quantifiable, include inventory savings, less floor space, improved return on equity (ROE), and reduced unit cost of production. The intangible benefits, which are difficult to quantify, include an enhanced competitive advantage, increased flexibility, improved product quality, and quick response to customer demand. The potential benefits, which can be accrued from investments in MT have become increasingly evident with growing global competition (Swamidass & Majerus, 1991; Primrose, 1991; Small & Chen, 1995).

2.6 Previous Research in the context of Environmental Factors, Strategy and Performance

Cadogan, Sundqvist, Puumalainen and Salminen (2012) tested the following framework, in which strategy, environmental factors and performance were tested together. These researchers also noted that there was a need to extend the domain of environmental uncertainty faced by firms beyond market dynamism and competitive intensity. Different kinds of environmental condition, such as technological turbulence, regulatory pressure and political instability should be considered as the response of the firms are expected to be different and thus will require specific sources of action and responses.

Again, the contingency theory assumptions have been suggested as being at play in explaining the variables relationship. The researchers also stressed that EMO behavior may be more useful when environmental conditions are more turbulent, a finding that was also supported by their earlier findings on a similar subject matter. This further strengthens the posited relationship between EMO behavior and export sales performance, which is stronger when firms operate in a more competitive environment compared to a more stable one.

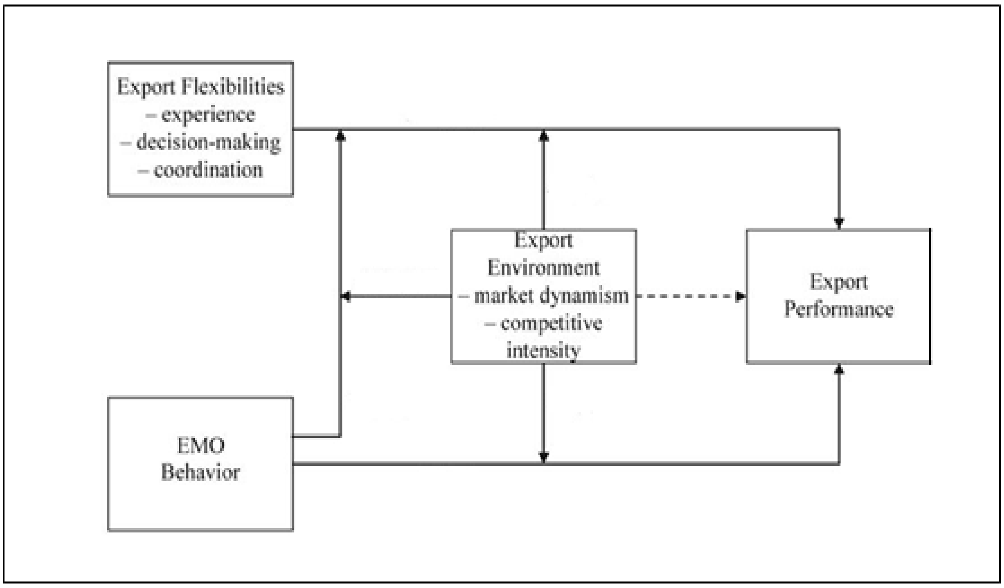


Figure 2.3
Export Flexibilities as Drivers of Export Performance: The Moderating Roles of EMO Behavior and the Export Environment Model
Source: Cadogan *et al.*, 2012

Nadkarni and Narayanan (2007) also focused on the relationship between industry clock-speed, strategic flexibility, strategic schema and firm performance. These scholars examined the moderating effect of industry clock-speed on the relationship between strategic schemas, strategic flexibility and firm performance. They employed two key properties of strategic schemas, which are complexity and focus. The study was on a sample of 225 firms from 14 industries, and managed to show that the pattern of relationships among the theoretical constructs is different in fast- and slow clock-speed industries. The results suggest that the complexity of strategic schemas promotes strategic flexibility and success in fast clock-speed industries, whereas the focus of strategic schemas fosters strategic persistence, which is effective in slow clock-speed industries.

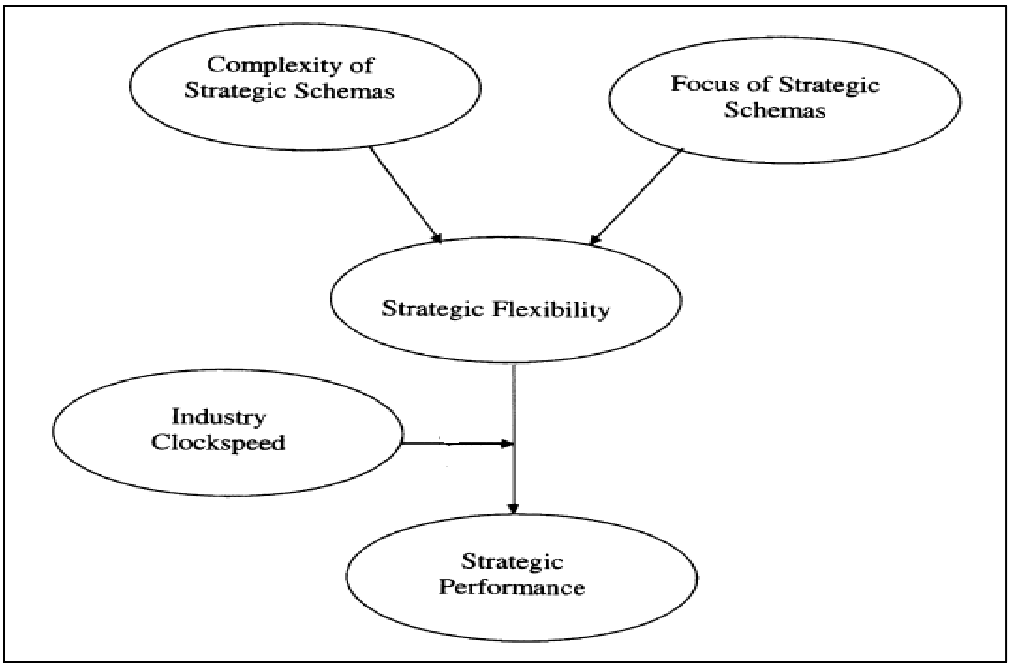


Figure 2.4
The Moderating Role of Clock-Speed, Strategic Schema and Performance Model
Source: Nadkarni and Narayanan, 2007

Among the earliest scholars who explored the environmental-strategy-performance relationships were Swamidass and Newell (1987). These prominent scholars were also among the first to suggest the contingent theory approach to explain the relationship between all the variables.

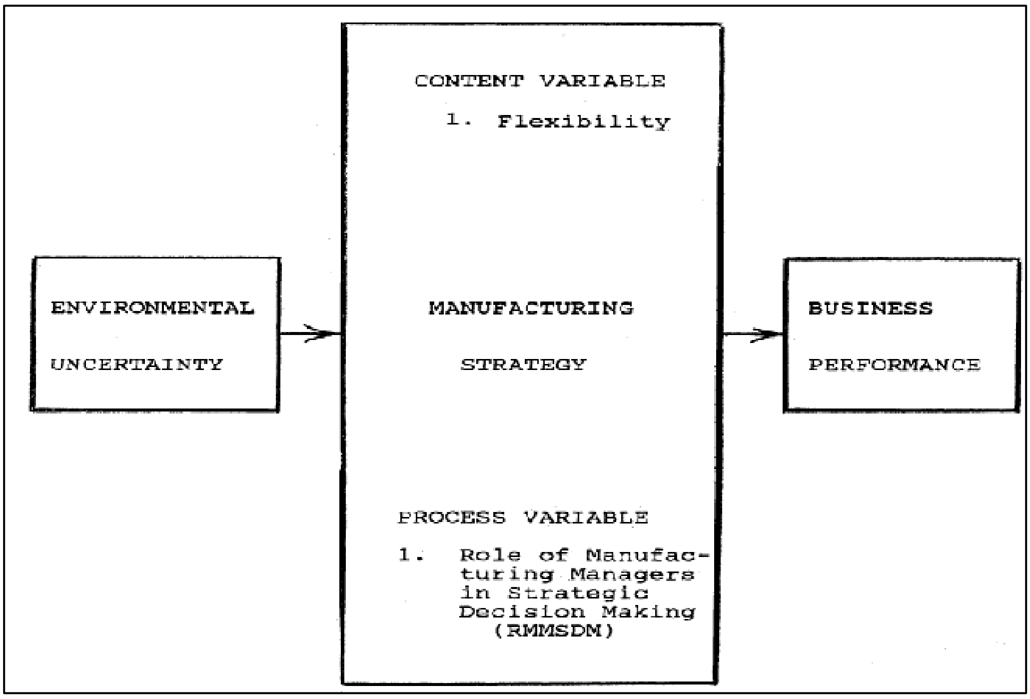


Figure 2.5
A Contingency Theory Based Model of Manufacturing Strategy
Source: Swamidass and Newell, 1987

This study took a step in that direction by clarifying, organizing and integrating terms and concepts relevant to manufacturing strategy in the process of conducting an empirical investigation of key manufacturing strategy variables. The empirical section of this study, which is based on data gathered from 35 manufacturers, found that environmental uncertainty influenced manufacturing strategy variables, such as manufacturing flexibility and the role of manufacturing managers in strategic decision- making. The first conclusion concerns manufacturing flexibility. The findings show that the greater the flexibility the better the performance, which confirms the reasonable intuitive expectation and the literature on flexibility and uncertainty.

2.7 Research Framework

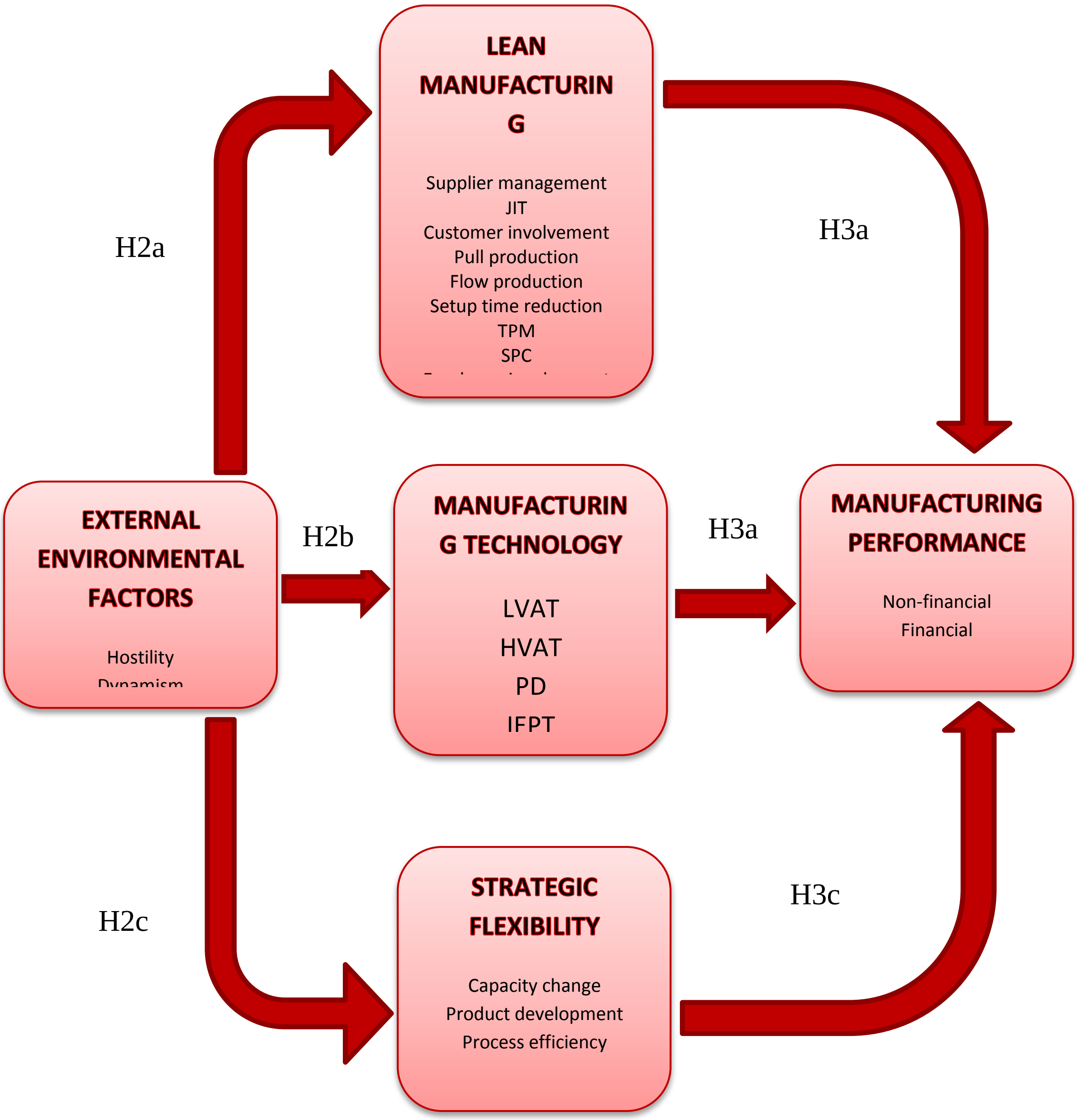


Figure 2.6
Research Framework

Table 2.7
Literary Support for the Framework

Hypothesis	Literature Supports
H1	Swamidass & Newell (1987); Costa, Pereira & Serodio(2007); Germain (2007); Ward & Duray (2000); Kose, Ayhan,Prasad & Terrones*(*2003); Singh *et al. (*2010); Anand & Ward (2004)
H2a	Shah & Ward (2007); Boyle *et al.* (2011); Lewis (2000); Doolen & Hacker(2005); Anand & Ward (2004); Womack & Jones (2003); Ward, McCreery & Anand (2007)
H2b	Liao & Tu (2008); Sontagg (2003); Orr & Sohal (1999); Raymond & Croteau (2006); Chung & Swink (2009); Raymond (2005)
H2c	Swamidass & Newell (1987); Ward, Duray, Leong & Chee-Chuong (1995); Vokurka & O'Leary-Kelly (2000); Hutchison & Das (2007); Lloréns-Montes (2004); Worren *et al.* (2002); Zhang *(*2005)
H3a	Taj & Morosan (2011); Davies & Kochhar (2002); Shah & Ward (2007); Shah & Ward (2003); Cua *et al*. (2001); Muslimen, Mohd Yusof & Zainal Abidin (2011); Abdallah & Matsui (2007); Anand & Ward (2004)
H3b	Abd Rahman & Bennet (2009); Kotha & Swamidass (2000); Swamidass & Nair (2004); Liu & Yang (2008) ; Oberoi (2007); Black & Lynch (2004); Bartel *et al. (*2007)
H3c	Rose *et al*. (2008); Jack & Raturi (2002); Cagliano, Blackmon & Voss (2001); Gunasekaran & Ngai (2004); Zhang *(*2005); Lloréns-Montes (2004); Hutchison & Das (2007)

Based on the literature review concerning research variables on external environmental factors, lean manufacturing, strategic flexibility, manufacturing technology and manufacturing performance, the theoretical framework for this research is as presented in Figure 2.6. The contingency theory was utilized as the underlying theory of the research framework. In essence, this framework postulates that manufacturing strategies mediate external environmental factors and manufacturing performance.

This postulation is in line with previous researchers (for example Nahm, Vonderembse & Koufteros, 2007; Christiansen, 2003; Yusuf *et al.*, 2004; Karim *et al.*, 2008a, 2008b). This research examines the multiple mediator effect; namely, lean manufacturing, strategic flexibility and manufacturing technology on manufacturing performance. Lean manufacturing has been suggested by previous researchers to be directly and positively associated with manufacturing performance (namely Taj & Morosan, 2011; Davies & Kochhar, 2002; Shah & Ward 2003; Cua *et al.*, 2001).

Furthermore, the framework also postulated that both strategic flexibility and manufacturing technology mediates between external environmental factors and manufacturing performance. Strategic flexibility has been proposed (by Narain *et al*., 2000; Oberoi *et al.,* 2007; Nadkarni & Narayanan, 2007; Lloréns-Montes , 2004; Liao *et al.,* 2010) as being critical to firms that choose to adapt to a changing environment and has a direct effect on the firms performance. The third mediating variable is manufacturing technology. Manufacturing technology is the third mediating variable in this study. Manufacturing technology has been reported (by Liu & Yang, 2008; Abd Rahman & Bennet, 2009; Raymond, 2005; Chung & Swink, 2009) as having a positive relationship with manufacturing performance.

2.8 Postulated Hypotheses

From the theoretical framework, the research hypotheses for this study are formulated. Previous empirical findings on the relationship between the variables are presented to support the proposed hypotheses. Specifically, the hypotheses postulated are to answer the research questions in this study.

2.8.1 Relationship between External Environmental Factors (IV) and Manufacturing Performance (DV)

The extent to which external environmental factors significantly impacts manufacturing performance has been empirically documented in previous research. To a large extent, the external environmental factors of any organization determine its adopted strategy for reaping the competitive advantage (Murray, 1988; Lotayif, 2010). External environmental factors have been empirically proven as crucial elements that affect manufacturing performance. Firms that respond correctly to external environment factors and align properly with the firm strategies, perform better (Swamidass & Newell, 1987; Joseph *et al*., 1999; Ward & Duray, 2000; Anand & Ward, 2004). In order to be competitive and ensure survival, manufacturers need to respond rapidly to a changing environment (Easterly, Roumen & Joseph, 2001; Kose *et al.,* 2003, Gouvea Da Costa *et al*., 2006; Germain *et al.,* 2007; Singh *et al.,* 2010). Lloréns-Montes, Molina and Verdú-Jover (2005) and Germain *et al*. (2007) reported how external environmental factors, such as changes in demand, customer requirements and overall uncertainty could have a negative impact on the growth, output, operation and strategies of firms.

Therefore, external environmental factors directly impact the performance of manufacturing firms. In the context of this research, external environmental factors are measured by two dimensions; namely, dynamism (Miller & Friesen, 1983; Li, 2001; Chi *et al.,* 2009) and hostility (Chi *et al.,* 2009; Özsomer *et al., 1997*; Miller & Friesen, 1983). Hence, hypothesis 1 is postulated as follows:

Hypothesis one (H1): A lower level of external environmental factors positively impacts manufacturing performance.

2.8.2 Relationship between External Environmental Factors (IV) and Manufacturing Strategies Represented by Three Mediators, which are Lean Manufacturing, Strategic Flexibility and Manufacturing Technology

External Environmental Factors and Lean Manufacturing.

The literature review showed that external environmental factors affect lean manufacturing implementation. These external conditions could either promote or slow the extent of lean implementation in organizations (Boyle *et al.*, 2011; Doolen & Hacker, 2005). This statement was supported by Lewis (2000), and Shah and Ward (2007) who stressed that manufacturing's aim of delivering competitive advantage is contingent upon the external factors surrounding the firm. The lean use customer focus approach, which aims to ensure that despite required changes – demand, market or customer requirement – the product must be delivered meeting the customer requirements (Womack & Jones, 2003; Anand & Ward, 2004; Shah & Ward, 2007). From the lean literature, environmental factors, such as dynamism do affect lean manufacturing.

Supporting, this notion was the research conducted by Ward *et al.* (2007) that showed a positive relationship between the two variables.

External Environmental Factors and Manufacturing Technology

The extent of external environmental factor's impact on manufacturing technology has been discussed in the literature before. Liao and Tu (2008) stressed the issue of automation integration in response to increasing environmental uncertainty. The external environmental factor is part and parcel of operation, in which organizations are constantly surrounded by pressure from the environment. In order to adapt and cope with such pressure, firms are willing to invest heavily in manufacturing technology to improve their production capability (Chung & Swink, 2009). Similarly, Raymond (2005) reported the criticality of adopting manufacturing technology in order to increase firm competitiveness.

External Environmental Factors and Strategic Flexibility

Flexibility is an important route that manufacturers take in order to deal with external environmental factors. While early lean implementers focused more on operational flexibility (Pagell & Krause, 1999), as time progressed, strategic flexibility has been identified as the strategic approach of flexibility that could increase the overall performance of manufacturers (Corbett, 2007; Ketokivi & Castaner, 2004; De Toni & Tonchia, 2005; D'Souza & Williams, 2000). Strategic flexibility has been seen as an effective strategy in dealing with fluctuation and changes in the operating environment (Rose *et al.*, 2008; Dangayach & Deshmukh, 2001; Swamidass & Newell; 1987; Narain *et al.*, 2000; Oberoi *et al.*, 2007; Nadkarni & Narayanan, 2007), and the type of manufacturing flexibility acquired has often been dictated by environmental factors (Gerwin, 1993). Previous researchers; namely, Swamidass & Newell (1987) and Ward *et al*. (1995), also supported these assertions. Ward *et al.* (1995) also identified a strong relationship between market flexibility (which is one of the items used to measure strategic flexibility) and environmental factors. Hutchison & Das (2007) supported a similar notion in their study.

Hence from the literature, the following hypotheses are postulated as follows:

H2: External environmental factors will significantly impact manufacturing strategies

H2a: A lower level of external environmental factors negatively impacts lean manufacturing implementation.

H2b: A lower level of external environmental factors negatively impacts manufacturing technology implementation.

H2c: A lower level of external environmental factors negatively impacts strategic flexibility.

2.8.3 Relationship between Mediating Variables and Manufacturing Performance.

Lean manufacturing and Manufacturing Performance.

Lean manufacturing has been regarded as superior manufacturing practice since Toyota's excellent achievement was reported by Womack *et al.* in 1990 in his book entitled "The Machine that Changed the World". This book basically summed up the study of 90 Japanese automotive assemblers that cemented lean as best practice, showing the dominance of Japanese manufacturers compared to traditional mass US manufacturers. Later, various researchers followed this earlier work, further proving the performance elevating practice of lean implementation (Shah & Ward, 2003; Shah & Ward, 2007; Ahmad *et al.*, 2004; Abdallah & Matsui, 2007). Similarly, research conducted on Malaysian manufacturers showed that the successful implementation of lean manufacturing practices leads to an increase in manufacturing performance (Wong & Wong, 2011; Wong *et al.,* 2009; Nordin *et al.,* 2010, 2011; Muslimen *et al.*, 2011).

<u>Manufacturing Technology and Manufacturing Performance</u>

Manufacturing technology has been identified as not only a high performance enabler, but also as a weapon of competitiveness in previous literature (namely Patterson *et al.,* 2004; Narasimhan & Swink, 2005; Zhang, Vonderembse & Cao, 2006; Chung & Swink, 2009). However, empirically, it was also shown that in order to have a significant, positive impact on firm performance, manufacturing technology must be properly implemented and integrated into the operation of the company (Raymond & Croteau, 2006; Liao & Tu, 2008). Otherwise, high investment on manufacturing technology would not be beneficial to the manufacturers. The level of technology implemented is dependent not only on the requirement of the operation but also on the external factors of the firms. In order to achieve the strategic goals, investment on these technologies must be coherent with the environment surrounding the firms, (Raymond & Croteau, 2006; Abd Rahman & Bennet, 2008).

Strategic Flexibility and Manufacturing Performance

The literature has shown that strategic flexibility imperatively impacts on manufacturing performance (Jack & Raturi, 2002; Chang, Yang, Cheng & Sheu, 2003; Ward & Duray, 2000). Firms with high flexibility have been observed to be able to cope better in uncertain environments compared with their counterparts with lower flexibility capability (Rose *et al.*, 2008; De Toni & Tonchia, 2005). Firms used to compete based on generic strategies, such as price and quality, however, nowadays, due to the current economic environment, competitive aspects are more critical, such as flexibility and responsiveness (Karim *et al.*, 2008b; Gunasekaran & Ngai, 2004; 2003; Cagliano *et al*., 2001).

Hence from the literature, the following hypotheses are postulated as follows:

H3: Manufacturing strategies will significantly impact manufacturing performance

H3a: Higher lean manufacturing implementation will positively affect manufacturing performance

H3b: Higher strategic flexibility implementation will positively affect manufacturing performance.

H3c: Higher manufacturing technology implementation will positively affect manufacturing performance.

2.9 Multiple Mediation Analysis in a Single Model

Earlier researchers (namely Cua *et al.,* 2001; Raymond, 2005; Ward & Duray, 2000) unanimously agreed that firm performance is the consequence of several elements within the firm that integrate and support each other. Ward & Duray (2000), and Raymond (2005), all supported the supposition that compatibility among such factors, e.g. strategy, structure and technology, would enhance organizational performance. This shows how the implementation of strategy and practices is not a standalone element, but requires compatible addition in order to significantly impact the strategic outcome. Such a requirement might be the reason behind the unsuccessful implementation of lean. The suggestion that lean is not a piecemeal approach is also supported by various lean researchers (namely Shah & Ward, 2003, 2007; Schonberger, 2007; Hallgren & Olhager, 2009). Recent literature often mentions automation as part of the strategy that should be incorporated more prominently in lean implementation (Harris & Harris, 2008; Lindeke, Wyrick & Chen, 2008; Chen *et al.,* 2010).

Inevitably, in discussing the topic of automation in lean as a strategy, flexibility comes into perspective. Flexibility has long being linked to manufacturing technology. Firms choose to invest heavily in hard and soft production technology in order to increase their capability to be flexible (Boyle, 2006; Hutchison & Das, 2007; Gerwin, 2005; Beach *et al.*, 2000). At the operational level, such an investment will ensure lower machine breakdown, and more product variety, etc., while accumulation of operational flexibility will enable the achievement of strategic flexibility for the firms; a notion supported by De Toni & Tonchia (2005). Although lean manufacturing is undoubtedly superior (Shah & Ward, 2003; Ahmad *et al*., 2004; Abdallah & Matsui, 2007), the low success rate (Ballé, 2005; Schonberger, 2007; Papadopoulou & Ozbayrak, 2005) has resulted in manufacturers and researchers looking for ways to enhance their chosen strategy in order to improve the outcome of their manufacturing performance.

From the review of the literature, manufacturing technology and strategic flexibility have a part in making lean work for manufacturers through indirect effects on the performance, thus proposing a multiple mediation relationship. Theoretically, the concept of multiple mediations is still new to researchers (Hayes, 2009). Multiple mediations are a condition where more than one mediator has an indirect effect on the dependent variable, in this case, manufacturing performance. Researchers frequently test more complex models that include multiple linkages between the independent variables, proposed mediators, and outcomes (Hayes, 2009).

Testing them together in the same models will (1) avoid estimation bias if they are correlated but tested individually, (2) allow pairwise contrast where using SEM, the better or worse fitted model can be examined, and (3) the quantification of indirect effects allows the researcher to answer such questions concerning whether the specific indirect effect of IV on DV through proposed mediator 1 differs in size from the specific indirect effects through the proposed mediator 2 or 3. Therefore, based on such argument, this research uses structural equation modeling for simultaneous multiple mediation analyses.

2.10 Underpinning Theory

Sekaran and Bougie (2009) suggested that any good research model must be based on a sound theory. In such research a theory is used to explain the linkage between variables in the research model that was put forward. It serves as a guide for the researcher to better understand all the relationships between the tested variables and how they come to explain and affect one another (Zikmund, Babin, Carr & Griffin, 2010). In the context of this research, two theories were selected to aid the researcher in explaining and predicting the relationship between the various variables within the research framework.

2.10.1 Contingency Theory

The first theory used to help understand this research is the contingency theory. Traditional contingency literature suggests that the business environment influences firms' decisions on competitive strategy (Burns and Stalker, 1961; Hambrick, 1983).

The business environment consists of a myriad of forces that are beyond the control of the management, providing opportunities and threats. The contingency theory of organizations has a rich tradition in management research, and has received much empirical support in the literature (Donaldson 2001). The fundamental approach of the contingency theory is the argument that organizational performance is the result of the organization's degree of fit, in terms of some organizational characteristic, such as strategy, to some contingencies reflecting the situation of the organization, such as the circumstances surrounding the firm's environmental state. Fit has been claimed to affect performance, and the lack of fit negatively influences performance. Environmental contingencies, such as dynamism and munificence (Dess & Beard, 1984), degree of competition in the industry (Jaworski & Kohli, 1993), perceived environmental uncertainty (Swamidass & Newell, 1987) and hostility and dynamism (Ward, Duray, Leong & Sum, 1995), have been discussed thoroughly in the perspective of the external contingencies of firms. Another view of the contingency theory is through the internal contingency. The internal contingency of organizations, such as competitive strategy and production design (Miller, 1986), and strategic assets, culture and structure (Terjesen, Patel & Covin, 2011) are among some internal elements that have been thoroughly discussed and found to have an impact on performance. However, based on the review of past literature it has been clearly seen, that discussion on the platform of this theory has clearly focused on the external contingencies of the organizations rather than the internal contingencies.

Importantly, the theory does not state that all firms will fit; rather, it argues that when firms experience a sufficient lack of fit, they will attempt to adapt in order to make themselves fit. Consequently, a lack of fit may well be the norm, since a wide variety of firm-specific factors are likely to influence a firm's degree of reaction, such as the organization's structures, systems and managerial attitudes (Jaworski & Kohli, 1993; Cadogan *et al.,* 2001).

In strategy-performance studies the contingent factors are the external environmental factors that affect how firms react to various changes that threaten their very existence. Therefore, in extending this logic, based on the arguments of scholars, it is safe to conclude that from the contingency perspective, the ability of firms to react against the demand for change from their operating business environment will determine their survival and well-being in the long-term.

2.10.2 Complementarity Theory

The second underpinning theory is the complementarity theory. The concept of complementarity was originally propositioned by Edgeworth (1881), who defined complementary as performing more than one activity whereby the coupling increases the returns of doing (more of) the others. Choi, Poon and Davis (2008) summed up Edgeworth by clearly defining the complementarity theory as a theory that suggests that separate elements should be enhanced together instead of individually in order to have a significant impact on the performance. Another well-known perspective taken by scholars to explain complementarity is through the concept of fit (Ahmad *et al.*, 2003; Cua *et al*., 2001; Venkatraman, 1989). The complementarity theory is seen as central to the study of strategy.

The mathematics of complementarity is based on the theory of optimization of super modular functions. By drawing on the super modular functions theory, Milgrom and Roberts (1990, 1995) built a formalized model that operates on Edgeworth's approach to complementarity between productive factors. Using this framework, these scholars argued that if two or more practices are complementary, they tend to be adopted together since each of them fosters the contribution of the others. Such synergistic effects of collective practices will eventually lead to an overall performance that is greater than the sum of the performance contributions of each of its parts individually.

Scholars have put this theory into test with various combinations of practices and strategies. Arora and Gambardella (1990), Cassiman and Veugelers (2006), Cockburn and Henderson (1998), and Miravete and Pernias (2006) explored the complementarities between different innovation strategies. Milgrom and Roberts (1995) studied how productivity-improvement teams were more effective when firms adopt a set of complementary practices that include human resource management elements. Other scholars that perpetuated this theory were Ichniowski, Shaw and Prennushi (1997) who investigated the complementarity function among HRM practices and information sharing, which was then followed by Bocquet *et al.* (2007) who suggested that the adoption of information and communication technologies is not only influenced by the traditional factors of technology diffusion, but also by the complementarity effects between organizational practices, strategic practices and technological choices within the complementarity framework. Thus, the basis of using more than one practice or strategy in firms has been established by these scholars, which added credit to this theory.

2.10.3 Resource Based Theory

Finally, the last underpinning used is resource base theory. Like other theory, it draws on prior theoretical work in developing predictions and prescriptions. Resource based theory comes from at least four sources which are the traditional study of distinctive competencies, Ricardo's analysis of land rent, Penrose (1995) and the study of the antitrust implications on economics (Barney & Clark, 2007). Beginning from work by Porter(1987), scholars have relentless to understand the reason why some firms persistently outperform others. Many of this effort concentrated on a firm's distinctive capabilities. Different capabilities are those attributes of a firm that enable it to pursue a strategy more efficiently and effectively than other firms. Firms can vary in the resources and capabilities that they possess. However, even when operating in the same industry, manufacturers make different choices in strategy, technology, geographic locations and others. These differences can exist for various reasons that might include personal preferences of firms, financial constraint and uncertainty in the competitive environment facing the firms (Barney & Clark, 2007).

RBV highlighted the potential for processes as source of competitive advantage (Dutta, Zbaracki & Bergen, 2003; Pisano, 1994), and the emerging practice-based perspective significantly reinforces this focus on the strategy process (Jarzabkowski, 2003, 2004; Whittington, 2003; Whittington *et al.,* 2003). Thus, if a firm does not possess excellence within its operations capabilities there will be a gap between strategic intent and strategic performance. It is this gap between intent and capability that remains a massive hurdle for firms and it has cost firms various degrees of damages. Under the condition of high uncertainty, it may not be possible for manufacturers to know for certain, what resources and capabilities it will need to successfully compete in the long run. In such setting, manufacturer has a strong incentive to retain flexibility. Resource based theory make a few central assumptions about the nature of resources and capabilities, their impact on firm's performance and the sustainability of these performance differences. These assumptions help define the kinds of empirical work that is required to test this theory. It is widely accepted that resources whether tangible or intangible assets control by a firm enable it to create an implement strategies (Barney, 2002). A wide variety of strategies have been described including cost leadership, product differentiation, vertical integration, flexibility and others. However, there has been limited works that links specific resources to particular strategies and most of this work is carried out on limited sample of firms within a single industry (Barney, 2002). Current literature seems to point in the direction of linking a particular resource and capabilities with specific strategies (Barney & Clark, 2007). Resource based theory suggested that valuable strategies that are created and implemented using resource that are widely held or easy to imitate however, could not be a source of sustained competitive advantage (Barney, 2002). The bulk of empirical resource-based work in the field of strategic management has focused on identifying resources which have the attributes that predict the firm performance. Further specific research on the impact of resources and capabilities on firm performance includes the contingent combination of firm-specific resources (Brush & Artz, 1999) and identification and acquisition of complementary capabilities (Ruiz-Navarro, 1998) and technological competence and imitability (De Carolis, 2003).

In conclusion, based on the contingency, complementarity and resource based theories, the system of multiple manufacturing strategies help organizations gain superior performance and is expected to maintain advantage in the long-run. This assumption was tested empirically in this research, focusing on manufacturing firms in Malaysia.

2.11 Gaps in the Literature

Based on extensive examination of past literature, several inferences are made regarding the research gaps. In respect of all the chosen variables from the research framework, namely, external environmental factors, manufacturing strategies, i.e. lean manufacturing, strategic flexibility, manufacturing technology and manufacturing performance, the following gaps are identified:

1. Manufacturing performance remains and continues to be the critical sector that spearheads the Malaysian economy; however, limited research has been conducted to further understand the composition and critical elements that are contingent to the changes in the global business environment. Despite the devastating impact of global occurrences, such as financial crises, rising prices of raw material, open market liberation, etc., not many scholars have tackled the issue exhaustively from various economic and management perspectives. Existing research on Malaysian manufacturing performance has mostly been conducted through the Department of Statistics, Malaysia. The review of the pertinent literature has shown how trade performance directly affects economic growth (Liang *et al.*, 2011; Yusoff, 2005; Hassan & Talib, 2011; Al-Yousif, 1999) and how global financial crisis impacts Malaysia's business cycles (Talib, 2012; Hassan & Talib, 2011; Yap, 2009). Most of the external factors previously studied emphasized the financial crisis in general and none concern the expansively defined external business factors so the

outcome of these past researches are more case specific. The overall study of such impact on Asian countries, such as India and China, in general, is still evidently and greatly lacking. Therefore, there is still a lack of investigation concerning the specific impact of different factors on the manufacturing sector, its performance and its relation to the nation's economic well-being. Whereas the findings from studies in other areas, such as human resources, quality, general management and even lean manufacturing, can be generalized over the world, manufacturing performance study is more intrinsically centered.

The impact of manufacturing performance is more critical in a country like Malaysia, which has a smaller population, and, thus, a smaller internal market to support manufactured goods, and, hence, tends to rely heavily on trade with external countries. In such circumstances, the country is more sensitive to any global, external threats. Similarly, Malaysia's dependency on the industrialized economy means that any decline in the performance of the manufacturing sector will inevitably adversely affect the GDP of the country.

2. The empirical research conducted on lean manufacturing is relatively little in Malaysia (Samat, Ramayah & Saad, 2006; Wong *et al.*, 2009; Muslimen *et al.*, 2011) and hardly any studies have been done in Malaysia or globally from the strategic perspective of lean. Current and past studies on lean focus more on the implementation know how as well as the barriers (Nordin *et al.* 2011; 2010) that render its implementation arduous and challenging.

However, such a focus is no longer adequate as the adoption of lean as a strategy by global manufacturers is part of an undergoing evolution, a contingent force used in combating fierce global competition to stay ahead in the business. Such an approach is well advocated as lean as an internal core competency of manufacturers has been proven to significantly contribute toward the success of various international manufacturers (Nordin *et al*., 2012; Nawanir, Othman & Lim, 2011; Rahman, Laosirihongthong & Sohal, 2010; Hallgren & Olhager, 2009; Finch, 2008 ; Fullerton & McWatters, 2001).

3. Previous research on manufacturing centralized on operational flexibility as part of a plant's capability achieved through lean, but did not tackle flexibility from the strategic perspective stance, even though both are interlinked through cause and effect competence (Christiansen, 2003; Shah & Ward, 2007; De Toni & Tonchia, 2005). Strategic flexibility can only be achieved if operational flexibility is achieved. It needs to be considered as the strategic ability that complements other strategies, such as lean and manufacturing technology and not merely as an element that could be measured.

4. Harris and Harris (2008) proposed that automation that enhances flow is considered lean in nature but automation that reduces uptime and extends changeover is not part of the lean philosophy and approach. In fact, some lean researchers have argued that automation and technology investment is against the basic lean principle, which stresses on cost saving and waste eradication to increase production efficiency instead of further investment in the facility. This shows that previous manufacturing researchers did not view manufacturing technology as part of the element that is critically complementary to lean (Shah & Ward, 2007; Narasimhan, Swink & Kim,

2005). Although some scholars (such as Liu & Yang, 2008; Abd Rahman & Bennet, 2009; Oberoi *et al.,* 2007) have suggested that manufacturing technology should be considered as part of lean manufacturers competence that supports and complements the practice, they have not provided the empirical proof to support the framework for such a relationship.

5. Based on the review of past literature, there is scarce empirical support concerning multiple mediators by researchers. In addition, to date, those who took the initiative to explore such a method are scholars from the field of communications (for example Afifi, Afifi, Morse & Hamrick, 2008; Ledbetter, 2009; Southwell & Torres, 2006). While multiple pathways study is more complicated than the simpler single mediation, the importance is becoming more crucial to understand. In most situations, it is unlikely that the effect of an independent variable on an outcome is transmitted by only one means (Preacher & Hayes, 2008); thus, considering a single variable to explain an outcome can fall short of explaining and capturing the complete and comprehensive relationship in a tested framework.

6. In view of the concept of multiple practices or multiple strategies, there is a huge gap in terms of the available literature. However, the concept is attracting considerable attention from various fields including in the field of strategy-performance research. This view is parsimonious with the assertions of various scholars (namely Gurumurthy & Kodali, 2009; Shah & Ward, 2007; Doolen & Hacker, 2005).

2.12 Summary

This chapter has reviewed the literature pertaining to the study variables. Gaps within the literature and studied variables have also been identified. The underlying theories that explained the criterion variables in this study have been taken into account and properly discussed. Based on the contingency and complementarity theories, the theoretical framework for this study has been formulated and presented. Finally, based on the cumulative literature review and derivation of relationships among the constructs, the study hypotheses have been postulated.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter contains the research methodology used in this study. It provides details of the research design and methods used for collection of data as well as the data analysis. The section that follows is devoted to explaining the research approach, population of samples, the sampling procedures, data collection procedure, the research instruments, pretest stage and the statistical analyses used to test the hypotheses.

3.1 Research Approach

This research is correlational in nature since the primary objective was to study the impact of those variables that have been suggested as having an influence on manufacturing performance, when manufacturers are exposed to certain types of external business environment. Correlational analysis is used when attempts are made to study causal relationships between variables (Gay & Diehl, 1996; Zikmund *et al.*, 2010). For this study, the relationship between each dimension of external environmental factors, lean manufacturing practice, manufacturing technology, strategic flexibility and manufacturing performance among Malaysia's manufacturers was examined. This study is confirmatory in nature, in which data were collected cross-sectionals and all the variables were measured at the same point of time. The following subsections are devoted to providing a detailed description of the research approach, population and subject, sampling procedure, data collection procedure, research instrument, pilot study, and the statistical analyses used to test the hypotheses. The field study for this research was conducted in a non-contrived setting in which self-administered questionnaire was used to collect data on the studied variables.

3.2 Source of Data

The unit of analysis for this study is the organization, specifically, manufacturing firms. The questionnaires were intended for managers, executives and engineers who were involved directly with the operation of manufacturing plants. The rationale for choosing these respondents as the source of data collection was based on the earlier work by Phillips (1981), who stressed that high ranking informants are more reliable sources of information than their lower ranking counterparts. For the purpose of this research, these managers, executives and engineers were defined as full time technical, management or highly skilled employees who have been employed for more than six months at the company and were attached to the operation side of the manufacturing function, such as quality, production, maintenance or engineering departments. These groups were chosen because (1) they were considered to be key employees in the manufacturing operation, and, thus, would be most familiar with the core elements of their plants, (2) their job task is critical to the performance of any manufacturing plant (Wong & Wong, 2011), (3) previous research on lean manufacturing used them as respondents for more reliable and accurate data as they were directly involved in the forming and implementation of manufacturing practices within the company (Nordin *et al*., 2010; Wong *et al*., 2009). Only employees that have been employed for more than six months were selected, because six months is an adequate period of organizational socialization for employees to provide a stable evaluation of their organizations (Lashley & Best, 2002). These employees are also part of lean teams, which drove lean implementation throughout the company. In lean organization, members of the lean team are especially well trained and well versed in all lean activities within the company making them suitable and most knowledgeable to answers the questionnaires.

3.3 Population and Sample Size

The population of this study consists of Malaysian manufacturers located throughout Peninsular Malaysia. Sampling is done in quantitative research to study a representative sample that closely reproduces features of interest in a larger population (Neumann, 2009). Due to the fact that lean manufacturers were not listed in any databases, the selection of the sampling frame had to be based on available data from previous research in the area of lean. Based on the review of the literature, and as summarized in Table 3.1 below, it showed that the industries known to implement lean were electrical and electronic, automotive and aeronautical. Therefore, the industries selected for this study comprised of electrical and electronic, automotive and aeronautical. However at this point, the lean -manufacturers could not be distinguished from the non-lean implementers as yet. In order to properly identify whether the responders are lean manufacturers or not, a question regarding the lean status of the manufacturers was inserted in the demographic section of the questionnaire. The list of manufacturers from these three predetermined sector, was sourced from the FMM Directory 2010. These manufactures not only include main manufacturers, but also consist of the supporting industries. The collected name of the manufacturers were then scanned through to ensure that there is no duplicity as the supporting manufacturers for one sub sector could also be supporting manufacturer for the other sub sectors. All together, the total population size is 1246 manufacturers. Stratified proportionate sampling method was then used in this research. Proportionate stratification is a type of stratified sampling in which the sample size of each stratum is proportionate to the population size of the stratum (Gay & Diehl, 1996; Hair, Money, Samouel & Page, 2007, p. 178). This means that each stratum has the same sampling fraction. The sample for each stratum is then calculated using the following formulae:

$$n_h = (N_h / N) * n$$

where n_h is the sample size for stratum *h*, N_h is the population size for stratum *h*, N is the total population size, and n is the total sample size.

Follows is the breakdown of the sampling frame chosen for this research.

Table 3.1
Summary of Malaysian Lean Manufacturers Studied by Previous scholars

Industry group	**Previous research on lean implementation on Malaysian manufacturers**	**Number of manufacturers registered with FMM**
Automobiles	Simpson, Sykes & Abdullah (1998) Abdul Raman & Jamaluddin (2008) Moud Nawawi (2009) Nordin *et al.* (2010) Nordin *et al.*(2011) Muslimen *et al*. (2011)	155

Table 3.1 (Continued)

Industry group	**Previous research on lean implementation on Malaysian manufacturers**	**Number of manufacturers registered with FMM**
Aerospace	Mohamad *et al.* (2008) Puvanaswaran *et al.* (2009) Mohamad *et al.* (2009) Mohd Aminudin(2010)	6
Electrical & Electronic	Wong *et al.* (2009) Wong (2010) Wong & Wong (2011) Wong & Cheah (2011)	1085
Total		**N=1246**

Based on Krejcie and Morgan (1970), a minimum sample of 291 is an appropriate sample size for a population of 1,200 to 1,300. However, due to the expectation of a low response rate (at around 12%), which is common among Malaysian manufacturers, as exhibited in previous studies (Jusoh, 2007; Wong, 2010), the researcher decided to implement over sampling. A low response rate would prove to be a problem during the data analysis using SEM as at least 100 usable samples are required (Byrne, 2010). Vogt (2007) also stated that in such circumstances a larger sample would help reduce the sampling error and avoid failure to detect actual relationships in any actual given population. Therefore, in order to achieve the maximum number of usable samples, the number of questionnaires sent out was increased by 50%. This method of over sampling is not new to the field of social sciences. Scholars, such as Salkind (1997), have suggested the over sampling method where sample sizes are increased by 40-50% to make up for unusable responses and low response rate. Vogt (2007) also stated that in such circumstances, a larger sample would help reduce the sampling error and avoid failure to detect actual relationships in any actual given population. Based on these arguments, the researcher decided that it was justifiable to send questionnaires to all the lean manufacturers.

Therefore, after factoring the 50% increase, the number of questionnaires sent out in this research was 437. The breakdown of questionnaires by industry was 154 for automobiles, 3 for aerospace and 380 for the electrical and electronic.

3.4 Data Collection Procedure

Data were collected using questionnaires by postal mail as well as via electronic mail. A survey is one means of data collection for quantitative studies, which is administered to sample within the population under study to generalize to the population as a whole (Robson, 2002; Rowley, 2002). The mail method was employed for this study because of its advantage in covering a wide geographical area with less time and cost (Sekaran, 2003). Although data collection through the survey method does have some benefits over other research methods, it also imposes certain problems. With questionnaires, the respondents do not have the opportunity to ask for clarification as in a face-to-face interview. To overcome or at least minimize this foreseen problem, pretesting of the questionnaires was done beforehand in order to ensure that they were user friendly, simple enough to be understood by the respondents but detailed enough to capture adequate information for the study. The conducted pretest phase is further discussed in section 3.8.

Questionnaires in the form of a printed booklet and email were used in data collection. Initially the printed booklets were posted to the respondents accompanied by a cover letter, stating the purpose of the study and the assurance of confidentiality for the collected data. In the second stage, the questionnaires were then distributed again two weeks after the first stage to respondents who did not reply to the initial posted questionnaires. After two weeks passed, the first follow up by telephone was conducted with the respondents and followed by weekly reminders until an adequate number of responses had been received.

3.5 Research Instrument

This section describes the measures used in this study. The dependent variable for this study is manufacturing performance. The three mediating variables proposed are lean manufacturing, manufacturing technology and strategic flexibility, and the independent variable in this study is external environmental factors. The research hypotheses for this study were formulated from the theoretical framework. Previous empirical findings on the relationship between variables are presented later in this chapter to support the proposed hypotheses. Specifically, the hypotheses postulated are to answer the research questions in this study.

The questionnaire is made up of four sections. Section A consists of ten items measuring manufacturing performance. Section B consists of forty-eight items measuring lean manufacturing, while section C contains fourteen items measuring strategic flexibility. This is followed by section D with nineteen items measuring manufacturing technology. Section E comprises twelve items measuring external environmental factors relating to dynamism and hostility, and section F contains twelve questions on the respondent demographic-related items as well as the organizational information.

All these measures for sections A to E were adapted from various sources of earlier scholars, which were chosen based on their respectable Cronbach's alpha (α) value. Table 3.2 summarizes the measures used in this study with their associated Cronbach's α value. A value of more than 0.70 means that a chosen measurement tool is highly reliable and is fit for use (Nunnally, 1978). However, in the context of this study, the minimum acceptable level was set at 0.60 (Sekaran, 2010) even though in actualization it could even have a lesser value, such as 0.50, which would still be acceptable in the case of factors that only include two or three items but are theoretically meaningful with the conceptualization of the construct under study (Larcker, 1981; Ary, Jacobs & Razavieh, 1996; Blaikie, 2003).

Table 3.2
Measures of The Study

Variable	Variable Measured	Source of Scale	No. of Items	Cronbach's α
DV	**Manufacturing Performance** -financial measurement -nonfinancial	Jusoh (2010) Dossi & Patelli (2010) Swamidass & Newell (1987) Papke-Shields & Malhotra (2001)	10	0.64-0.91
IV	**External business factor** -dynamism -hostility	Anand & Ward (2004) Liao & Tu (2008) Swamidass & Newell (1987) Covin & Slevin (1988)	12	0.69-0.88

Table 3.2 (Continued)

Variable	Variable Measured	Source of Scale	No. of Items	Cronbach's α
MV	**Lean manufacturing**	Shah & Ward (2003, 2007)	48	0.73-0.86
	- supplier management			
	- just-in-time delivery			
	- customer involvement			
	- pull production			
	- flow production			
	- setup time reduction efforts			
	- total productive /total preventive maintenance			
	- statistical process control			
	- employee involvement			

Table 3.2 (Continued)

Variable	Variable Measured	Source of Scale	No. of Items	Cronbach's α
MV	**Strategic Flexibility** - capacity change - process efficiency - product development	Sethi & Sethi (1990) Sanchez (1995) Lau (1996)	14	0.79-0.92
	Manufacturing Technology - information exchange and planning technology - product design - low volume flexible automation technology - high volume automation technology	Swamidass & Kotha (1998) Kotha & Swamidass (2000)	19	0.75-0.84
Demographic and organizational information		Industry type, number of employees, annual sales turnover, type of ownership, length of tenure, respondent's position, respondent's department, lean implementation history, type of process, number of products.		

3.5.1 Instrument Development for Measurement of Manufacturing Performance.

The dependent variable for this study is manufacturing performance. In order to fully capture the comprehensive performance outcome of the manufacturing performance, two angles of the performance measurement – financial and nonfinancial assessment – were used.

Manufacturing performance is best measured using both nonfinancial and financial measurement (Abdel-Maksoud *et al*., 2005). Therefore, in the context of this study, manufacturing performance was measured using both dimensions. A ten-item measurement, which was adapted from Jusoh (2010), Dossi and Patelli (2010), Swamidass and Newell (1987), and Papke-Shields and Malhotra (2001), was used in this study to assess manufacturing performance. It is important to include nonfinancial measures as it broadens the spectrum of control by avoiding short- sighted measurement while financial measurement is heavily favored as it is directly linked to the outcome of the implemented strategies (Dossi & Patelli, 2010).

Nonfinancial measures included market share, sales growth, quality performance as well as end product/process innovation. The manufacturing performance measurement for this study used interval scales, ranging from 1 = low end of industry to 5 = high end of industry. Respondents were asked to rate their manufacturing performance in comparison to their competitors.

Table 3.3
Items Constituting Manufacturing Performance

1	Profit
2	Return on assets
3	Sales revenue
4	Cash flow
5	Operating income
6	Market share
7	Sales growth
8	Number of new product launch
9	Time-to-market launches
10	Quality of product performance

Source: Jusoh, 2010; Dossi and Patelli, 2010; Swamidass and Newell,1987; Papke-Shields and Malhotra, 2001

3.5.2 Instrument Development for Measurement of Lean Manufacturing

A forty-eight item measure adapted from Shah and Ward (2003, 2007) was used to measure lean manufacturing. The questions measure nine dimensions that collectively and additively contribute to the forming of lean manufacturing practices. These dimensions were (1) supplier management, (2) just-in-time delivery, (3) customer involvement, (4) pull production, (5) flow production, (6) setup time reduction efforts, (7) total productive/total preventive maintenance, (8) statistical process control, and (9) employee involvement. Level of lean manufacturing was measured using interval scales, ranging from 1 = strongly disagree to 5 = strongly agree. Forty-eight measures of lean manufacturing are shown in Table 3.4 below. The respondents were asked to rate their lean manufacturing implementation level within their own manufacturing facility.

Table 3.4
Items Constituting Lean Manufacturing

Question no.	Dimension	Items
1	Supplier management	We are in frequent contact with our suppliers
2		We often receive visits from our suppliers
3		We seldom visit our suppliers' plants
4		We give our suppliers feedback on quality and delivery performance
5		We strive to establish a long-term relationship with our suppliers
6		Suppliers are directly involved in the new product development process
7	JIT delivery	Our key suppliers deliver to plant on JIT basis
8		We have a formal supplier certification program
9		Our suppliers are contractually committed to annual cost reductions
10		We have corporate level communication on import issues with key suppliers
11		We take active steps to reduce the number of suppliers in each category
12		Our key suppliers manage our inventory
13		We evaluate suppliers on the basis of total cost of bulk purchasing and not per unit price of individual purchased item

Table 3.4 (Continued)

Question no	Dimension	Items
14	Customer involvement	We are frequently in close contact with our customers
15		Our customers give us feedback on quality and delivery performance
16		Our customers seldom visit our plants
17		Our customers give us feedback on quality and delivery performance
18		Our customers are actively involved in current and future product offerings
19		Our customers are directly involved in the producing of current and future product offerings
20		Our customers frequently share current and future demand information with marketing department
21		We regularly conduct customer satisfaction surveys
22	Pull production	Production is "pulled" by the shipment of finished goods
23		Production at stations is "pulled" by the current demand of the next station
24		We use "pull" production system
25		We use *Kanban*, squares, or containers of signals for production control
26	Flow production	Products are classified into groups with similar processing requirement
27		Products are classified into groups with similar routing requirement
28		Equipment is grouped to produce a continuous flow of families of products
29		Families of products determine our factory layout

Table 3.4 (Continued)

Question no.	Dimension	Items
30		Pace of production is directly linked to the rate of customer demand
31	Set up time	Our employees practice setups to reduce the time required
32		We are working to lower setup times in our factory
33		We have a low set up time of equipment in our plants
34		Long production cycle times prevent responding quickly to customer requests
35		Long supply lead times prevent responding quickly to customer requests

Table 3.4 (Continued)

Question no.	Dimension	Items
36	SPC	Large number of equipment/processes on shop floor are currently under SPC
37		Extensive use of statistical techniques to reduce process variances
38		Chart showing defect rates are used as tools on shop-floor
39		We use fishbone type diagrams to identify causes of quality problems
40		We conduct process capability studies before product launch
41	Employee involvement	Shop floor employees are key to problem solving teams
42		Shop floor employees drive suggestion programs
43		Shop floor employees lead product/process improvement efforts
44		Shop floor employees undergo cross functional training
45	TPM	We dedicate a portion of every day to planned equipment maintenance related activities
46		We maintain all our equipment regularly
47		We maintain excellent records of all equipment maintenance related activities
48		We post equipment maintenance records on shop floor for active sharing with employees.

Source: Shah and Ward, 2003, 2007

3.5.3 Instrument development for Measurement of Strategic Flexibility

Strategic flexibility was determined using a fourteen items measure, adapted from Sethi and Sethi (1990), Sanchez (1995) and Lau (1996). In this study, the measures for strategic flexibility were adapted from the dimensions; namely, capacity change, process efficiency and product development. Strategic flexibility was measured using interval scales, ranging from 1 = strongly disagree to 5 = strongly agree. The fourteen measures for strategic flexibility are shown Table 3.5 below. The respondents were asked to rate their organization's ability in making strategic changes within their operation.

Table 3.5
Items Constituting Strategic Flexibility

Question no.	**Dimension**	**Items**
1	Capacity changes	Our firm can quickly and easily respond to changes in customer demand
2		Our firm can quickly and easily expand into new regional or international markets
3		Our firm can quickly and easily introduce new pricing schedules in response to changes in competitors' prices
4		Our firm can quickly and easily react to new product launches by competitors
5	Process efficiency	Our firm can quickly and easily adopt new technologies to produce better, products
6		Our firm can quickly and easily adopt new technologies to produce faster process
7		Our firm can quickly and easily adopt new technologies to produce cheaper products
8		Our firm can quickly and easily switch to new suppliers to avail of lower costs, better quality or improved delivery times.
9		Our major suppliers can quickly and easily respond to changing production volume
10		Our major suppliers can quickly and easily respond to changing production variety
11	Product development	Our firm can quickly and easily customize a product or service to suit an individual customer
12		Our firm can quickly and easily introduce new product to customer
13		Our firm can quickly and easily reduce the variety of products available for sale.
14		Our firm can quickly and easily add the variety of products available for sale

3.5.4 Instrument development for Measurement of Manufacturing Technology

Nineteen item measures were adapted from Swamidass and Kotha (1998) and Kotha and Swamidass (2000) to measure the level of manufacturing technology usage by different manufacturers. Manufacturing technology is usually measured by the level of investment, level of adoption and level of benefit from implementing these strategies. However, measuring the benefit is problematic due to manager's inability to accurately gauge the benefit due to their limited knowledge of certain technologies (Swamidass & Nair, 2004).

As for the level of investment made on the technology, even though previous scholars (Schroeder & Congden, 2000; Kotha & Swamidass, 2000) indicated that the performance in SMEs increased significantly with increased investment in manufacturing technology, in the context of this study it was not included due to the difference between the financial capability of MNC manufacturers compared to their smaller counterparts.

This study focuses on lean manufactures regardless of their size, thus measuring the manufacturers' level of investment in technology despite the different financial vigor would yield a distorted outcome. These measures were formed from four dimensions of manufacturing technology, which were grouped into information exchange and planning technology, production design technology, high volume automation technology and low volume flexible automation based on the earlier work by Swamidass and Kotha (1998) and Kotha and Swamidass (2000). Manufacturing technology was measured using interval scales, ranging from 1 = strongly disagree to 5=strongly agree. The respondents were asked to rate the usage of manufacturing technology for their organization within their operation.

Table 3.6
Items Constituting Manufacturing Technology

Question no.	Dimension	Items
1	Information exchange & planning technology (IEPT)	We use Local Area Network for factory in our firm
2		We use Computers used for control on Factory floor in our firm
3		We use Local Area Network for Technical Data in our firm
4		We use Computers for Production Scheduling in our firm
5		We use Electronic Data Interchange in our firm
6		We use Material Requirement Planning (MRP)and Manufacturing Resource Planning (MRP II) systems in our firm
7		We use Intercompany Networks in our firm.
8	Product design (PD)	We use Automated Drafting Technologies in our firm
9		We use Computer Aided Design (CAD) in our firm
10		We use Computer Aided Engineering (CAE) in our firm

Table 3.5 (Continued)

Question no.	Dimension	Items
11	High volume automation technology	We use Computer Aided Quality Control performed on final products in our firm
12	(HVAT)	We use Computer Aided Inspection Performed on incoming or in process material in our firm
13		We use Robots others than 'Pick and Place' in our firm
14		We use 'Pick and Place' Robots in our firm
15		We use Manufacturing Automation protocol in our firm
16	Low volume flexible automation technology	We use Numerical Control (NC)/Computerized Numerical Control (CNC) machines in our firm
17	(LVAT)	We use programmable controllers in our firm
18		We use Computer Aided Design (CAD)/ Computer Aided Manufacturing (CAM) in our firm
19		We use Flexible Manufacturing System (FMS) in our firm

Source: Swamidass and Kotha,1998, Kotha and Swamidass,2000.

3.5.5 Instrument Development for Measurement of External Environmental Factors

The extent to which external environmental factors significantly impacted manufacturing performance has been empirically documented in previous research. To a large extent, the external factors of any organization determine its adopted strategy for reaping the competitive advantage (Murray, 1988; Lotayif, 2010). Due to the vast number of environmental factors, the selection of which factor to focus on depends on the research objectives itself (Zahra, 1993). In the scope of this study, dynamism and hostility are the two dimensions used to measure the external environmental factors.

Despite various factors, dynamism and hostility are the two most measured factors in various business environment studies (Lumpkin & Dess, 2001; Moreno & Casillas, 2008; Wiklund & Shepherd, 2005). External environmental factors were measured using twelve items, adapted from Covin and Slevin (1988), Miller (1992), Lau (1996), Anand and Ward (2004) and Liao and Tu (2008). In this study, the measures of environmental factors were adapted from its dimensions, i.e. dynamism and hostility. Environmental dynamism was measured using interval scales, ranging from 1 = strongly disagree to 5 = strongly agree. The twelve measurements for environmental factors are shown in Tables 3.7 and 3.8 below.

Table 3.7
Items Constituting Environmental Dynamism

1	Our firm rarely changes its marketing practices to keep up with competitors
2	There is a high obsolescence rate for our products
3	Our competitors action are easily predicted
4	Our customers' demands are easily forecast
5	The rate of process technology innovation in our industry is high

Environmental hostility was then measured using interval scales, ranging from 1 = strongly disagree low to 5 = strongly agree.

Table 3.8
Items Constituting Environmental Hostility

1	Our overall business environment is threatening
2	There is tough price competition in our industry
3	There is competition in product quality in our industry
4	There is a scarce supply of labor in our industry
5	The market is dwindling for our product
6	There is a scarce supply of material
7	There is no government interference in our industry

3.6 Demographic and Organizational Information

Several questions regarding the organization and respondent's information were also collected and included as part of the questionnaire. Among the demographic information requested from the respondents were jobs positions, length of employment and department to which the respondents were attached. Among the organizational information requested were type of industry, number of employees, ownership, sales turnover, type of process, quality certification endorsement, lean implementation duration and number of products. This research was conducted in order to study the mediating effect of lean manufacturing, manufacturing technology and strategic flexibility on the relationship between external environmental factors and manufacturing performance. Demographic information was identified as the control variable in the statistical analyses of this study.

3.7 Pretest

No questionnaire should be administered before an evaluation of the likely accuracy and consistency is conducted (Hair *et al.*, 2007, p. 278). Pretesting was conducted using a small sample of respondents with characteristics similar to the targeted population. A pretest is a small scale version of the study that collects data from respondents similar to the actual study, which serves as a guide to see if the selected approach and method will work as intended (Zikmund *et al.*, 2010). A pretest is also used as a fine tuning step to avoid any impending critical error that is foreseen in the actual study. For the first phase, questionnaire items were pretested for face validity on three chosen academicians in Universiti Utara Malaysia (UUM) and three engineers and managers working in lean manufacturing firms. Gay and Diehl (1996, p. 247) suggested two to three people to perform pretesting of the questionnaire before being used in the actual study in order to detect any deficiencies and provide suggestions for improvement. The selection of these academicians and industry based respondents was based on their industrial experience and their previous research activities in the manufacturing study. The respondents were asked to evaluate the items for readability, accuracy of words, clearness of questions as well as adequacy of the items used for concept measurement in the questionnaire. The following factors, which mainly focus on the quality of the questionnaires were evaluated during this stage.

Table 3.9
Face Validity – Pretest Questions for Experts

Evaluated factors	**Probing questions**
Clearly worded sentences	Is there any part of any sentence that you find confusing? Is there any part of any sentence that you find difficult to comprehend? Is there any part of the questionnaire that you feel is difficult to understand? Are there any words that you do not understand? Are there any sentences that you are unsure of the meaning?
Ambiguous sentence	Do you clearly understand the printed questions? Are there any questions that you do not clearly understand the meaning of? Based on each section, do you clearly understand the focus of the questions? Are there any questions that you feel overlap with another?
Scaling, formatting & instruction	Do you feel comfortable reading the questions in terms of clarity of the printed words? Is the font big enough? Do you clearly understand the scaling in relation to each question? Do you find it difficult to move from one section of the questionnaire to another? Is the paging of each section convenient to read? Is the structuring of the questionnaire convenient to read and to answer?

At this point, these questions were asked for each section of the questionnaire. Since there was a small number of suitable respondent to choose from in this study, the researcher chose not to include too many respondents in the pretest. The appropriate pretest sample size, as suggested by Hair *et al*. (2007, p. 278), ranges from 4 to 30. Based on the individual feedback received during this pretest, the questionnaires were analyzed, reviewed and refined. In this research, multi item scales were used to measure the variables, thus this process provides a check of face validity.

3.8 Data Analysis Procedure

Sekaran (2000) stated that prior to data analysis, steps, such as coding, data screening and selecting the appropriate data analyses strategy, must be completed. Raw data must be coded properly and consistently to assist statistical analysis. In addition, data screening was also conducted to ensure detection of any data entry related error. The method used for screening data was by performing descriptive statistics of the variables. From the outcome, the missing data and normality were determined. In this research, normality was first tested when the researcher realized that there were only 85 data to be analyzed after the initial screening.

Data for this research were analyzed using structural equation modeling, known as SEM. The SEM approach is claimed to be useful in the behavioral and social sciences when many constructs are unobservable (Sharma, 1996). SEM helps researchers to assess the uni-dimensionality, reliability and validity of each construct. In addition, SEM provides an overall test of model fit and individual parameter estimate tests simultaneously (Hair, Anderson, Tatham & Black, 1998; Kline, 2005). Recently, SEM has become a common statistical tool applied in academic research (Anderson & Gerbing, 1988; Bollen, 1989; Kline, 2005; Hair *et al.*, 1998). Moreover, the literature confirms that SEM is the pre-eminent method of multivariate data analysis (Hershberger, 2003). Applying SEM to test hypothesized relationships between factors allows a complete investigation of all hypothesized relationships simultaneously including relationships among multiple dependent variables in a study (Byrne, 2001). Further explanation on this approach can be found in section 3.10 of this chapter.

3.8.1 Data Coding

After collecting the data, coding was carried out in order to store the data systematically (Zikmund, 2003). Data need to be coded accordingly and arranged consistently in the required numerical pattern deemed suitable for statistical analysis. Some of the questions in the questionnaire used reverse coding and noted down according for re coding at the end of data collection, prior to data analysis.

3.8.2 Descriptive Statistics

Descriptive statistics provide an abstract description of the overall data statistics. This analysis was used to examine the characteristics of the studied lean manufacturers. Descriptive statistics refers to the transformation of raw data into a form that makes it easy to understand and interpret (Suzaki, Karim & Wang, 2001). This analysis provides a clear meaning of the data through frequency distribution, means and standard deviation. The main descriptive statistics for the respondents in the present study include mean and standard deviation.

3.8.3 Data Screening

Data screening involves a number of steps to make sure that the effect of characteristics of data might not adversely affect the results. The importance of data screening can be seen in the following steps of analysis.

3.8.4 Missing Data

There are many ways to handle missing data, such as through its deletion, distribution or replacement. The first initial step in the data screening process is by identifying the missing data involved. Missing data might occur when respondents omit or refuse to answer certain questions or lack knowledge concerning certain questions in the questionnaire.

3.8.5 Assessment of Normality

The normality test is used to assess the distribution of the collected data. The normal distribution is particularly important because it provides the underlying basis for many of the inferences made by business researchers who collect data through a survey (Hair *et al*., 2007)

3.9 Data Analysis using Structural Equation Modeling (SEM)

The data collected from the surveys, as mentioned earlier, were analyzed using SEM. SEM is an attempt to model the causal relationship between variables by including all the variables that are known to have some involvement in a study (Byrne, 2010). SEM is a powerful multivariate analysis technique. When most multivariate analysis is for descriptive or exploratory research, SEM takes on a confirmatory approach that involves hypotheses testing. In the context of this research, SEM provides the researcher with the ability to model multiple mediating variables simultaneously.

SEM Terminology – when using SEM, the variables involved are termed differently. In such manner, the independent variables are referred to as exogenous, whereas the mediating variables are known as endogenous variables. The SEM terminology used in the context of this study is summarized in Table 3.10 below.

Table 3.10
SEM Terminology for Studied Variables

Variable	**Variable Measured**	**Dimension/ *Latent constructs***
DV *endogenous*	Manufacturing Performance	- Financial measurement - Nonfinancial
IV *exogenous*	External business factor	- Dynamism - Hostility
MV *endogenous*	Lean manufacturing	- Supplier management - JIT delivery - Customer involvement - Pull production - Flow production - Set up time - SPC - Employee involvement - TPM
MV *endogenous*	Strategic Flexibility	- Capacity change - Process efficiency - Product development
MV (*endogenous)*	Manufacturing technology	- HVAT - LVAT - PD - IEPT

Construct validity – In this study CFA (confirmatory factor analysis) was used to determine the significant observed items related to each of the latent variables. This relationship is described by factor loading. The value of factor loading, represented by the validity coefficient from CFA, will provide information on the measures of the latent variables. The biggest advantage of using CFA is its ability to measure the construct validity of the proposed measurement model. Construct validity is made up of convergent validity (factor loading, variance extracted and reliability) and discriminant validity. Table 3.11 summarizes the acceptable results from the aforementioned analysis.

Table 3.11
Acceptable Level for Structural Equation Modeling Analyses

Analyses	**Acceptable level**	**Reference**
Average Variance Extracted (AVE)	More than 0.5 for adequate convergent validity	Bagozzi & Yi, (1988)
Composite Reliability (CR)	More than 0.7 to indicate adequate convergence or internal consistency	Gefen, Straub & Boudreau (2000)
Cronbach's α	Cronbach's α value should be 0.7 or higher to indicate adequate convergence or internal consistency However the minimum acceptable level was set at 0.60 but could even have the lower value of 0.50, which is still acceptable for factors that contain only two or three items but is theoretically meaningful with the conceptualization of the construct under study	Nunnally (1978) Sekaran (2010) Larcker (1981) Ary *et al.* (1996) Blaikie (2003)
Discriminant Validity	Square root of the Average Variance Extracted (AVE) that exceeds the inter correlations of the construct with the other constructs in the model to ensure discriminant validity	Chin (2010); Chin (1998b); Fornell & Larcker (1981).

3.9.1 Mediation Analysis using SEM

According to Größler and Grübner (2006), the nature of the relationships among several elements can be tested by a structural equation modeling (SEM). In using SEM, researchers are exposed to two main alternatives, i.e. to use covariance based software such as AMOS, LISREL and EQS, or variance based software, such as PLS-Graph and Smart PLS (Chin & Newsted, 1999). The decision very much depends on the characteristics of the research itself. Covariance-based SEM is best used for theory testing and development. Conversely, variance based SEM tools, such as SmartPLS, are more suitable for predictive analysis, especially in the condition of high complexity and low theoretical information (Barclay, Higgins & Thompson, 1995); hence, they were deemed to be apt for this study.

In the context of this research, analysis will be done among three of the studied manufacturing strategies. The SEM approach consists of two components – the measurement model and the structural model. While the former relates theoretical constructs, such as manufacturing strategies to empirical variables that are indicators of the underlying theoretical construct, the latter represents the relationships between the theoretical constructs (Jöreskog & Sörbom, 2001). In the context of this research, the proposed model consists of three different mediators – manufacturing technology, lean manufacturing practices and strategic flexibility.

While Baron and Kenny (1986) mapped out the procedure to identify and how to treat mediator relationship, it was done in the perspective of a single mediator at a time, termed as the simple mediation model. In this case, however, the researcher chose to explore the method of multiple mediators using the method suggested by Preacher and Hayes (2008). This type of mediation study has received less attention in both the methodological and applied literature, and involves simultaneous mediation tests by multiple variables, or multiple mediators (Preacher & Hayes, 2008).

However, more research is now using the approach of multiple mediation analyses as they explore more complex relationships among the variables being studied. One of the biggest advantages of using multiple mediation models is that researchers are able to analyze and compare the strength of mediation effect among the mediating variables toward the dependent variables. Mediation models are best estimated in a SEM context because of the greater flexibility of SEM programs provided by the model specification and estimation options (Preacher & Hayes, 2008).

3.10 Summary

This chapter has articulated the methodology that was used in this study. It has highlighted the research approach, population and sampling procedure for this research. It has also summarized the measuring instrument, data collection procedure, as well as the method of data analyses to verify the postulated hypotheses. The results of the analyses and findings will be presented in the next chapter, Chapter Four.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.0 Introduction

This chapter describes the analysis undertaken and presents the empirical results to test the research hypotheses. Data were analyzed using one of the structural equation modeling (SEM) methods – partial least squares (PLS-SEM). SmartPLS 2.0 statistical package software was utilized for path modeling. The arrangement of this chapter is as follows. Firstly, the profile of the respondents will be presented based on their demographic information. This is followed by the goodness of measure part, in which the measurement model validity is established. Subsequently, this is followed by validation of the structural model in which the hypotheses are tested to confirm the final outcome of this research. Finally, a short summary of the chapter is provided.

4.1 Data Analysis and Overview of the Results

In the first part, the demographic data are analyzed and presented. This part focuses on the respondents profile as well as the industry profiles. A brief overview of the sampling procedure and response rate are also discussed. Then, in the second phase, Structural Equation Modeling (SEM) using confirmatory factor analysis is employed to test the hypotheses proposed in Chapter Three.

The choice of SEM for analysis in this research stems from its capacity to simultaneously model relationships among multiple independent and dependent constructs (Gefen *et al.,* 2000). This research contains not just independent and dependent variables but also three different mediators that need to be tested together. In SEM, the need to differentiate between dependent and independent variables is not required. Instead, this second generation technique distinguishes between the exogenous and endogenous latent variables, the former being variables that are not explained by the postulated model and the latter being variables that are explained by the relationships contained in the model. In the context of this study, the researcher adopted the approach supported by Urbach & Ahleman (2010) and chose PLS-SEM as the statistical means for testing structural equation models as its assumption (1) makes fewer demands regarding sample size than other statistical methods, (2) does not require normally distributed input data, (3) can be applied to complex structural equation models with a large number of constructs, and (4) is able to handle both reflective and formative constructs and is especially useful for prediction. As mentioned earlier, in this research only 85 sets of data were successfully collected; in addition, as the data are not normally distributed, it limits the choice of statistical tools for analyses. These data properties along with the existence of three mediators that need to be tested simultaneously, prompted the decision to choose PLS-SEM as the suitable analysis tool.

In congruence with the approach for any other SEM tool, the analysis was divided into two separate sections. The first section focuses on the validation of the measurement model used in this research, followed by the validation of the structural model.

4.2 Data Screening

All 112 questionnaires were carefully sorted through. From the demographic data detailing the information concerning the respondents that actually answered the given questionnaires, the researcher managed to identify 27 questionnaires that were answered by personnel from the Human Resource department instead of the initial intended respondents. All 27 questionnaires were discarded and not used in any part of the analysis leaving only 85 data for further analysis.

4.3 Response Rate

Out of the 437 questionnaires sent out, 250 (57.21%) respondents replied, of which only 112 were identified as lean manufacturers, giving a response rate of 25.6%. However, out of the 112 questionnaires received, only 85 were answered by the intended respondents while another 27 were answered by the Human Resource (HR) department. Therefore, only 85 (19.4%) questionnaires were deemed usable and subsequently coded and analyzed. All the respondents were from the E&E and automotive sectors, with no response from the aeronautical industry being received.

4.4 Profile of Companies and Respondents

The first aspects to be investigated were the general background of the manufacturers and the respondents involved in this research. Table 4.1 shows the summarized general background of these manufacturers.

Table 4.1
Profile of Companies

Background Information		n	Percentage %
Sectors	E & E	46	45.88
	Automotive	39	54.12
Company ownership	MNC	51	60.00
	JV	10	11.77
	Local	24	28.24
Size of Company (Number of employees)	< 50	7	8.24
	51-150	10	11.76
	> 150	68	80.00
Lean history (implementation in year)	< 1	8	9.41
	1-3	21	24.71
	> 3	56	68.88
Annual revenue (RM)	< 10 million	14	16.47
	10-25 million	22	25.88
	> 25 million	49	57.65
Number of product lines	1 product	9	10.59
	2 products	5	5.88
	>3 products	71	83.53

The background information investigated comprised the type of industry, ownership, size (number of employees), annual revenue, number of product lines and lean manufacturing implementation history. From the 85 received responses, 45.88% were from the automotive industries while another 54.12% were from the electric and electronic manufacturers. None of the questionnaires sent to manufacturers from the aeronautical sector were returned. Most of the respondents (60%) came from multinational corporations (MNCs), 28.24% were from locally owned companies while the balance, 11.77%, were from joint venture manufacturers. The size of the organization in this study was determined by the number of workers employed in the manufacturing plants. Accordingly, 49.41% of these manufacturers were large companies employing more than 150 workers, while 30.59% of the respondents were from medium companies and another 8.24% of respondents worked with small companies with less than 51 workers. Approximately, 70% of the respondents have more than three production lines in their facilities, with more than 57% earning more than 25 million according to their annual review.

In terms of lean implementation, the majority (90%) of the companies had implemented lean manufacturing for more than one year and only 9.41% had been lean manufacturers for less than a year.

The second aspect investigated was the general background of the individual respondents in this research. Table 4.2 below shows the general information concerning the respondents, such as job position and department of attachment in the company as well as years of employment. They were selected because they have firsthand knowledge and experience and they are directly involved in the implementation of the lean manufacturing program in their companies.

Table 4.2
Profile of Respondents

Background Information		**n**	**Percentage %**
Department	Operation	44	51.76
	Engineering/Maintenance	6	7.06
	QA	6	7.06
	Production	29	34.12
Job Position	Executives	30	35.29
	Junior Manager	10	11.76
	Middle Manager	27	31.76
	Senior Manager	18	21.18
Length of employment	<1 year	4	4.71
	1-3 years	22	25.88
	3< years	59	69.41

It was found that half of the respondents were mainly from the Operation department while another 34% from the Production department with the rest from QA, Engineering and Maintenance. The majority (70%) have been working for more than three years in that particular company at the managerial level.

4.4.1 Data Normality

The collected data was analyzed and data normality was tested. The results from the descriptive statistic (Appendix IV) and normality test show that the data for this study are not normal (Appendix III). Normality means that the distribution of the data is normally distributed with the mean of 0, standard deviation of 1 and a symmetric bell shaped curve. The non-normal distribution could be due to the small number of samples. The central limit theorem states that if a large enough sample is taken, the mean will follow an approximate normal distribution. Normality is an issue because it is one of the basic assumptions required in order to carry out structural equation modeling (SEM) analysis (Byrne, 2010). However, this problem is much less severe when using PLS-SEM (Hair, Hult, Ringle, Sarstedt, 2013, p. 55). PLS-SEM employs the bootstrapping method in determining the significant relationship within a model for non-normal data. This is one of the major advantages of using PLS-SEM. Unlike other SEM techniques, PLS-SEM does not require any normality assumption and handles non-normal data rather well (Chin, 1998b; Bontis & Booker, 2007). Despite such allowance, Hair *et al.* (2013) suggested a close examination of the data to make sure substantial deviation could be recognized and removed before running PLS-SEM to ensure that the quality of the data does not compromise the outcome of the study. Absolute skewness value of more than 1 means that the data are extremely non-normal and must be removed before PLS-SEM is applied (Hair *et al.*, 2013 p. 54). Fortunately, upon scrutiny of this data set (Appendix IV), no indication of highly non-normal data was found, thus prompting the researcher to proceed with the ensuing analysis using PLS-SEM without removing any data.

4.4.2 Missing Data

Out of the 85 questionnaires that were answered by the intended respondents, no data were detected as missing. All questions were completely answered by the respondents. Therefore, all 85 sets of questionnaire were used in the next stage of analysis, using PLS.

4.5 Measuring Instrument Validity and Reliability

The premise of this research is categorized as prediction-oriented modeling. In general, two applications of PLS-SEM are possible (Chin, 1998a). It can either be used for theory confirmation or theory development. In the case of this research, PLS-SEM was used to develop propositions by exploring the relationships between variables. This research constitutes an incremental study, which was initially based on a prior model, albeit with newly adapted measures and structural paths introduced. In this respect the statement is supported by the previous study conducted by Reinartz *et al.* (2009) in which PLS-SEM is the preferable approach when researchers focus on prediction and/or theory development.

4.5.1 Goodness of Measure

The first step in PLS-SEM path modeling is to validate the measurement model used in this research. This initial step is to determine how well the indicators (specific questions) load on the theoretically defined constructs.

Examining the outer model ensures that the survey items measure the constructs they are designed to measure, thus ensuring that the survey instrument is reliable. To determine individual item reliabilities, the researcher looked at each of their loadings to the respective constructs.

For this part, confirmatory factor analysis (CFA) was conducted to assess the validity of the measurement model. Due to this research being a confirmatory research in which variables have been determined through earlier research, CFA was chosen instead of exploratory factor analysis (EFA). CFA is philosophically different from EFA. In using CFA, the number of factors within each set of variables is predetermined and those with high loading are determined before computation of the results. Whereas, in EFA, factor analysis can be conducted without knowing the number of factors that really exist or which variables belong with which constructs. This is the critical difference between EFA and CFA. For the purpose of testing goodness of measure, the two main criteria used are validity and reliability. Validity is meant to test how well the instruments used in the research measure the intended concept.

4.5.2 Construct Validity

Construct validity is used to confirm the fit between the outcome or the results obtained from the use of the measuring instruments and the theories from which the test was formed. This type of validity is actually a measurement of the extent to which a set of measured items actually reflect the theoretical latent construct they are designed to measure. The measurement is done through the calculation of convergent and discriminant validity. Convergent validity is measured and assessed through three different elements – factor loading (loading and cross-loadings), variance extracted and reliability.

4.5.3 Internal consistency reliability, Indicator reliability and Convergent validity

The listed constructs, as defined in the research framework and listed in Table 4.3, were each measured individually. Convergent validity is tested to examine the extent to which the multiple items used to measure the same concept are in agreement. Chin, Marcolin and Newsted (2003), and Chin and Henseler (2010) suggested using 0.7 for loadings as this value makes the measurement models meet the conventional acceptance thresholds of reliability and validity (Chin & Henseler, 2010). However, Hair, Black, Babin, Anderson and Tatham (2010) suggested 0.5 as the minimum value for significant loadings. As the measurement items for this study were based on previous studies and had been tested before, with a strong showing of instrument validity value, 0.5 was chosen and used as the minimal cutoff point for factor loadings. Examining the loadings for each of the seven constructs; out of 103 items, 14 had loadings of less than 0.5, and, thus, were eliminated. In total, 13.6% of the items were taken out during measurement model validation.

As suggested by Podsakoff, Bommer, Podsakoff and MacKenzie (2006), removing reflective constructs is allowable as they share the same common theme and are viewed as equivalent manifestations of the same construct, and, therefore, are interchangeable and equally reliable. Thus removing any of them should not have a significant impact on the conceptual domain of the construct.

All of the remaining elements met the 0.5 threshold, signifying that the measures were adequate in their validity individually.

However, this does not indicate if the items only loaded on the intended construct. To determine if the items loaded on the other constructs equally as well as on their theorized construct, the cross-loadings were computed. For cross-validated items to be included in the finalized data set, the loading must be larger on the intended construct than any other construct. This was also achieved.

Using the loadings from the constructs, composite reliabilities (CR) were created for the variables in the model. Table 4.3 also shows the number of items in each scale and the composite reliabilities for each construct. Gefen *et al*. (2000) suggested that the CR value should be 0.7 or higher to indicate adequate convergence or internal consistency. The composite reliability for all constructs, as exhibited in Table 4.3 below, is more than 0.7, and, thus, is reliable. Finally, as a means of evaluating discriminant validity, the average variance extracted for each construct should be greater than the squares of the correlations between the construct and all other constructs (Fornell & Larcker, 1981). For Cronbach's alpha (α), any value of more than 0.70 means that the measurement tool is reliable and can be used in the research (Nunally, 1978). However, the minimum acceptable level was set at 0.60, as suggested by Sekaran (2010), as lower Cronbach's α values of 0.50 are still acceptable for factors that only contain two or three items but are theoretically meaningful with the conceptualization of the construct under study (Larcker, 1981; Ary *et al.*, 1996; Blaikie, 2003).

Equally important, the correlations between the constructs should be lower than the square root of the average variance extracted. As shown in Table 4.3, all of the average variance extracted (AVE) were greater than the recommended 0.50 level.

Table 4.3
Quality of the Measurement Model

Latent variable	Construct	Item	Factor Loadings	Ave	CR	Cronbach's α
Manufacturing Performance	Non-Financial	NF1	0.806	0.597	0.881	0.830
		NF2	0.822			
		NF3	0.702			
		NF4	0.768			
		NF5	0.759			
	Financial	F1	0.871	0.736	0.933	0.910
		F2	0.881			
		F3	0.823			
		F4	0.868			
		F5	0.845			
External Environmental Factors	Environmental Dynamism	ED1	0.760	0.598	0.856	0.776
		ED2	0.812			
		ED3	0.780			
		ED4	0.739			
		ED5*	NA			
	Environmental Hostility	EH1*	NA	0.502	0.742	0.518
		EH2*	NA			
		EH3*	NA			
		EH4	0.700			
		EH5*	NA			
		EH6	0.501			
		EH7	0.873			

Table 4.3 (Continued)

Latent variable	Construct	Item	Factor Loadings	Ave	CR	Cronbach α
Lean Manufacturing	Customer Involvement	CUSTINV1*	NA	0.602	0.858	0.778
		CUSTINV2*	NA			
		CUSTINV3*	NA			
		CUSTINV4	0.669			
		CUSTINV5	0.828			
		CUSTINV6	0.819			
		CUSTINV7	0.779			
		CUSTINV8*	NA			
	Employee Involvement	EMPINV1	0.872	0.801	0.941	0.917
		EMPINV2	0.921			
		EMPINV3	0.920			
		EMPINV4	0.865			
	Flow Production	FLOW1	0.872	0.737	0.933	0.911
		FLOW2	0.865			
		FLOW3	0.887			
		FLOW4	0.854			
		FLOW5	0.812			
	Just In Time Delivery	JIT1	0.736	0.540	0.875	0.832
		JIT2	0.807			
		JIT3	0.737			
		JIT4	0.770			
		JIT5	0.695			
		JIT6	0.655			
		JIT7*	NA			

Table 4.3 (Continued)

Latent variable	Construct	Item	Factor Loadings	Ave	CR	Cronbach's α
Lean Manufacturing	Setup Time	SETUP1	0.880	0.705	0.922	0.895
		SETUP2	0.882			
		SETUP3	0.810			
		SETUP4	0.788			
		SETUP5	0.833			
	Statistical Process Control	SPC1	0.733	0.703	0.922	0.894
		SPC2	0.839			
		SPC3	0.868			
		SPC4	0.847			
		SPC5	0.896			
	Supplier Management	SUPP1	0.663	0.540	0.852	0.777
		SUPP2	0.683			
		SUPP3*	NA			
		SUPP4	0.821			
		SUPP5	0.886			
		SUPP6	0.580			
	TPM	TPM1	0.813	0.712	0.832	0.599
		TPM2*	NA			
		TPM3*	NA			
		TPM4	0.874			
	Pull Production	PULL1	0.628	0.562	0.835	0.788
		PULL2	0.734			
		PULL3	0.833			
		PULL4	0.788			

Table 4.3 (Continued)

Latent variable	Construct	Item	Factor Loadings	Ave	CR	Cronbach α
Manufacturing Technology	High Volume Automation Technology	HVAT1	0.788	0.725	0.929	0.905
		HVAT2	0.880			
		HVAT3	0.850			
		HVAT4	0.858			
		HVAT5	0.877			
	Information Exchange & Planning Technology	IEPT1	0.835	0.691	0.939	0.923
		IEPT2	0.854			
		IEPT3	0.891			
		IEPT4	0.841			
		IEPT5	0.877			
		IEPT6	0.867			
		IEPT7	0.623			
	Low Volume Flexible Automation Technology	LVAT1	0.880	0.783	0.935	0.907
		LVAT2	0.926			
		LVAT3	0.883			
		LVAT4	0.849			
	Product Design	PD1	0.876	0.809	0.927	0.882
		PD2	0.908			
		PD3	0.914			

Table 4.3 (Continued)

Latent variable	Construct	Item	Factor Loadings	Ave	CR	Cronbach α
Strategic Flexibility	Capacity Change	CAPCHA1	0.706	0.728	0.914	0.873
		CAPCHA2	0.920			
		CAPCHA3	0.877			
		CAPCHA4	0.893			
	Product Development	PRODEV1	0.861	0.763	0.906	0.844
		PRODEV2*	NA			
		PRODEV3	0.907			
		PRODEV4	0.851			
	Process Efficiency	PROEFF1	0.860	0.709	0.936	0.918
		PROEFF2	0.903			
		PROEFF3	0.839			
		PROEFF4	0.831			
		PROEFF5	0.819			
		PROEFF6	0.796			

[a] Composite reliability (CR) = (square of the summation of the factor loadings)/{(square of the summation of the factor loadings) / (square of the summation of the error variances)}.
[b] Average variance extracted (AVE) = (summation of the square of the factor loadings)/{(summation of the square of the factor loadings)/ (summation of the error variances)}
*Construct items excluded due to low loading and AVE

4.5.4 Discriminant validity

Besides considering the indicator and construct reliability, a thorough validation procedure also requires the evaluation of a measurement (or structural) model's discriminant validity. Discriminant validity is defined as the dissimilarity in a measurement tool's measurement of different constructs. A necessary condition for discriminant validity is that the shared variance between the latent variable and its indicators must be larger than the variance shared with other latent variables. Likewise, the square root of the average variance extracted must be greater than the correlation between the constructs. Accordingly, the reflective measurement for this model's validation process has been achieved and completed. Because this model consisted of a reflective measure, the two approaches used to determine discriminant validity were Fornell-Larcker criterion and cross-loadings.

This approach asserts that a latent variable should better explain the variance of its own indicators than the variance of other latent variables. The AVE of a latent variable should be higher than the squared correlations between the latent variable and all other variables (Chin, 2010; Chin, 1998; Fornell & Larcker, 1981). The second method is through the use of the cross-loadings value. By means of cross-loadings, the focus is on the loadings of each indicator. The loadings of an indicator on its assigned latent variable should be higher than its loadings on all other latent variables. Both these requirements for discriminant validity were met successfully. Details of the results of cross-loading are exhibited in Appendix V.

Table 4.4

Discriminants Validity of Constructs (Fornell-Larcker Criterion)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	**0.853**																			
2	0.445	**0.776**																		
3	-0.254	-0.179	**0.773**																	
4	-0.329	-0.147	0.461	**0.708**																
5	0.580	0.561	-0.311	-0.165	**0.895**															
6	0.256	0.124	0.320	0.171	0.275	**0.858**														
7	0.518	0.638	-0.304	-0.208	0.772	0.199	**0.858**													
8	0.259	0.125	0.269	0.017	0.149	0.651	0.131	**0.851**												
9	0.222	0.100	0.252	0.126	0.210	0.603	0.066	0.636	**0.831**											
10	0.393	0.455	-0.180	-0.014	0.691	0.325	0.584	0.243	0.321	**0.735**										
11	0.211	0.125	0.215	0.005	0.164	0.561	0.207	0.801	0.631	0.272	**0.885**									
12	0.212	0.162	0.268	0.155	0.309	0.812	0.176	0.546	0.636	0.391	0.413	**0.772**								
13	0.308	0.170	0.208	-0.107	0.243	0.619	0.183	0.781	0.639	0.328	0.823	0.488	**0.899**							
14	0.727	0.496	-0.353	-0.448	0.664	0.252	0.646	0.260	0.124	0.536	0.279	0.139	0.336	**0.873**						
15	0.780	0.517	-0.419	-0.364	0.711	0.174	0.704	0.210	0.154	0.612	0.264	0.157	0.267	0.847	**0.842**					
16	0.335	0.406	0.004	0.110	0.453	0.434	0.554	0.251	0.112	0.441	0.152	0.392	0.200	0.305	0.333	**0.749**				
17	0.582	0.480	-0.275	-0.211	0.772	0.230	0.725	0.193	0.149	0.665	0.146	0.276	0.165	0.606	0.677	0.523	**0.839**			
18	0.474	0.467	-0.265	-0.200	0.796	0.192	0.679	0.168	0.144	0.658	0.171	0.234	0.150	0.604	0.610	0.486	0.776	**0.839**		
19	0.328	0.532	-0.082	0.035	0.518	0.489	0.413	0.313	0.332	0.557	0.250	0.491	0.341	0.462	0.368	0.553	0.533	0.429	**0.735**	
20	0.495	0.421	-0.289	-0.160	0.760	0.120	0.636	0.104	0.115	0.603	0.104	0.143	0.161	0.567	0.602	0.325	0.706	0.724	0.332	**0.844**

Note: [1] CAPCHANGE, [2] CUSTINV, [3] ED, [4] EH, [5] EMPINV, [6] FIN, [7] FLOW, [8] HVAT, [9] IEPT, [10] JIT, [11] LVAT, [12] NONFIN, [13] PD, [14] PRODEV, [15] PROEFF, [16] PULL, [17] SETUP, [18] SPC, [19] SUPP, [20] TPM

4.6 Assessment of PLS-SEM Structural Model

After analyzing the validity of the measurement model, the next step in a PLS-SEM analysis is to create a structural model, this is done by analyzing the inner model. Given an adequate measurement model, the hypotheses could be tested by examining the structural model. Mediation studies using PLS-SEM consist of several alternative approaches, and, for the purpose of this research, the researcher chose the bootstrapping approach. The research framework for this structural model consisted of five variables – external environmental factors; mediating variables, which were lean manufacturing, strategic flexibility and manufacturing technology; and manufacturing performance.

4.6.1 Assessment of Significance and Relevance of the Structural Model Relationships.

After running the PLS-SEM algorithm, estimates were obtained for the structural model relationship through path coefficients, which represented the hypothesized relationship among the constructs.

4.6.2 External Environmental Factors and Manufacturing Performance.

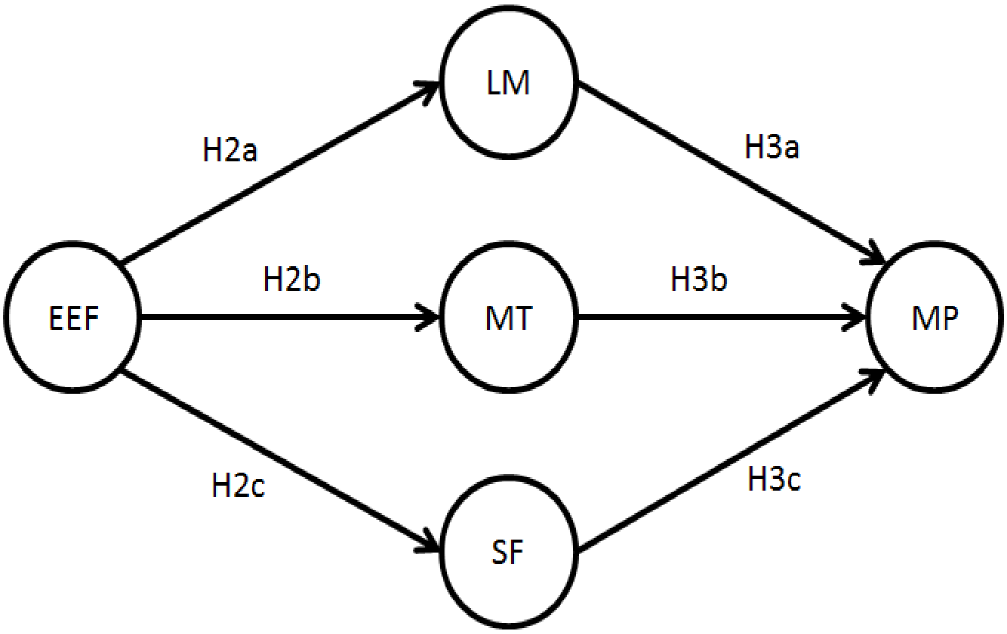
Even though the establishment of the direct link between manufacturing performance (MP) and external environmental factor (EEF) was not required by this method, the link was statistically tested to answer the first research question and its related hypothesis. The first hypothesis stated that a lower level of EEF will positively impact manufacturing performance (MP). The results indicate that the lower level of EEF significantly and positively impacts MP at $p<0.05$.

4.6.3 Mediation impact of Manufacturing Strategies on EEF and MP

Most researchers took either one onf the two most used mediation analysis techniques which are the traditional Baron and Kenny (1986) and another one will be bootstrapping method. The first one is the method made prominent by Baron and Kenny (1986). This approach takes into account the determination of every path between several variables. The mediation effect estimation requires the estimation of each of these paths. When certain statistical criterion are met, the ascertained variables are regarded as mediators. This approach requires a significant reduction of impact of the independent variable on the dependent variable (often labelled as path c) with the introduction of mediator/s. However, this approach has been heavily criticized on multiple grounds. Simulation studies using this method have shown that this approach to mediation study exhibits the lowest power (Fritz & MacKinnon, 2007; Mackinnon, Harrison, Chow & Wu, 2003). Perhaps the most highlighted flaw is the fact that this approach is least likely to detect the impact of the introduced mediator on path 'c' when compared with other available methods for mediation testing. Another criticism of this approach is that it does not quantify the effect being tested. Instead, inference is made on the existence of the intervening effect by looking at the significant criterion of paths between the independent variable and the dependent variable.

Logically the indirect effect exists if these paths are not zero. However, pertinently, traditional social sciences bases decisions and claims on the test of quantities, in which the indirect effect is quantified as the product of its constituent paths (Hayes, 2009). Based on this argument, the researcher took a modern, newer approach to mediation analysis, which is bootstrapping. Bootstrapping is able to generate an empirical representation of the sampling distribution of the individual effect. Bootstrapping is the preferable method due to the sample size of study being small (<100) compared to Barron and Kenny(1986) method, the latter requiring a larger sample size. Upon completion, the indirect effect is estimated and used to generate the confidence interval (CI). Simulation studies have shown that bootstrapping is one of the more valid and powerful methods in testing the mediation effect (MacKinnon, Lockwood & Williams, 2004; Williams & MacKinnon, 2008). Unlike Sobel, it does not require the assumption of normality, and, thus, remains consistent with the approach of the PLS-SEM method. One obvious difference in this approach when compared to the recognized Baron and Kenny causal approach is how path 'c' need not be detectable to prove the mediation effect.

Therefore, for the purpose of this study, the bootstrapping procedure with J = 5000 and n=85 was employed. Based on the outcome of bootstrapping, several 95% confidence intervals (CI) were constructed. There are six hypothesized paths of latent variables displayed in this model as depicted in Figure 4.2 below.



Note: EEF= external environmental factor, MT =manufacturing technology, LM=lean manufacturing, SF =strategic flexibility, MP = manufacturing performance

Figure 4 .1

The Hypothesized Research Model

This section answers the second and third research questions of this study, which probed the impact of EEF on the implementation of manufacturing strategies, such as LM, MT and SF, and, consequently, the impact of these three implemented strategies on MP. The postulated hypotheses for this research question were individually postulated as follows:

4.6.3.1 Mediation impact of LM on EEF and MP

The first part of hypothesis 2 (H2a) postulated that a lower level of EEF will negatively impact LM implementation among these manufacturers. This means that in a business environment that consists of a high level of dynamism and hostility, manufacturers tend to adopt lean more in order to cope with the environmental threats compared to manufacturers in a more stable environment. Such a relationship has previously been suggested by lean researchers (such as Shah & Ward, 2007; Agus & Hajinoor, 2012; Pham & Thomas, 2012), who consistently insisted that in the circumstances of growing competition, increased uncertainty, hostility and depleting resources, lean manufacturing has been chosen by various manufacturers as the solution for dealing with such threats.

This part was then followed by hypothesis 3 (H3a), which postulated that a higher level of LM implementation will positively impact MP. This hypothesis proposes that Malaysian manufacturers that implement elevated LM will achieve superior performance. Various researchers have pointed out that if an organization ignores LM strategy, the company would not stand a chance against the current global competition for higher quality, faster delivery and lower costs, thus, ultimately, suffering from diminished performance (Srinivasaraghavan & Allada, 2006; Nordin *et al.*, 2010). The results are as exhibited in the Figure 4.2 below.

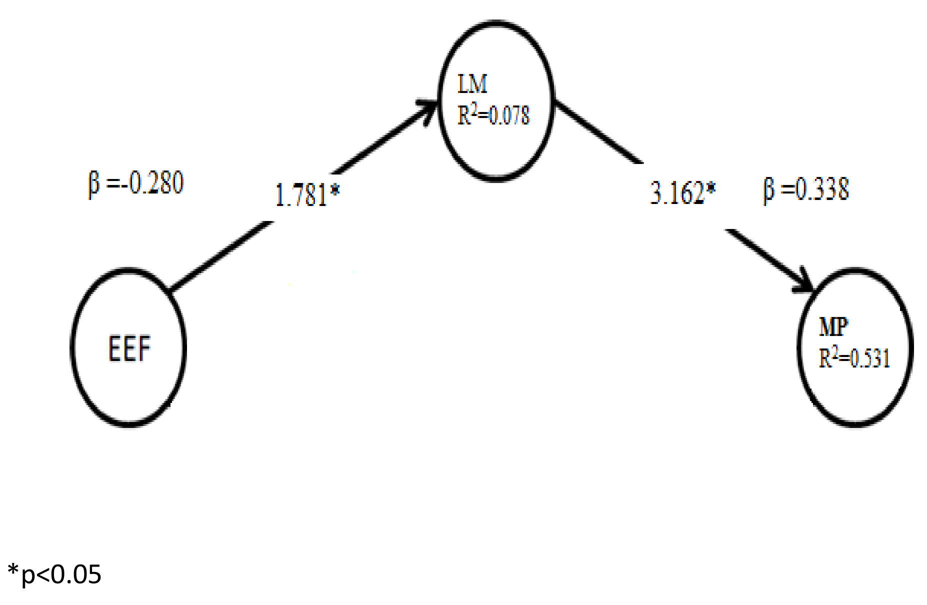


Figure 4.2
Analysis of Outcome of Hypotheses H2a and H3a

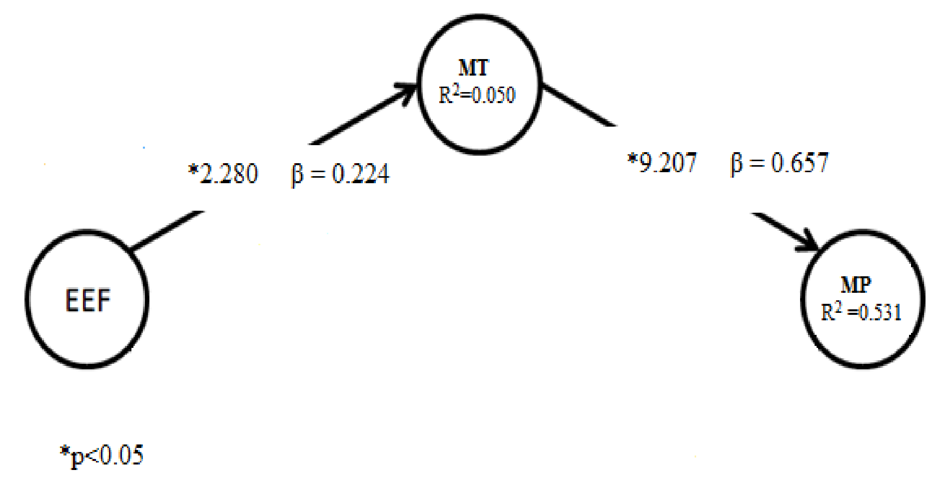
The results show that for the first portion of the model, which demonstrates that the relationship between EEF-LM, at $p<0.05$, t value = 1.781, the relationship is significant. From the R^2 value, almost 8% of the variance in LM implementation was accounted for by EEF dimensions. This result was in tandem with previous researchers where in a more stable environment, adoption and implementation of LM become less compared to environment with higher level of dynamism and hostility. Katayama and Bennett (1996), as well as Hallgren and Olhager (2009) identified competitive pressure as the driver for a lean production response through cost reductions and facilitation of price competition to expand market share. However, implementation of lean manufacturing is complicated and not without multifaceted challenges. From the perspective of this research, the findings clearly corroborated and are in tandem with the previously mentioned studies. LM focuses on increasing the operation efficiency of manufacturers, through the lessening of cost, elimination of waste and ensuring that the process flow incorporates value added activities that customers are willing to pay for. In an operating environment that surrounds manufacturers with the demand for better quality and cheaper shelf price, they would favor a proven manufacturing strategy that gives them maximum operation benefits in order to stay in competition within their niche industries. Nevertheless, lean has become one of the stratagems in handling the peril of external environmental factors. In addition, it provides a structured system to handle the stressors while complementing and utilizing the firms existing resources in order to increase the capability of the manufacturers to meet various business demands.

After establishing the relationship between EEF and LM, the next analysis was done to establish if there is a significant relationship between the LM and MP. The PLS-SEM analysis results show that for hypothesis 3 (H3a), which was between LM and MP, at $p < 0.05$, t value = 3.163, the relationship was significant. The first step of proving a relationship between LM and MP was met. This outcome confirmed that an increase in LM practice by Malaysian manufacturers will result in increased performance. This result is in tandem with previous researchers where in order to stay competitive, companies attempt to improve their manufacturing operations via lean manufacturing. LM improves overall operations and customer satisfaction (Taj, 2008; Singh *et al.,* 2010). Narasimhan *et al.* (2006) empirically investigated leanness and found that lean performers are better in terms of performance.

4.6.3.2 Mediation impact of MT on EEF and MP

For the second tested mediator (H2b), it was hypothesized that a lower level of EEF will negatively impact MT implementation among lean manufacturers. This hypothesis suggests that the MT implementation level is higher when manufacturers are faced with a higher level of dynamism and hostility in their environment. In an environment where there is a high degree of external factors, i.e. dynamism and hostility, it will inevitably warrant companies considering implementing manufacturing technology to cope with any external perils that threaten their performance (Bucher *et al.*, 2005; Narayan, 2001).

The next hypothesis to be tested was H3b, which postulated that MT positively impacts MP. This hypothesis proposes that higher MT implementation will result in an increase in manufacturing performance.



Note: EEF= external environmental factor, MT =manufacturing technology, MP = manufacturing performance

Figure 4.3
Analysis of Outcome of Hypotheses H2b and H3b

For the second postulated section, the postulated relationship between EEF and MT, the relationship was also significant. The first step of proving a relationship between EEF and MT was met. From the R^2 value, 5% of the variance in manufacturing technology was accounted for by external environmental factor dimensions. However, the direction of the relationship was the opposite from the postulated hypothesis. The results from the PLS-SEM showed that a lower level of EEF positively affects the MT implementation level. This means that the Malaysian lean manufacturers in this study tend to implement more MT in an environment that is more stable. The supposition that contextual factors, i.e. environmental and technology, might be the complementary tools that could affect the success or failure of this manufacturing practice was relatively common (Shah & Ward, 2003; Lewis, 2000). Such a phenomenon is not unknown and is paramount to MT. A similar result was observed for previous researchers in which in a more stable environment, the adoption and implementation of manufacturing technology by manufacturers was higher when compared to companies operating in higher level of dynamism and hostility environment. Even though the use of manufacturing technology in modern production systems is unavoidable, some authors (Ghani, Jayabalan & Sugumar, 2002) have shown that only modest benefits can be accrued from such huge investment. Perhaps due to this concern, most firms that intended to invest in technology prefer to do so in a more stable environment. This view was also supported by Agrawal and Hurriyet (2004) who stressed that uncertainties with regards to environmental factors shaped the debates on whether to invest more in expensive manufacturing technologies or other ‘cheaper’ tools such as human resources.

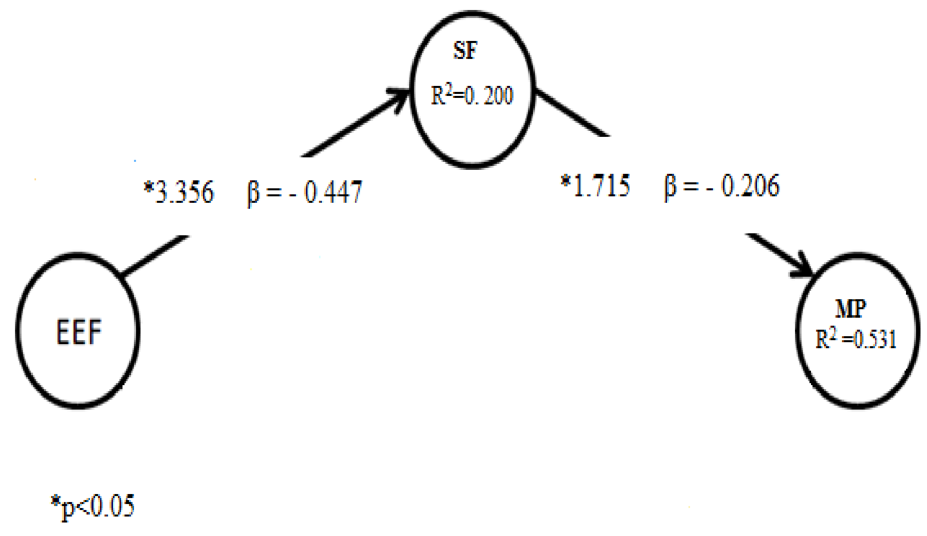
Manufacturing technology is basically a mode of strategy composed from the strategic decisions and actions, required by manufacturers. The acquisition of appropriate manufacturing technologies to facilitate the manufacture of products is of primary importance in enabling a competitive advantage to be gained (Burcher *et al*., 2005; Narayan, 2001; Phaal *et al.*, 2001).

As for the relationship between MT to MP, at $p < 0.05$, t value = 1.715, the relationship was significant. The first step of describing the relationship between MT and MP was also met. This result indicates that an increase in the implementation of MT technology will subsequently increase the MP of these lean implementers. This finding complements the work of previous researchers concerning the impact of technology and performance. Previous researchers, such as Raymond (2005), showed how the implementation of manufacturing technology, such as CAD/CAM, EDI, FMS, MRP and others, aids manufacturers in increasing productivity, quality flexibility and reduces cost. Singh and Khamba (2010) also described how MT utilization contributed significantly toward the realization of strategic manufacturing performance outcomes, which was also supported by the work of such scholars as Swamidass and Nair (2004), Liu and Yang (2008), as well as Jabar and Soosay (2010), among others.

4.6.3.3 Mediation impact of SF on EEF and MP

As for the third mediator tested (H2c), it was hypothesized that a lower level of EEF will negatively impact SF implementation among the surveyed manufacturers. This hypothesis suggested that SF implementation by manufacturers was higher when pushed on by a higher level of hostility and dynamism in its operating environment. Cadogan *et al.* (2012), and Lloréns-Montes (2004) both argued that SF is crucial to companies in the presence of a highly unstable environment and turbulence and that it is used as a coping mechanism by various companies to handle frequent changes and variations in demand.

Finally, the last postulated hypothesis (H3c) was that the increase of SF implementation would result in higher MP. Previous researchers (such as Hallgren & Olhager, 2009; Rose *et al.*, 2008; D'Souza & William, 2000) suggested that SF build up will increase the performance of companies. This hypothesis suggested that the higher the organization's capability to quickly commit and respond (on the strategic level) to changes in capacity, product development and its own process efficiency, the better off they will be in terms of nonfinancial and financial performance.



Note: EEF= external environmental factor, SF = strategic flexibility, MP = manufacturing performance

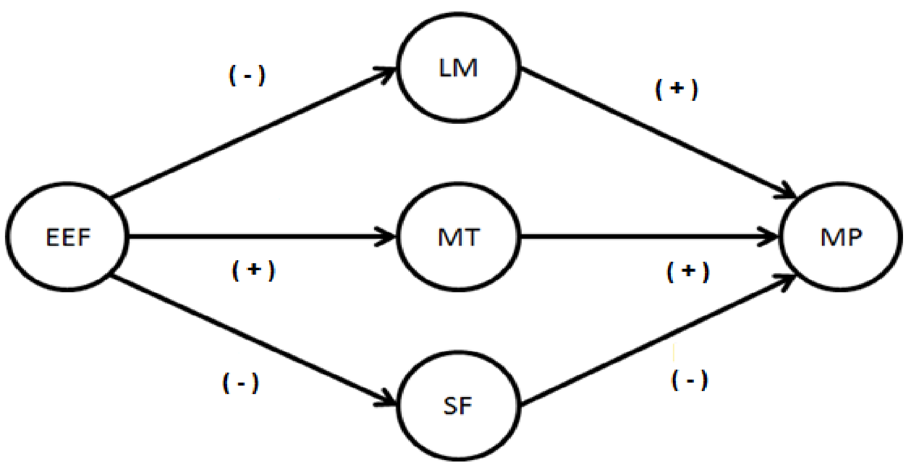
Figure 4. 4
Analysis Outcome of Hypotheses H2c and H3c.

The third mediator tested was SF, which is presented in Figure 4.6 above. The PLS-SEM results show that at $p<0.05$, t value = 3.354, EEF significantly impacts SF. From the R^2 value, almost 20% of the variance in SF was accounted for by EEF dimensions. This result is in tandem with previous researchers who found that in a more stable environment the need for the adoption and implementation of SF is less crucial when compared to higher dynamism and hostile surroundings. This result mirrors previous work by earlier researchers on SF. Cadogan *et al.* (2012) reported how in a turbulent and highly unstable environment, SF becomes crucial for exporting firms. To survive in such an environment, firms must introduce new products and process manufacturing technology faster (Nerkar & Roberts, 2004; Cottrell & Nault, 2004), developed complex schemas that promote strategic flexibility (Nadkarni & Narayanan, 2007). Lloréns-Montes (2004) also stated that an efficiently flexible organization is an organization that manages to adapt to the environmental changes and needs.

The next and last part of this analysis was for hypothesis H3c, which postulated that increasing SF would boost MP. The PLS-SEM results show that at $p<0.05$, t value = 9.2078, SF significantly affected MP. The first step of proving a relationship between SF and MP was also met. However the direction of the relationship was the opposite from the postulated hypothesis. The outcome of the analysis shows that SF negatively impacts MP. This means that lean manufacturers in this study deemed that increasing SF in their plants will reduce their performance. In the context of this research, SF was operationalized as the manufacturer's abilities to facilitate a change in capacity, process efficiency and product development capability. In view of these three capabilities, this research measured the ability of manufacturers to quickly and easily customize a product or service to suit an individual customer, quickly and easily reduce the variety of products available for sale and the ability to quickly and easily add a variety of products available for sale. The outcome of the results suggests that Malaysian lean manufacturers have yet to achieve the level of SF that they could view as beneficial toward their performance.

4.6.4 Determination of Mediation Impact through Confidence Interval (CI).

The summary of the results of the structural model shows the existence of a different direction of impact between the latent variables in the model. In order to corroborate and confirm the mediation effect (and eliminate suspicion of any suppressor effect) the upper and lower limit was further established based on the bootstrapping procedure.



Note : EEF = external environmental factors , LM=lean manufacturing , MT=manufacturing technology , SF= strategic flexibility , MP= manufacturing performance

All paths significant at $p<0.05$

Figure 4.5

Summary of the Results of the Hypotheses

Using the percentile bootstrapping technique, the upper level CI (BootULCI) and lower level CI (LLCI) were calculated for the determination of the indirect effect of multiple mediators in this model. This approach does not make any assumption about the shape of sampling distribution and produces better inferential test (Hayes, 2013, p.105). For CI the value of a*b (indirect effect) in the distribution of 5000 at CI 95% was used to calculate the bootstrapping using EXCEL worksheet. Indirect effect a*b data were taken from bootstrapping done using PLS-SEM software. The details are as attached in Appendix VI.

Calculation of pathways in the model resulted as follows:

Path 1 : EEF→LM→MP

BootLLCI = -0.1253 Boot ULCI= -0.0415

Path 2: EEF→MT→MP

BootLLCI = 0.1001 Boot ULCI= 0.0391

Path 3: EEF→SF→MP

BootLLCI = 0.1943 Boot ULCI= 0.1374

Based on this outcome where none of the CI straddles zero in the interval, this result affirms the existence of the impact of multiple mediation in this model in the form of LM, MT and SF, thus answering research question number 4 (RQ 4).

4.6.5 Assessment of Coefficient of Determination (R^2 value)

The next step of the analysis is the determination of R^2. The R^2 value is one of the methods that can be used to predict model accuracy in which a higher value of R^2 means a higher level of predictive accuracy. The rule of thumb for acceptable R^2 varies across different disciplines; however, R^2 value of 0.75, 0.5 and 0.25 can be respectively described as substantial, moderate and weak (Hair, Ringle & Sarstedt, 2011; Henseler, Ringle & Sinkovic, 2009).

In this study, the coefficients of the endogenous variables in the model are summarized as below:

Table 4.5
Endogenous Variable Coefficients of Determination

Latent variable Paths	t value	R^2
EEF→LM	1.781	0.08
EEF→MT	2.280	0.05
EEF→SF	3.536	0.20
LM→MP	3.163	
MT→MP	9.207	0.53
SF→MP	3.793	

From the R^2, it was found that, separately, 8% of the variance in LM, 5% of variance in MT and 20% of variance in SF, is explained by EEF. Based on the earlier mentioned rule of thumb, this value was considered weak. However, the cumulative impacts of multiple endogenous latent variables on MP show that more than 50% of the variance in MP was from LM, MT and SF, suggesting that the tested model was more than moderate in its predicting ability.

Despite the low R^2 value, all three paths are significant. The R^2 value is closely associated with the number of predictors to a particular variable, thus the more predictors a variable has, the higher the R^2 value will be. It is always ideal to have more of the variation explained. However in this research, the objective of the study was not to come up with a prediction model but rather the assessment of the impact of mediation of these three manufacturing strategies on the relationship between EEF and MP. For an outcome that is generally well understood for the population being studied, there is a higher expectation of being able to explain most of the variation. However, there are some outcome variables for wider populations that just will never be explained adequately. Therefore, it is not a matter of another variable being left out of a model, but either so many competing variables each with a tiny effect that cannot all be included or just randomness.

Manufacturing strategies, as defined and explained in Chapter 2, contain wide ranging conceptualization, and interpretation with abundant types of approach, therefore, although putting all of them into a model would indeed give better predicted values, it would be unrealistic if not impossible. If the only point of the model is for prediction, perhaps a R^2 value of more than 0.7 would be more acceptable. However, this was not the emphasis and objective of this research. The point was to see if there were any significant impacts among the variables, especially the mediation impact of manufacturing strategy. This objective was successfully met.

The low level of R^2 between EEF and MP strongly suggests that there is a high possibility of mediator existence between them, and these significant pathways prove that the mediation impact does exist. In order to gauge the strength of this relationship, further analysis was conducted to determine the effect size of each mediator on MP.

4.6.6 Effect Size

The effect size (f^2) is the complementary test to R^2, whereby changes to R^2 was observed with the omission of any selected exogenous variable from the model. The change was calculated by estimating the model twice (with and without the latent variable inclusion. The f^2 result for the model is as follows:

Table 4.6
Effect Size Calculation for the Model

Latent Variables	R^2 **included**	R^2 **excluded**	f^2
LM	0.53	0.479	0.11
MT	0.53	0.137	0.84
SF	0.53	0.512	0.04

Based on Cohen (1988), these results suggest that the effect size of SF and LM were medium and the effect size of MT on MP was the largest among the three mediators.

4.6.7 Predictive Relevance of Model

Using blindfolding technique, PLS-SEM enables the predictive relevance of a model to be measured. Model estimation will be done on every block of the estimated data. In calculating the predictive relevance, the block wise sum of the squared prediction error and the sum of the original omitted values were used. Q2 represents a measure of how well-observed values are reconstructed by the model and the parameter estimates.

$Q^2 > 0$ implies the model has predictive relevance whereas $Q^2 < 0$ represents a lack of predictive relevance. Different forms of Q^2 can be obtained depending on the form of prediction. A cross validated communality Q^2 is obtained if prediction of the data points is made by the underlying latent variable score, whereas a cross-validated redundancy Q^2 is obtained if prediction is made by those LVs that predict the block in question. One would use the cross-validated redundancy measure to examine the predictive relevance of one's theoretical/structural model (Chin, 2010). For this model, omission distance of 4 and the following formula are used:

$$Q^2 = 1 - \frac{\sum_D E_D}{\sum_D O_D}$$

The results for this model yielded a Q^2 (cross validated redundancy) value of 0.522 and Q^2 (cross validated communality) value of 0.974. The rule of thumb indicates that a cross validated redundancy $Q^2 > 0.5$ is regarded as a predictive model (Chin, 2010). The two results for Q^2 obtained from this research suggest that this is a predictive model. This finding indicates that prediction of observables or potential observables is of much greater relevance than the estimation of what are often artificial construct parameters (Geisser, 1975).

4.7 Summary of Quantitative Results

The results showed that all of the lean manufacturers that participated in this research applied manufacturing strategies, such as lean practices, manufacturing technology and strategic flexibility, in order to maintain business performance. The measurement model used in this research was statistically significant based on the factor loadings and parsimony of the models. Hypotheses testing with PLS-SEM provided empirical evidence concerning the relationship between the external environmental factors, manufacturing strategies and performance. The details of these findings are discussed in Chapter 5.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.0 Introduction

This chapter provides the summary of the findings, discussion and conclusion of the study. The general aim of this research was to have a better understanding of the impact of external environmental factors on Malaysian manufacturer performance. The study also systematically and empirically investigated the mediation effect of three different manufacturing strategies; namely, lean manufacturing, manufacturing technology and strategic flexibility. This study used a quantitative approach whereby data were collected form lean manufacturers around Peninsular Malaysia. This study also provided unprecedented evidence concerning the study of a multiple strategy implementation framework for Malaysian manufacturers.

The chapter starts with a recapitulation of the study followed by a section on the summary of the results of this research. Next is Section 5.3, which includes a discussion of the findings from this study. Subsequently, Section 5.4 presents the contributions of the study, which are divided into theoretical, methodological and practical contributions. Then, Section 5.5 covers the limitations of the study followed by Section 5.6, which presents suggestions for future research. The conclusion is then covered in Section 5.7, which summarizes the whole chapter.

5.1 Recapitulation of the study

This research approached the subject of Malaysian manufacturing performance, mitigated by manufacturing strategies in the presence of external environmental factors. Questionnaires were distributed to lean manufacturers via post and online and collected data were then analyzed using partial least squares (SmartPLS) software. The analysis was carried out based on the research framework, which was represented by manufacturing performance as the dependent variable, mediating variables that consisted of three manufacturing strategies – manufacturing technology, strategic flexibility and lean manufacturing – and the last part was the independent variable, which was external environmental factors. To recap, the study research questions were as stated below:

RQ1- Do external environmental factors have an impact on the performance of Malaysian manufacturers?

RQ2 - Do external environmental factors have an impact on the implementation of manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility?

RQ3 - Do manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility have an impact on the Malaysian manufacturing performance?

RQ4 - Do manufacturing strategies, such as manufacturing technology, lean manufacturing and strategic flexibility, mediate the relationship between external environmental factors and Malaysian manufacturing performance?

5.2 Summary of Results

Based on this research, the following conclusions can be drawn:

Firstly, this study found that external environmental factors affect the performance of Malaysian manufacturers. An increase in hostility and dynamism is found to cause a decline in manufacturing performance. The evidence corroborated the earlier findings of Lloréns-Montes (2005) as well as Germain *et al*. (2007), both of whom reported how external environmental factors, such as frequent changes in customer demand, increased complexity in customer requirements and overall uncertainty, could negatively impact the growth, output, operation and strategies of firms. Previous studies by scholars, such as Al-Amin, Jaafar and Siwar (2008) and Nambiar (2011), also emphasized how the Malaysian economy, focusing on the manufacturing sector is very sensitive to external factors, such as import price, shifting customer demand, downturn demand from trade partners and fierce competition.

Secondly, in this research, lean manufacturing was also empirically proven to mediate the relationship between dynamism and hostility toward manufacturing performance. Malaysian manufacturers choose to adopt lean when the level of dynamism and hostility increases in the business environment. Lean, in this context, was being utilized as a reactive strategy toward threatening environmental factors. Previous lean research focusing on the Malaysian manufacturing sector hardly ever associated the implementation of this strategy in relation to the hostility and dynamism faced by these manufacturers. However, Rose *et al.* (2008) did suggest that based on their research on local E&E producers, this group of Malaysian manufacturers preferred manufacturing techniques that promoted production efficiency while reducing production cost, a concept that sustained the core of lean manufacturing. This finding also uncovered an interesting fact concerning MNCs with parent companies located overseas. These manufacturers choose lean manufacturing as part of their strategy based on the alignment made by the parent companies, thus making lean part and parcel of their competitive strategy. Similarly, the automotive sector incorporated lean manufacturing as part of its long-term approach to achieve efficiency in its products and maintain its ability to operate effectively against competitors (Nordin *et al.,* 2012).

Thirdly, the research also provided an interesting observation concerning the mediating impact of manufacturing technology on the relationship between dynamism and hostility against manufacturing performance. This result suggested that Malaysian manufacturers prefer to implement manufacturing technology in a more stable environment. This concurred with the suggestion from previous research that highlighted how manufacturing technology was associated with high cost of implementation (Sabri & Jusoh, 2011), complexity of implementation (Elitan, 2012), and intricate requirements for organic structure (Rosnah, Megat Ahmad and Osman, 2004), and, thus, approached with caution as a tool to be strategically competitive.

This study also suggested empirically, how strategic flexibility mediated the relationship between external environmental factors and manufacturing performance. Lean manufacturers in this study also viewed strategic flexibility as a reactive strategy toward the level of hostility and dynamism surrounding their business. However, an interesting finding provisional to strategic flexibility, was that the complementary effect on manufacturing performance enhancement was not observed. This finding suggested that an increase in strategic flexibility implementation does not enhance the performance of lean implementers, unlike lean and manufacturing technology implementation.

Finally, this research also provided evidence that manufacturing strategies cumulatively provided the mediation impact on the relationship between the external environmental factors. The three manufacturing strategies testing complementarity suggested a mediation effect between dynamism and hostility, and the manufacturer's performance.

5.3 Discussion

In this research, the results indicated that a higher level of external environmental factors represented by dynamism and hostility causes a lower level of manufacturing performance. The performance was measured by both financial and nonfinancial measures. As anticipated, this finding was consistent with the earlier works of Nandakumar, Ghobadian and O'Regan (2010) and Kabadayi *et al.* (2007). The findings from this research further cemented the work of Swamidass and Newell (1987), who stressed that environmental factors play a significant role in firm performance. Earlier researchers, such as Ward and Duray (1997), who also studied the relationship between environmental dynamism and environmental hostility, mentioned the existence of mediators in the form of manufacturing strategy and operation strategy. In an environment perceived to be threatening to the organization and the operation of any manufacturers, the affected manufacturers would have to react swiftly in order to maintain survival and ensure future prosperity. One of the main paths taken by manufacturers was through the realignment, readjustment and rethinking of their manufacturing strategy.

5.3.1 Complementarity of Different Manufacturing Strategies

Lean as a strategy has long been recognized by prominent operation gurus and well established manufacturers, such as Toyota. Toyota's lean manufacturing was born out of troubled economic times after World War II. At one point, in 1948, Toyota's cash flow was so severely affected that its debt was eight times more than its total capital (Liker, 2004). In order to avoid bankruptcy, Toyota adopted a very strict cost cutting policy, which included staff pay cuts, the laying off more than 1,600 workers, and, eventually, the resignation of its prominent leader Kiichiro Toyoda. In the 1950s, Keiichiri's cousin Eiji Toyoda and Toyota's plant manager Taiichi Ohno started to work on reinventing manufacturing after Eiji's tour of American manufacturers. Expecting to see advanced manufacturing facilities and techniques, he was surprised to discover that mass production still dominated the US and no significant progress had happened since the 1930s. Upon returning, Eiji asked Ohno to come up with a system that was more efficient and could at least match Ford's mass production rate. Starting from the shop floor, Ohno began to apply the principles of *jidoka* and one-piece flow. Inspired by the concept of supermarkets, Ohno added the 'pull system' and included the idea of *kanban* inventory. *Jidoka* is the principle of building quality into the product. The combination of *kanban* and the 'pull system' produced the just-in-time (JIT) system. JIT is a set of principles, tools, and techniques that allowed Toyota to make and deliver products in small quantities, with a short lead time, to meet the quality requirements of the customer (Liker, 2004). The strategy became even more discernible and spread globally when the oil crisis hit in 1973, which caused global recession (Liker, 2004). Notably, lean manufacturing continued to progress, and, in the 1990s, the global business community finally realized that focusing on quality will actually reduce cost more significantly than focusing on cost itself. Based on empirical proof provided by scholars (such as Ahmad *et al*., 2003; Forrester *et al.*, 2010; Schroeder & Flynn, 2002; Salvador, Forza, Rungtusanantham & Choi, 2003), lean manufacturing undoubtedly fulfills the criteria of being a manufacturing strategy and has been deemed invaluable as it contributes positively to manufacturers performance.

However, the implementation of lean production itself is complex. The system requires additional tools and technologies (Harris & Harris, 2008; Withers, Garza-Reyes, Kumar & Rocha-Lona, 2013; Hedelind & Jackson, 2011), and implementation guidelines or implementing handbooks are not readily available for interested companies. Therefore, in trying to implement lean, companies have no knowledge about the importance of the respective complementary strategies, such as manufacturing technologies, and rely solely on the opinions of experts (Li, Gu & Liu, 2009), which might or might not work for their specific plants and operations. The importance of adding technology to the lean system cannot be avoided, as to cope better with the uncertainties and disruptions in the dynamic market environment, more intelligent and flexible manufacturing systems are needed, a huge challenge, especially for the companies in which tooling and equipment require large capital investment (Suh, De Weck, Kim & Chang, 2007; Chen *et al.*, 2010). Given the advantage of being flexible through automation, lean manufacturers should be able to respond to changes more effectively if strategic plans are properly developed ahead of their absolute need. In respect of the findings from this research, Malaysian lean manufacturers cautiously approach the addition of manufacturing technology to their lean system. In contrast, an increase in dynamism and hostility surrounding the manufacturers does not suggest an increase in the implementation of manufacturing technology in their system.

Such a suggestion could be due to several factors, such as the high cost of investment involved in order to implement manufacturing technology. Thus, such a strategic choice cannot be handled lightly as a short-term stop gap measure because it poses a risk of failure that could be detrimental to the financial well-being of manufacturers; therefore, it requires careful planning and investigation prior to application. As suggested by Morey (2008), the key to the successful introduction of automation to the lean system is choosing the right technology to be implemented in the production. The crucial aspect is the strategy of the Malaysian manufacturer in selecting and adopting suitable manufacturing technology to maximize the benefits, and to recoup the huge investment involved in its implementation.

Another factor that could explain the cautious approach by the Malaysian manufacturers toward manufacturing technology is the nature of the lean manufacturing concept itself. Lean manufacturing focuses more on labor creativity before turning to automation for a solution (Morey, 2008). The basic concept of lean is to ensure that no waste is incorporated in the production system. Thus, deciding to include manufacturing technology as part of such a system would call for not only financial justification but operational justification of whether such an addition would result in an increase in efficiency or an increase in the production process, and deciding whether the inclusion would cause a more elaborate process and thus prove wasteful. Lean manufacturers such as Toyota do incorporate automation in their production, which includes an automated *poka yoke* and flexibility enhancement machines, which could offer a faster solution to the production issue. However, such 'frugal' incorporation is justifiable when its addition increases the flexibility and escalates the ability of production to support customized products with a lower changeover cost. The lean concept also stresses high autonomy for the production line workers and that they are responsible for the processes and products that go through their stations. Thus, by including automation into the mix, higher skilled operators are needed to operate such an addition in the process line. Training is required for these operators in order for them to handle this extra responsibility, and demanding more resources and support from the manufacturers in order to produce higher skilled workers, which again raises the issue of whether additional mechanization would provide leverage for lean manufacturers to make such an attempt.

However despite the cautious approach in the implementation of manufacturing technology at their plants, Malaysian lean manufacturers have exhibited confidence in the impact of such implementation. In parallel to previous research (namely Abd. Rahman & Bennet, 2009; Raymond, 2005; Theodorou & Florou, 2008; Kotha & Swamidass, 2000; Monge, Rao, Gonzalez & Sohal, 2006) manufacturing technology has been shown to have a positive impact on enhancing the performance of manufacturers, by strengthening the structural aspect of the organization. Accordingly, Malaysian manufacturers continue to demand the latest technologies, which amounts to a staggering value of RM30 billion annually (Business Times, 2006, p.45). Most of these technologies are acquired from various countries overseas (Abd. Rahman & Bennet, 2009). Malaysia continues to remain a crucial importer of machinery equipment, and, by 2013, such investment amounted to RM35 billion (Malaysia External Trade Development Corporation (MATRADE), 2013). Such an astronomical figure indicates how despite the associated high risk and high financial obligation of investing in manufacturing technology, Malaysian manufacturers continue to use it as a strategic choice in order to continue gaining momentum in this competitive business environment.

Provisional to strategic flexibility, this study suggested that manufacturers in Malaysia tend to adopt strategic flexibility when there is a higher level of dynamism and hostility in the environment. However, interestingly, such a complementary effect was not observed due to the ensuing result, which indicated that an increase in strategic flexibility did not enhance manufacturing performance, unlike the two other two strategies.

In defining flexibility, emphasis on the level of flexibility must be considered (Gerwin, 1987). By means of definition, flexibility is the ability of any organization to react to changes surrounding their operation. The reaction could either be offensive or defensive, as shown in this research. Flexibility has always been linked to environmental uncertainty, comprising elements that include (but not limited to) agility, adaptability and robustness. The level of flexibility could be as low as operational flexibility, such as an individual production line or specific machinery, or could be as high as corporate level, which includes expansion, market penetration as well as plant capacity flexibility. Based on the studies of past researchers (Hallgren & Olhager, 2009; Rose *et al.*, 2008; D'Souza & William, 2000; Nakane & Hall, 1991; De Meyer *et al*., 1989; Swamidass & Newell, 1987), the implementation of flexibility at the strategic level always results in an increase in performance and manufacturers choose to incorporate various types of flexibility in order to remain agile and responsive to any changes in the environment. The result of this research, however, suggests otherwise. The outcome from this research implies that from the standpoint of lean manufacturers in this study, strategic flexibility could in fact negatively influence manufacturing performance. This result is clearly different from the earlier outcomes of previous research on strategic flexibility and manufacturing performance. Strategic flexibility was measured in this study through three different dimensions – change in capacity, process efficiency and product development. Closer inspection on the entity of this study was done in order to explain the relevance of such a finding. The most obvious element of the research was the fact that, demographically, 70% of respondents in this study consisted of multinational corporations (MNCs) and joint venture companies. Previous research on MNCs and joint venture companies in Malaysia revealed that these business units serve as subsidiaries to headquarters (HQ) or parent companies, located overseas. The relationship of subsidiaries to their HQ's varies among companies, but, notably, in some aspects, overlaps, such as the degree of control mechanisms put in place by the HQ. There are many types of control mechanism, one such being the control of decision making or autonomy. The degree of autonomy given to subsidiaries in respect of several aspects, such as the development of the product itself (Young & Tavares, 2004), the strategic sensitiveness of knowledge-related activities (Bartlett & Goshal, 1989; Martinez & Jarillo, 1991) and responsiveness toward a long-term strategic approach (Dekkers & Kanapathy, 2012) have long been found to be inadequate. Although these groups of manufacturers recognized the importance of proper integration in their multinationals in order to be flexible, implementing it is not as straight forward and simple. Previous research (Muslimen *et al.*, 2011; Edwards, Ahmad & Moss., 2002) on local MNCs and JVs indicated how regardless of these operating plants being located in Malaysia, major changes involving innovation and approaches to various strategic blueprints and decisions are still being coordinated, commanded and controlled by their HQs. From the perspective of these locally located companies, they are given the responsibility to manufacture goods as directed, and, most of the time, local managers are not being involved by their HQs in terms of long-term planning and decision-making. The findings from this research support the notion that local manufacturers could have focused more on the short-term perspective, and neglecting the long-term (strategic) approach at the plant level. The responsibilities of local manufacturers are confined to implementing manufacturing strategies that involve order completion and cost reduction. Local managers hardly ever have the time or opportunity to contribute to strategic planning and decision-making. The research findings concur with the previous research involving Malaysian manufacturers conducted by Dekkers and Kanapathy (2012), in which it was shown how the factual priorities of the managers of local manufacturers are more inclined toward meeting short-term goals. Emphasis was mostly on operational flexibility at the plant, based on meeting production capacity and optimizing the production lines to serve the manufacturers better in contributing toward order fulfillment and cost reduction. This could be one of the reasons why local manufacturers focus intensely on meeting customer orders instead of being actively involved in any strategic planning activities. Several other studies on Malaysian MNCs also corroborate how HQ provides support in the form of consultants (Muslimen *et al.,* 2011) while still exclusively retaining strategic decision-making and planning within the jurisdiction of the parent company (Edwards *et al.,* 2002).

Similarly, there is also the possibility that Malaysian manufacturers view new processes or products as potentially disruptive to the current established products and processes. In other words, manufacturers might consider major changes that come with the introduction of new products or processes or sources of raw material as arduous as it requires the manufacturing system to adapt to 'new' elements, which, in turn, could reduce the performance of routine operations, whilst disrupting the existing stability of 'in house' production. Such disruption could cause these manufacturers to fail to attain their objectives, such as targeted order completion, assigned production lead time, and, in due course, delay the delivery of products to the customers. This outcome is similar to that reported by Adler *et al.* (1999) in which flexibility was viewed as a trade-off for efficiency during model changeover at the Toyota plant itself, especially when the human resources involved lack the necessary knowledge and skill to handle it properly.

Another issue that might clarify this finding is the level of flexibility measured in this research and the overall focus of local lean manufacturers. While manufacturers prefer operation flexibility, strategic flexibility is the outcome of the cumulative operation level flexibility that impacts the long-term goal of the companies. Apart from being a potent tool against handling environmental challenges, strategic flexibility ensures that the manufacturers operate as optimal cost producers instead of the lowest cost producer to the market. However, as lean producers, these manufacturers might have made various changes by eliminating waste and increasing value throughout their process; again the attention being on the operation where process optimization remains as the main core target of production. Therefore, clearly the focus of locally located manufacturers remains on their ability to achieve plant level targets as lean manufacturers instead of the overall strategic goals of the global focused HQs. A similar inclination of Malaysian manufacturers toward operational flexibility in meeting customer demands was also observed in an earlier study by Anuar and Mohd Yusuff (2011), and Yusuff (2004). Hence, while implementing these required flexibility elements in their operations, as required by the HQs, local lean manufacturers in this study were unable to distinguish the positive impacts of these elements on their performance. Thus, as exhibited in the outcome of this research, such strategic level flexibility was viewed as detrimental to the overall manufacturing performance by these Malaysian lean manufacturers.

5.4 Contributions of the Study

In this section, the contributions of the study in respect of academics, policy makers and manufacturers are discussed in separate sections.

5.4.1 Theoretical Contribution for Academics

This study exhibits the importance of emphasizing the use of the contingency theory in explaining external environmental factors as well as encouraging a focus on the internal contingent of the manufacturing firms and the employment of the complementarity theory in explaining the important concept of complementing strategies in strategy-performance research. In strategy studies, the emerging practices, which include the concept of 'fit', the concept of integrated strategy and the concept of complementary, would direct strategy researchers to look into finding the combination of effective strategies that add value to each other, and, hence, stimulate overall performance. Such an approach to the concept of manufacturing strategies is more reflective of the actual practice in the industry in which a mixture of different strategies is put to use as to enable manufacturers to be more dynamic in their operational and strategic foundation.

This study also contributes to the understanding of the utilization of SEM PLS-SEM for multiple mediators testing with a limited sample. It adds to the current body of knowledge on mediation analyses by providing a deeper understanding of alternative multiple mediation testing approaches beside the more traditional and limited Baron and Kenny method. The study also highlights the robustness of SEM PLS-SEM and its ability to predict the impact of manufacturing strategies on performance.

Another theoretical contribution from this research is the support it provides concerning the theoretical relationship between the strategies and performance among manufacturers, particularly lean implementers. In using the strategic measurement of performance, this study differs from others. It also provides an extension to the existing body of knowledge concerning the strategy-performance study while utilizing the Malaysian manufacturing sector as its setting.

5.4.2 Methodological Contributions

This study provides the reliability and validity of multiple mediator testing in the context of operation and technology management. While marketing and psychology research has established its usage, the operation and technology field has rarely fielded and tested such an application of the method. During the process of conducting this research, one of the main implications is the highlighted ability of the framework in testing multiple mediators simultaneously using the structural modeling approach. As mentioned before, the single mediation model of Baron and Kenny (1986) needs reconsideration as it is no longer able to explain the more complicated relationships among business elements. By using the alternative route of multiple mediation analysis, the researcher believes that a more inclusive approach can be established to capture all the relationships and links between the various variables in any framework. Even though multiple mediation analysis is still in its infancy in the field of social sciences, particularly in strategy-performance studies, this methodology has received strong support from psychology based researchers due to its efficiency in illustrating the relationships among various tested variables.

It also provides future researchers with an extended example of the method used for testing mediators with the utilization of bootstrapping and confidence interval (CI). By using the bootstrapping method as confirmation of the mediation effect, this study allows the researcher to further investigate the quasi-paradoxical relationship, which, otherwise, would be overlooked in traditional mediation analyses. By taking this approach, any 'spurious' relationship between variables can be confirmed, when, otherwise, it would have been totally discarded as being false or considered as a suppressor of the intervening variables without much consideration. Such a view causes the dismissal of the mediation effect without further investigation concerning the relationship being tested in such research.

5.4.3 Practical Contribution

The practical contribution of this study is discussed in two different perspectives; namely, for policy makers and the direct contribution for manufacturers themselves.

5.4.3.1 Policy Makers

As mentioned before, the importance of the manufacturing sector has resulted in the inclusion of various means of support for the manufacturing sector in the 10th Malaysia Plan framework. Among the key enablers identified in the plan are competing globally in order to support economic growth. This study provides evidence concerning what constitutes workable manufacturing practices – lean approach and implementation of manufacturing technology – to achieve superior manufacturing performance, which, in turn, will spearhead growth through manufacturing output. The outcome of this study should be able to aid policy makers in establishing the foundation for the implementation and progression of every component that supports lean practices and manufacturing technology. Such a foundation can commence with the stipulation of stimuli relating to human resources, for example, through providing training scheme incentives for increasing skilled workers. Both lean manufacturing and manufacturing technology requires a specific set of skills in order to be successfully implemented.

In addition, a development allocation could also be provided to manufacturers through growth inducement policies that provide financial support for manufacturers who intend to implement these two strategies. By providing government support through such a stimulus, all manufacturers from different sectors, and, regardless of financial capability, will have better access to both. Such a policy would encourage smaller manufacturers, such as the local small and medium enterprises (SME), to look into the possibility of upgrading their manufacturing operation without the perils of the financial burden through huge investment.

5.4.3.2 Manufacturers

The impact of this study on manufacturers is more straightforward. In terms of environmental threat, manufacturers would better understand how hostility and dynamism could affect their performance and how alternatives in the form of manufacturing strategies are available for them to strategically react toward such threats while maintaining their competitiveness. By focusing on the strategic approach of lean and manufacturing technology, companies are given an insight into how these strategies could better serve the sustainable objectives of the firms for long-term superior performance.

For non-lean implementers, this study also offers them insights into the benefits that they could achieve in implementing lean in their operation. As for lean implementers, they are given an opportunity to further enhance their operation through the coupling of the existing lean manufacturing with manufacturing technology to further increase their performance. This study provides them with crucial evidence concerning what constitutes superior performance strategies and the adaptable methods that were readily available to suit their needs.

5.5 Limitations of study

The main limitation found in this research is the small number of respondents. Even though 85 respondents are deemed adequate in terms of processing using the structural equation modeling tool, it would been better to have more.

Initially, a total of 112 questionnaires were received, however, due to some being answered by human resource personnel instead of the intended respondent, more than 10% of the answered questionnaires had to be discarded, leaving only 85 questionnaires fit for analyses. Had the infringement not been captured, it could have affected the overall quality of the data and the outcome of the research. Hence, the small sample size of this study may affect the generalizability of the findings.

The second limitation is the lack of a list of lean manufacturers from any governmental or non-governmental agency. Consequently, the researcher had to call 1,246 different manufacturers listed by the FMM personally in order to construct a sampling frame, which took quite a long time. Another limitation is the subjectivity of classifying manufacturers into lean and non-lean manufacturers. In this study, the companies approached were initially asked whether they implement lean manufacturing in their plants. Based on their response, the manufacturers were then classified as either lean or non-lean implementers. This classification took the basis of lean without considering the different levels of implementation, such as newly implemented or having implemented the strategy for a long time. It is difficult to classify these types of strategy as there has never been a formal classification method for lean implementers and whether the length or duration of lean implementation is associated with manufacturer performance. Due to the limited number of lean manufacturers in Malaysia, further grouping of this type of respondents would result in an even smaller number of available respondents/companies deemed suitable for study.

The last limitation is due to the respondent profiles. The findings of this study must be cautiously interpreted due to respondents originating from only the E&E and automotive industries. Earlier, in Chapter 3, the respondents were chosen from several industries, which included the aeronautical industry, however, all the feedback received was from the electrical and electronic, and automobile based manufacturers. Thus, generalization of the findings could be limited.

Another limitation is due to the number of strategies tested in this model. Based on the available strategies for manufacturers in Malaysia, the interpretation of the model in this study is limited to the three tested strategies.

In addition, the findings of the quasi-paradoxical mediation characteristic of manufacturing technology and strategic flexibility could not be delved into further with the limited information gathered during the span of this research. Lastly, this study was cross-sectional, and, thus, a longitudinal follow up would help validate the findings obtained from this initial cross-sectional research.

The limitations noted above provide the impetus for future research. The suggestions for future research are addressed below.

5.6 Suggestions for Future Research

The results suggest that future research would be helpful to provide a deeper understanding of Malaysian manufacturing strategies and their performance in dealings with external business threats and challenges.

The results clearly indicate that there is more ground to explore and investigate in the manufacturing performance area. As it is obviously vital to the well-being of the nation's economy, manufacturing performance should remain the core of scholarly research. In terms of measuring the performance, future research should focus on the wider dimension of future measurement to ensure it will be able to capture and provide a more thorough and case sensitive measurement tool for manufacturing performance. New elements, such as innovation capability; supply chain flexibility; dynamic capability; as well as environmental indicators, such as green manufacturing, should be considered as part of the measurement of manufacturing performance in future research.

In addition, future research should also consider additional manufacturing strategies to be included as part of the research framework. While three strategies were included in this research, with the continual advancement made in the application of structural equation modeling, more complicated models could be tested in the future. Strategy studies are very complicated and can sometimes appear arbitrary, especially with a wider and deeper choice of new approaches to the concepts. Therefore, more complicated models are likely to appear soon on the horizon and require empirical proof.

Lastly, future research should also look into enlarging the scope of this study to increase the generalizability of the research outcome. Widening the area of focus to include as many manufacturers as possible will provide better and more representative data. Apart from larger industry involvement, respondents from the manufacturers should also include operation level workers that carry out and practice hands on manufacturing strategy; however, the inclusion of managerial and executives should still be included in order to ensure the strategic level data will also be captured. These two approaches will ensure a complete encapsulation of the perspective from the manufacturers. The existence of quasi-paradoxical variables further indicates that a longitudinal study would be encouraged to further investigate the nature of such relationships.

5.7 Conclusion

This study reveals the significant impact of the external business environment on the Malaysian manufacturing sector and the consequences if the manufacturers are not able to react strategically thereto. The importance of the contribution of the manufacturing sector to the Malaysia economy remains the main reason why the researcher chose to embark on this study. Based on the previous negative impact from the unsettled global economy that presented manufacturers various challenges to their operational stability, manufacturers have no choice but to figure out the best and most fitting way to protect their internal core from the effects of the external factors. It outlines the strategy-performance model for Malaysian lean manufacturers.

This research also reveals how multiple manufacturing strategies could help manufacturers to overcome and cushion the aforementioned challenges in order to stay competitive and remain profitable. However, from the perspective of manufacturers, choosing the right strategy is also crucial and contingent to the threats they face. This research model shows how important it is to decide which strategy to choose in order to protect their operation and yet remain competitive enough to be cost effective and profitable in the long-run. One thing for sure, heavy dependence on global trade is unavoidable as Malaysian manufacturers continue to expand their standings in the global market. Most previous research in the area of manufacturing took the traditional approach of choosing a 'stance' or any type of manufacturing strategy to adhere to, upon which the operation of the company would be based. Although this type of approach does work, the rigidity limits its expansion and customization, which has prevented it from being holistic enough to be embraced in totality for a long time. Due to the ever changing conditions of the external environmental factors, a rigid approach to how any firm should react to these changes would be detrimental to the company. The researcher acknowledges that while changing strategies frequently is not the answer, neither is sticking to strategies that do not work. Due to such an argument, and the wide variety of types of manufacturing, manufacturers should be able to pick and choose the strategies that best suits them. This is why the content approach to manufacturing strategy is suitable. By looking at what is actually available and best suited to its core operation requirement, manufacturers would be able to specifically customize their manufacturing strategy according to the needs and requirements of their external and internal operational needs. At the end of the day, such a choice should be to help manufacturers perform better and yield more profit irrespective of the challenges that come their way. While the government rigorously continues to establish an ideal manufacturing environment in terms of building more infrastructure in manufacturing zones around Malaysia, upgrading the transportation system, providing incentives to encourage the training of skilled workers, etc., at the end of the day, the manufacturers themselves must develop the capability to operate in a very dynamic environment and thus take charge to compete globally.

In addition, this research also disclosed the trait of lean manufacturers when it comes to complementary strategies within their operation. The literature pointed out how several implemented strategies would be complementary to each other and add value to the overall composition of the strategies used. Here, the study brought to light how lean manufacturing and manufacturing technology help mediate the impact of external challenges and increase manufacturing performance. The tested model provides a good understanding of the factors that explain manufacturing performance with high predictability value and high variance. The combination of all three manufacturing strategies managed to explained more than half of the manufacturing performance variance, thus indicating how when implemented together these three strategies can significantly affect the outcome of lean manufacturers performance.

In conclusion, the study of manufacturing strategy-manufacturing performance should continue to receive complete and substantial attention from manufacturing based researchers. In relation to the increasing global changes that provide both opportunities and threats, the study will prove to be crucial to the overall dynamics of Malaysia's economy and well-being. Given the critical impact of manufacturing performance on Malaysia's economy, it is the hope of the researcher that this study sheds some light on the enablers of high performing manufacturing systems so that future research could explore the subject more rigorously and comprehensively.

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APPENDICES:

APPENDIX 1 – Survey Cover Letter

UUM
Universiti Utara Malaysia 06010 UUM Sintok, Kedah Darul Aman, Malaysia. Tel: 604 - 928 4000

Date: 1 February 2012

Dear Sir/Madam Respondents,

Ref.: PhD Research: Mediating Impact of Manufacturing Strategies on External Environmental Factors and Manufacturing Performance.

Referring to the matter above, I would like to inform you that your esteem organization has been selected as one of the respondents for the mentioned academic research. This study is mainly to investigate the impact of external environmental factors on lean manufacturers performance. Your responses are crucial in helping us to understand on how strategies impacted lean manufacturer in handling external environmental factor.

The questionnaire will take about 15-20 minutes to complete. We would appreciate it very much if you could complete the attached questionnaire and return it to us by using the attached reply-paid envelope at your earliest possible.

Your answers to the questionnaire are **STRICTLY CONFIDENTIAL** and no individual answers can be link back to you or your organization. The information will be used for academic purposes only.

Your participation is highly anticipated and crucial to the outcome of this study. I would also like to take this opportunity to thank you in advance for your participation in this survey. If you have any question in respect to this study please do not hesitate to contact me at 012-5858064 or by email at risyawati@uum.edu.my.

Thank you very much for your time and cooperation.

Yours sincerely,

Risyawati Mohamed Ismail
PhD Student
OYA Graduate Business ,UUM
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Dr. Halim Mad Lazim

APPENDIX II - Questionnaire

PART A : MANUFACTURING PERFORMANCE

The following questions are designed to measure your firm's performance . Please circle the answer that indicates your plant performance compares to your competitors in your industry on local or global basis.

		Low end of industry				*High end of industry*
FI	Profit	1	2	3	4	5
F2	Return on assets	1	2	3	4	5
F3	Sales revenue	1	2	3	4	5
F4	Cash flow	1	2	3	4	5
F5	Operating income	1	2	3	4	5
NF1.	Market share	1	2	3	4	5
NF2.	Sales growth	1	2	3	4	5
NF3.	Number of new product launched	1	2	3	4	5
NF4.	Time-to-market launches	1	2	3	4	5
NF5.	Quality of product performance	1	2	3	4	5

PART B : LEAN MANUFACTURING PRACTICE

The following questions are designed to measure lean implementation in your firm. Please circle the answer that indicates the implementation of lean in the following practices at your plant

		Strongly Disagree				*Strongly Agree*
L1.	We are in frequent contact with our suppliers	1	2	3	4	5
L2.	We often receive visits from our suppliers	1	2	3	4	5
L3.	We seldom visit our suppliers' plants	1	2	3	4	5
L4.	We give our suppliers feedback on quality and delivery performance	1	2	3	4	5
L5.	We strive to establish a long-term relationship with our suppliers	1	2	3	4	5
L6.	Suppliers are directly involved in the new product development process	1	2	3	4	5
L7.	Our key suppliers deliver to plant on JIT basis	1	2	3	4	5
L8	We have a formal supplier certification program	1	2	3	4	5
L9.	Our suppliers are contractually committed to annual cost reductions	1	2	3	4	5
L10.	We have corporate level communication on import issues with key suppliers	1	2	3	4	5
L11.	We take active steps to reduce the number of suppliers in each category	1	2	3	4	5
L12.	Our key suppliers manage our inventory	1	2	3	4	5

		Strongly Disagree				Strongly Agree
L13.	We evaluate suppliers on the basis of total cost of bulk purchasing and not per unit price of individual purchased item	1	2	3	4	5
L14.	We are frequently in close contact with our customers	1	2	3	4	5
L15.	Our customers give us feedback on quality and delivery performance	1	2	3	4	5
L16.	Our customers seldom visit our plants	1	2	3	4	5
L17.	Our customers give us feedback on quality and delivery performance	1	2	3	4	5
L18	Our customers are actively involved in current and future product offerings	1	2	3	4	5
L19.	Our customers are directly involved in the producing of current and future product offerings	1	2	3	4	5
L20.	Our customers frequently share current and future demand information with marketing department	1	2	3	4	5
L21.	We regularly conduct customer satisfaction surveys	1	2	3	4	5
L22.	Production is "pulled" by the shipment of finished goods	1	2	3	4	5
L23.	Production at stations is "pulled" by the current demand of the next station	1	2	3	4	5
L24.	We use 'pull" production system	1	2	3	4	5
L25.	We use Kanban, squares, or containers of signals for production control	1	2	3	4	5
L26	Products are classified into groups with similar processing requirement	1	2	3	4	5

		Strongly Disagree				Strongly Agree
L27	Products are classified into groups with similar routing requirement	*1*	*2*	*3*	*4*	*5*
L28	Equipment is grouped to produce a continuous flow of families of products	*1*	*2*	*3*	*4*	*5*
L29	Families of products determine our factory layout	*1*	*2*	*3*	*4*	*5*
L30	Pace of production is directly linked to the rate of customer demand	*1*	*2*	*3*	*4*	*5*
L31	Our employees practice setups to reduce the time required	*1*	*2*	*3*	*4*	*5*
L32	We are working to lower setup times in our factory	*1*	*2*	*3*	*4*	*5*
L33	We have a low set up time of equipment in our plants	*1*	*2*	*3*	*4*	*5*
L34	Long production cycle times delay respond to customer requests	*1*	*2*	*3*	*4*	*5*
L35	Long supply lead times prevent responding quickly to customer requests	*1*	*2*	*3*	*4*	*5*
L36	Large number of equipment/processes on shop floor are currently under SPC	*1*	*2*	*3*	*4*	*5*
L37	Extensive use of statistical techniques to reduce process variances	*1*	*2*	*3*	*4*	*5*
L38	Chart showing defect rates are used as tools on shop-floor	*1*	*2*	*3*	*4*	*5*
L39	We use fishbone type diagrams to identify causes of quality problems	*1*	*2*	*3*	*4*	*5*
L40	We conduct process capability studies before product launch	*1*	*2*	*3*	*4*	*5*
L41	Shop floor employees are key to problem solving teams	*1*	*2*	*3*	*4*	*5*

		Strongly Disagree				*Strongly Agree*
L42	Shop floor employees drive suggestion programs	***1***	***2***	***3***	***4***	***5***
L43	Shop floor employees lead product/process improvement efforts	***1***	***2***	***3***	***4***	***5***
L44	Shop floor employees undergo cross functional training	***1***	***2***	***3***	***4***	***5***
L45	We dedicate a portion of every day to planned equipment maintenance related activities	***1***	***2***	***3***	***4***	***5***
L46	We maintain all our equipment regularly	***1***	***2***	***3***	***4***	***5***
L47	We maintain excellent records of all equipment maintenance related activities	***1***	***2***	***3***	***4***	***5***
L48	We post equipment maintenance records on shop floor for active sharing with employees.	***1***	***2***	***3***	***4***	***5***

PART C : STRATEGIC FLEXIBILITY

These questions are designed to gauge the level of strategic flexibility in your firm. Please circle the answer that indicates the level of flexibility for the items in your plant.

		Strongly Disagree				*Strongly Agree*
SF1.	Our firm can quickly and easily respond to changes in customer demand	*1*	*2*	*3*	*4*	*5*
SF2.	Our firm can quickly and easily expand into new regional or international markets	*1*	*2*	*3*	*4*	*5*
SF3	Our firm can quickly and easily introduce new pricing schedules in response to changes in competitors' prices	*1*	*2*	*3*	*4*	*5*
SF4.	Our firm can quickly and easily react to new product launches by competitors	*1*	*2*	*3*	*4*	*5*
SF5.	Our firm can quickly and easily adopt new technologies to produce better, products	*1*	*2*	*3*	*4*	*5*
SF6.	Our firm can quickly and easily adopt new technologies to produce faster process	*1*	*2*	*3*	*4*	*5*
SF7.	Our firm can quickly and easily adopt new technologies to produce cheaper products	*1*	*2*	*3*	*4*	*5*
SF8.	Our firm can quickly and easily switch to new suppliers to avail of lower costs, better quality or improved delivery times.	*1*	*2*	*3*	*4*	*5*
SF9	Our major suppliers can quickly and easily respond to changing production volume	*1*	*2*	*3*	*4*	*5*
SF10	Our major suppliers can quickly and easily respond to changing production variety	*1*	*2*	*3*	*4*	*5*

		Strongly Disagree				*Strongly Agree*
SF11	Our firm can quickly and easily customize a product or service to suit an individual customer	1	2	3	4	5
SF12	Our firm can quickly and easily introduce new product to customer	1	2	3	4	5
SF13	Our firm can quickly and easily reduce the variety of products available for sale	1	2	3	4	5
SF14	Our firm can quickly and easily add the variety of products available for sale	1	2	3	4	5

PART D : MANUFACTURING TECHNOLGY

These questions are designed to gauge the usage of manufacturing technology in your firm. Please circle the answer that indicates the level of implementation for the following technology in your plant

		Strongly Disagree				*Strongly Agree*
MT1	We use Local Area Network for factory in our firm	1	2	3	4	5
MT2	We use Computers used for control on Factory Floor in our firm	1	2	3	4	5
MT3	We use Local Area Network for Technical Data in our firm	1	2	3	4	5
MT4	We use Computers for Production Scheduling in our firm	1	2	3	4	5
MT5	We use Electronic Data Interchange in our firm	1	2	3	4	5
MT6	We use Material Requirement Planning (MRP) and Manufacturing Resource Planning (MRP II) systems in our firm	1	2	3	4	5
MT7	We use Intercompany Networks in our firm	1	2	3	4	5
MT8	We use Automated Drafting Technologies in our firm	1	2	3	4	5

MT9	We use Computer Aided Design (CAD) in our firm	*1*	*2*	*3*	*4*	*5*
MT10	We use Computer Aided Engineering (CAE) in our firm	*1*	*2*	*3*	*4*	*5*
MT11	We use Computer Aided Quality Control Performed on final products in our firm	*1*	*2*	*3*	*4*	*5*
MT12	We use Computer Aided Inspection Performed on incoming or in process material in our firm	*1*	*2*	*3*	*4*	*5*
MT13	We use Robots others than 'Pick and Place'in our firm	*1*	*2*	*3*	*4*	*5*
MT14	We use 'Pick and Place' Robots	*1*	*2*	*3*	*4*	*5*
MT15	We use Manufacturing Automation Protocol in our firm	*1*	*2*	*3*	*4*	*5*
MT16	We use Numerical Control(NC)/ Computerized Numerical Control (CNC) machines in our firm	*1*	*2*	*3*	*4*	*5*
MT17	We use programmable controllers in our firm	*1*	*2*	*3*	*4*	*5*
MT18	We use Computer Aided Design (CAD)/ Computer Aided Manufacturing(CAM) in our firm	*1*	*2*	*3*	*4*	*5*
MT19	We use Flexible Manufacturing System (FMS) in our firm	*1*	*2*	*3*	*4*	*5*

PART E : ENVIRONMENTAL FACTORS

The following questions are designed to assess environmental factors that surrounded your firm's operation. Please circle the appropriate answer that best describe your firm's operating environment.

PART 1 : ENVIRONMENTAL DYNAMISM

		Strongly Disagree				*Strongly Agree*
ED1	Our firm rarely changes its marketing practices to keep up with competitors	1	2	3	4	5
ED2	There is a high obsolescence rate for our products	1	2	3	4	5
ED3	Our competitors action are easily predicted	1	2	3	4	5
ED4	Our customers' demand are easily forecast	1	2	3	4	5
ED5	The rate of process technology innovation in our industry is high	1	2	3	4	5

PART 2 : ENVIRONMENTAL HOSTILITY

		Strongly Disagree				*Strongly Agree*
EH1	Our overall business environment is threatening	1	2	3	4	5
EH2	There is tough price competition in our industry	1	2	3	4	5
EH3	There is competition in product quality in our industry	1	2	3	4	5
EH4	There is scarce supply of labor in our industry	1	2	3	4	5
EH5	The market is dwindling for our product	1	2	3	4	5
EH6	There is a scarce supply of material	1	2	3	4	5
EH7	There is no government interference in our industry	1	2	3	4	5

PART F : DEMOGRAFIC INFORMATION

1. What is the main product produced by this company?

☐ Electrical ☐ Electronic ☐ Aeronautical

☐ Automotive

2. Number of full time employees in this company:

☐ <50 ☐ 51-150 ☐ 151 and more

3. Annual sales turnover (in RM)

☐ Less than RM10 millions

☐ RM10 - RM25millions ☐ More than RM25 millions

4. Types of company

☐ Multinational Corporation (MNC)

☐ Joint ventures ☐ Locally owned

5. How long have you firm been implementing lean ?

☐ Never implement ☐ < 1 year

☐ 1 -3 years ☐ More than 3 years

6. What is your position in the company?

☐ Engineers/Executives ☐ Junior Manager

☐ Middle Manager ☐ Senior Managers

7. What department are you attached to?

☐ Maintenance /Engineering ☐ Production

☐ Quality (QA/QC) ☐ Operation

☐ Others. Please state: ____________________

8. How long have you been with the company?

☐ < 1 year ☐ 1-3 years ☐ More than 3 years

9. Types of process. You can choose **more** than 1 answer.

☐ Job shop ☐ Batch

☐ Continuous flow ☐ Project

☐ Others .Please state:__________

10. Number of product produced.

☐ One ☐ Two

☐ Three and more

APPENDIX III - Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
F1	.213	85	.000	.895	85	.000
F2	.265	85	.000	.862	85	.000
F3	.231	85	.000	.884	85	.000
F4	.248	85	.000	.882	85	.000
F5	.269	85	.000	.858	85	.000
NF1	.247	85	.000	.883	85	.000
NF2	.258	85	.000	.851	85	.000
NF3	.228	85	.000	.863	85	.000
NF4	.235	85	.000	.896	85	.000
NF5	.263	85	.000	.880	85	.000
SUPP1	.227	85	.000	.882	85	.000
SUPP2	.243	85	.000	.874	85	.000
SUPP3	.170	85	.000	.902	85	.000
SUPP4	.277	85	.000	.734	85	.000
SUPP5	.278	85	.000	.735	85	.000
SUPP6	.200	85	.000	.904	85	.000
JIT1	.209	85	.000	.894	85	.000
JIT2	.230	85	.000	.887	85	.000
JIT3	.198	85	.000	.906	85	.000
JIT4	.238	85	.000	.890	85	.000
JIT5	.224	85	.000	.890	85	.000
JIT6	.184	85	.000	.901	85	.000
JIT7	.193	85	.000	.909	85	.000
CUSTINV1	.238	85	.000	.821	85	.000
CUSTINV2	.185	85	.000	.899	85	.000
CUSTINV3	.202	85	.000	.898	85	.000
CUSTINV4	.282	85	.000	.824	85	.000
CUSTINV5	.245	85	.000	.869	85	.000
CUSTINV6	.249	85	.000	.887	85	.000
CUSTINV7	.244	85	.000	.890	85	.000
CUSTINV8	.215	85	.000	.880	85	.000
PULL1	.245	85	.000	.868	85	.000
PULL2	.268	85	.000	.832	85	.000
PULL3	.219	85	.000	.871	85	.000
PULL4	.240	85	.000	.857	85	.000
FLOW1	.245	85	.000	.870	85	.000
FLOW2	.228	85	.000	.888	85	.000
FLOW3	.282	85	.000	.832	85	.000
FLOW4	.291	85	.000	.857	85	.000
FLOW5	.246	85	.000	.858	85	.000

Normality test (Continued)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	**Sig.**	Statistic	df	**Sig.**
SETUP1	.256	85	.000	.837	85	.000
SETUP2	.286	85	.000	.843	85	.000
SETUP3	.207	85	.000	.894	85	.000
SETUP4	.164	85	.000	.891	85	.000
SETUP5	.224	85	.000	.879	85	.000
SPC1	.195	85	.000	.914	85	.000
SPC2	.208	85	.000	.907	85	.000
SPC3	.204	85	.000	.889	85	.000
SPC4	.220	85	.000	.866	85	.000
SPC5	.249	85	.000	.837	85	.000
EMPINV1	.273	85	.000	.851	85	.000
EMPINV2	.337	85	.000	.798	85	.000
EMPINV3	.355	85	.000	.782	85	.000
EMPINV4	.320	85	.000	.812	85	.000
TPM1	.287	85	.000	.849	85	.000
TPM2	.255	85	.000	.823	85	.000
TPM3	.289	85	.000	.807	85	.000
TPM4	.255	85	.000	.859	85	.000
CAPCHA1	.289	85	.000	.835	85	.000
CAPCHA2	.197	85	.000	.904	85	.000
CAPCHA3	.211	85	.000	.902	85	.000
CAPCHA4	.200	85	.000	.903	85	.000
PROEFF1	.297	85	.000	.847	85	.000
PROEFF2	.246	85	.000	.856	85	.000
PROEFF3	.195	85	.000	.890	85	.000
PROEFF4	.232	85	.000	.893	85	.000
PROEFF5	.183	85	.000	.910	85	.000
PROEFF6	.182	85	.000	.910	85	.000
PRODEV1	.201	85	.000	.902	85	.000
PRODEV2	.206	85	.000	.910	85	.000
PRODEV3	.237	85	.000	.878	85	.000
PRODEV4	.206	85	.000	.909	85	.000
IEPT1	.280	85	.000	.741	85	.000
IEPT2	.254	85	.000	.814	85	.000
IEPT3	.209	85	.000	.827	85	.000
IEPT4	.259	85	.000	.785	85	.000
IEPT5	.216	85	.000	.838	85	.000
IEPT6	.225	85	.000	.812	85	.000
IEPT7	.183	85	.000	.852	85	.000
PD1	.163	85	.000	.882	85	.000
PD2	.226	85	.000	.811	85	.000

Normality test (Continued)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	**Sig.**	Statistic	df	**Sig.**
PD3	.200	85	.000	.843	85	.000
HVAT1	.195	85	.000	.853	85	.000
HVAT2	.156	85	.000	.887	85	.000
HVAT3	.182	85	.000	.891	85	.000
HVAT4	.154	85	.000	.888	85	.000
HVAT5	.157	85	.000	.889	85	.000
LVAT1	.216	85	.000	.851	85	.000
LVAT2	.203	85	.000	.835	85	.000
LVAT3	.205	85	.000	.827	85	.000
LVAT4	.185	85	.000	.890	85	.000
ED1	.183	85	.000	.908	85	.000
ED2	.204	85	.000	.903	85	.000
ED3	.243	85	.000	.892	85	.000
ED4	.201	85	.000	.898	85	.000
ED5	.249	85	.000	.876	85	.000
EH1	.279	85	.000	.850	85	.000
EH2	.284	85	.000	.838	85	.000
EH3	.284	85	.000	.836	85	.000
EH4	.201	85	.000	.903	85	.000
EH5	.261	85	.000	.865	85	.000
EH6	.224	85	.000	.887	85	.000
EH7	.194	85	.000	.903	85	.000

APPENDIX IV – Descriptive statistic and skewness test result

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error
F1	85	1	5	3.46	0.101	0.933	-0.148	0.261
F2	85	1	5	3.39	0.092	0.846	-0.122	0.261
F3	85	1	5	3.44	0.097	0.892	-0.367	0.261
F4	85	1	5	3.4	0.098	0.902	-0.092	0.261
F5	85	1	5	3.34	0.085	0.78	-0.069	0.261
NF1	85	1	5	3.45	0.098	0.906	-0.428	0.261
NF2	85	1	5	3.34	0.089	0.825	-0.583	0.261
NF3	85	1	5	3.21	0.09	0.832	-0.418	0.261
NF4	85	1	5	3.13	0.106	0.973	-0.107	0.261
NF5	85	1	5	3.45	0.115	1.064	-0.618	0.261
SUPP1	85	1	5	3.68	0.117	1.082	-0.485	0.261
SUPP2	85	1	5	3.46	0.104	0.958	-0.629	0.261
SUPP3	85	1	5	3.29	0.134	1.233	-0.272	0.261
SUPP4	85	1	5	4.25	0.09	0.83	-0.647	0.261
SUPP5	85	1	5	4.24	0.086	0.797	-0.61	0.261
SUPP6	85	1	5	3.34	0.118	1.086	-0.208	0.261
JIT1	85	1	5	3.46	0.1	0.92	-0.111	0.261
JIT2	85	1	5	3.32	0.132	1.217	-0.516	0.261
JIT3	85	1	5	3.25	0.108	0.999	-0.152	0.261
JIT4	85	1	5	3.55	0.117	1.075	-0.553	0.261
JIT5	85	1	5	3.2	0.097	0.897	0.097	0.261
JIT6	85	1	5	2.56	0.123	1.139	0.183	0.261
JIT7	85	1	5	3.24	0.121	1.12	-0.221	0.261
CUSTINV1	85	1	5	4.11	0.09	0.831	-0.839	0.261
CUSTINV2	85	1	5	3	0.145	1.336	0.031	0.261
CUSTINV3	85	1	5	3.18	0.121	1.115	-0.411	0.261
CUSTINV4	85	1	5	3.99	0.101	0.932	-0.86	0.261
CUSTINV5	85	2	5	3.78	0.098	0.905	-0.328	0.261
CUSTINV6	85	1	5	3.61	0.11	1.013	-0.488	0.261
CUSTINV7	85	1	5	3.46	0.118	1.086	-0.548	0.261
CUSTINV8	85	1	5	3.72	0.117	1.076	-0.585	0.261
PULL1	85	1	5	3.75	0.108	0.999	-0.729	0.261
PULL2	85	1	5	3.73	0.095	0.878	-0.841	0.261
PULL3	85	1	5	3.73	0.108	0.993	-0.625	0.261
PULL4	85	1	5	3.68	0.13	1.197	-0.806	0.261
FLOW1	85	1	5	3.71	0.115	1.056	-0.748	0.261
FLOW2	85	1	5	3.56	0.121	1.117	-0.585	0.261
FLOW3	85	1	5	3.73	0.116	1.073	-0.833	0.261
FLOW4	85	1	5	3.62	0.111	1.023	-0.821	0.261
FLOW5	85	1	5	3.75	0.122	1.122	-0.839	0.261

APPENDIX IV (Continued)

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error
SETUP 1	85	1	5	3.76	0.118	1.087	-0.994	0.261
SETUP 2	85	1	5	3.79	0.114	1.048	-0.961	0.261
SETUP 3	85	1	5	3.38	0.113	1.046	-0.302	0.261
SETUP 4	85	1	5	3.36	0.139	1.28	-0.37	0.261
SETUP 5	85	1	5	3.48	0.137	1.259	-0.582	0.261
SPC1	85	1	5	3.09	0.117	1.076	-0.132	0.261
SPC2	85	1	5	3.29	0.12	1.111	-0.343	0.261
SPC3	85	1	5	3.61	0.118	1.092	-0.518	0.261
SPC4	85	1	5	3.76	0.119	1.098	-0.731	0.261
SPC5	85	1	5	3.74	0.123	1.135	-0.97	0.261
EMPINV1	85	1	5	3.76	0.112	1.031	-0.911	0.261
EMPINV2	85	1	5	3.58	0.1	0.918	-0.83	0.261
EMPINV3	85	1	5	3.55	0.101	0.932	-0.951	0.261
EMPINV4	85	1	5	3.65	0.1	0.922	-0.899	0.261
TPM1	85	1	5	3.27	0.1	0.918	-0.097	0.261
TPM2	85	2	5	4.08	0.079	0.727	-0.318	0.261
TPM3	85	2	5	4.06	0.074	0.679	-0.306	0.261
TPM4	85	1	5	3.59	0.104	0.955	-0.763	0.261
CAPCHA1	85	2	5	3.95	0.085	0.785	-0.52	0.261
CAPCHA2	85	1	5	3.44	0.115	1.063	-0.345	0.261
CAPCHA3	85	1	5	3.32	0.11	1.014	-0.188	0.261
CAPCHA4	85	1	5	3.29	0.112	1.033	-0.357	0.261
PROEFF1	85	1	5	3.56	0.105	0.969	-0.87	0.261
PROEFF2	85	1	5	3.61	0.103	0.952	-0.752	0.261
PROEFF3	85	1	5	3.46	0.109	1.007	-0.387	0.261
PROEFF4	85	1	5	3.35	0.117	1.077	-0.516	0.261
PROEFF5	85	1	5	3.33	0.115	1.062	-0.211	0.261
PROEFF6	85	1	5	3.32	0.115	1.06	-0.181	0.261
PRODEV1	85	1	5	3.48	0.118	1.087	-0.381	0.261
PRODEV2	85	1	5	3.09	0.114	1.054	-0.192	0.261
PRODEV3	85	1	5	3.41	0.104	0.955	-0.582	0.261
PRODEV4	85	1	5	3.29	0.122	1.121	-0.245	0.261
IEPT1	85	1	5	3.91	0.148	1.368	-0.926	0.261
IEPT2	85	1	5	3.72	0.146	1.342	-0.919	0.261
IEPT3	85	1	5	3.72	0.143	1.315	-0.842	0.261
IEPT4	85	1	5	3.82	0.143	1.32	-0.898	0.261
IEPT5	85	1	5	3.48	0.157	1.444	-0.607	0.261
IEPT6	85	1	5	3.53	0.16	1.477	-0.706	0.261
IEPT7	85	1	5	3.49	0.151	1.394	-0.568	0.261
PD1	85	1	5	3.27	0.148	1.366	-0.334	0.261
PD2	85	1	5	3.78	0.143	1.322	-0.938	0.261

APPENDIX IV (Continued)

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error
PD3	85	1	5	3.6	0.148	1.365	-0.647	0.261
HVAT1	85	1	5	3.49	0.15	1.385	-0.593	0.261
HVAT2	85	1	5	3.27	0.148	1.366	-0.22	0.261
HVAT3	85	1	5	3.13	0.15	1.387	-0.182	0.261
HVAT4	85	1	5	3.04	0.152	1.401	-0.117	0.261
HVAT5	85	1	5	3.12	0.15	1.384	-0.05	0.261
LVAT1	85	1	5	3.39	0.16	1.473	-0.291	0.261
LVAT2	85	1	5	3.72	0.141	1.297	-0.797	0.261
LVAT3	85	1	5	3.68	0.146	1.347	-0.803	0.261
LVAT4	85	1	5	3.26	0.139	1.283	-0.224	0.261
ED1	85	1	5	3.01	0.13	1.2	-0.192	0.261
ED2	85	1	5	2.72	0.112	1.031	0.262	0.261
ED3	85	1	5	3.06	0.1	0.917	-0.024	0.261
ED4	85	1	5	3.18	0.101	0.928	-0.18	0.261
ED5	85	1	5	3.22	0.098	0.905	-0.264	0.261
EH1	85	1	5	3.11	0.103	0.951	-0.641	0.261
EH2	85	1	5	3.8	0.109	1.009	-0.907	0.261
EH3	85	1	5	3.78	0.106	0.98	-0.908	0.261
EH4	85	1	5	3.42	0.111	1.028	-0.193	0.261
EH5	85	1	5	2.88	0.116	1.074	-0.47	0.261
EH6	85	1	5	2.6	0.115	1.06	-0.115	0.261
EH7	85	1	5	2.66	0.124	1.14	0.215	0.261
CONTROL	85	1	2	1.54	0.054	0.501	-0.168	0.261
Valid N (listwise)	85							

APPENDIX V – Results of Cross loadings on constructs

	ED	EH	F	NF	FLOW	EMPINV	JIT	PULL	SETUP	SPC
ED1	**0.760**	0.467	0.120	0.045	-0.140	-0.239	-0.102	0.005	-0.186	-0.190
ED2	**0.812**	0.438	0.286	0.278	-0.262	-0.233	-0.083	0.042	-0.199	-0.181
ED3	**0.780**	0.323	0.325	0.319	-0.223	-0.205	-0.203	0.021	-0.229	-0.209
ED4	**0.739**	0.166	0.264	0.184	-0.331	-0.296	-0.180	-0.069	-0.243	-0.251
EH4	0.212	**0.700**	0.054	0.063	-0.195	-0.204	-0.058	0.133	-0.166	-0.151
EH6	0.177	**0.501**	0.192	0.175	0.212	0.298	0.228	0.143	0.276	0.283
EH7	0.491	**0.873**	0.144	0.122	-0.282	-0.248	-0.081	0.027	-0.330	-0.326
F1	0.346	0.154	**0.871**	0.672	0.070	0.175	0.216	0.316	0.164	0.161
F2	0.289	0.128	**0.881**	0.615	0.241	0.279	0.302	0.408	0.278	0.174
F3	0.209	0.087	**0.823**	0.620	0.185	0.213	0.361	0.431	0.226	0.255
F4	0.274	0.188	**0.868**	0.644	0.207	0.280	0.272	0.338	0.206	0.114
F5	0.251	0.177	**0.845**	0.622	0.154	0.237	0.246	0.369	0.107	0.118
NF1	0.251	0.139	0.682	**0.806**	0.090	0.190	0.303	0.284	0.142	0.145
NF2	0.093	0.097	0.657	**0.822**	0.132	0.133	0.236	0.339	0.096	0.104
NF3	0.284	0.229	0.591	**0.702**	0.144	0.254	0.299	0.285	0.271	0.203
NF4	0.140	0.048	0.539	**0.768**	0.183	0.329	0.387	0.249	0.309	0.231
NF5	0.269	0.090	0.654	**0.759**	0.142	0.305	0.296	0.353	0.271	0.233
FLOW1	-0.229	-0.205	0.202	0.113	**0.872**	0.668	0.439	0.537	0.612	0.585
FLOW2	-0.212	-0.135	0.126	0.112	**0.865**	0.599	0.465	0.482	0.523	0.511
FLOW3	-0.301	-0.163	0.201	0.220	**0.887**	0.705	0.567	0.494	0.701	0.658
FLOW4	-0.281	-0.170	0.158	0.216	**0.854**	0.728	0.545	0.405	0.617	0.596
FLOW5	-0.277	-0.219	0.163	0.083	**0.812**	0.602	0.481	0.462	0.646	0.553
EMPINV1	-0.238	-0.087	0.372	0.358	0.753	**0.872**	0.616	0.556	0.767	0.710
EMPINV2	-0.311	-0.231	0.258	0.266	0.670	**0.921**	0.620	0.340	0.634	0.710
EMPINV3	-0.248	-0.112	0.202	0.256	0.730	**0.920**	0.605	0.392	0.696	0.647
EMPINV4	-0.326	-0.167	0.141	0.218	0.598	**0.865**	0.532	0.315	0.659	0.677
JIT1	-0.075	0.111	0.224	0.261	0.359	0.355	**0.736**	0.358	0.387	0.282
JIT2	-0.157	0.057	0.187	0.279	0.632	0.717	**0.807**	0.425	0.633	0.620
JIT3	0.045	0.070	0.218	0.334	0.211	0.356	**0.737**	0.199	0.361	0.376
JIT4	-0.345	-0.227	0.264	0.288	0.573	0.672	**0.770**	0.388	0.710	0.681
JIT5	-0.012	-0.074	0.272	0.257	0.309	0.316	**0.695**	0.320	0.345	0.371
JIT6	-0.111	0.079	0.310	0.336	0.303	0.439	**0.655**	0.169	0.311	0.415

APPENDIX V (Continued)

	ED	EH	F	NF	FLOW	EMPINV	JIT	PULL	SETUP	SPC
PULL1	0.183	0.229	0.248	0.194	0.232	0.069	0.264	**0.628**	0.278	0.060
PULL2	0.277	0.199	0.456	0.300	0.193	0.074	0.185	**0.734**	0.175	0.101
PULL3	0.220	0.207	0.503	0.433	0.240	0.128	0.240	**0.833**	0.260	0.174
PULL4	-0.264	-0.069	0.236	0.276	0.659	0.646	0.460	**0.788**	0.588	0.674
SETUP1	-0.311	-0.123	0.198	0.231	0.732	0.745	0.566	0.577	**0.880**	0.693
SETUP2	-0.315	-0.258	0.204	0.279	0.634	0.739	0.545	0.470	**0.882**	0.656
SETUP3	-0.116	-0.215	0.305	0.282	0.588	0.704	0.643	0.386	**0.810**	0.678
SETUP4	-0.167	-0.095	0.184	0.227	0.486	0.492	0.486	0.354	**0.788**	0.553
SETUP5	-0.223	-0.181	0.053	0.125	0.568	0.506	0.544	0.376	**0.833**	0.536
SPC1	-0.145	-0.092	0.204	0.252	0.405	0.530	0.501	0.351	0.666	**0.733**
SPC2	-0.211	-0.200	0.225	0.149	0.404	0.611	0.527	0.311	0.531	**0.839**
SPC3	-0.154	-0.148	0.130	0.143	0.654	0.683	0.565	0.388	0.687	**0.868**
SPC4	-0.280	-0.233	0.163	0.260	0.698	0.765	0.595	0.482	0.701	**0.847**
SPC5	-0.303	-0.153	0.104	0.178	0.630	0.717	0.565	0.481	0.660	**0.896**
SUPP1	0.025	0.056	0.612	0.573	0.270	0.463	0.332	0.411	0.376	0.414
SUPP2	-0.044	-0.046	0.310	0.261	0.298	0.349	0.416	0.326	0.382	0.249
SUPP4	-0.170	-0.078	0.256	0.289	0.345	0.367	0.355	0.467	0.402	0.339
SUPP5	-0.111	0.026	0.387	0.350	0.373	0.393	0.414	0.549	0.452	0.322
SUPP6	0.023	0.195	0.215	0.327	0.209	0.323	0.552	0.235	0.335	0.239
CUSTINV4	-0.130	-0.028	0.153	0.199	0.434	0.462	0.264	0.330	0.407	0.392
CUSTINV5	-0.076	-0.113	0.212	0.240	0.506	0.386	0.322	0.350	0.252	0.267
CUSTINV6	0.012	-0.036	0.090	0.199	0.408	0.304	0.337	0.315	0.279	0.301
CUSTINV7	-0.299	-0.242	-0.037	-0.079	0.589	0.535	0.455	0.269	0.494	0.447
TPM1	-0.246	-0.196	0.018	-0.025	0.500	0.556	0.477	0.299	0.605	0.547
TPM4	-0.244	-0.085	0.170	0.242	0.569	0.715	0.537	0.255	0.590	0.667
HVAT1	0.162	-0.153	0.440	0.376	0.108	0.145	0.223	0.163	0.159	0.161
HVAT2	0.175	-0.089	0.503	0.395	0.179	0.223	0.266	0.203	0.240	0.242
HVAT3	0.294	0.150	0.623	0.539	0.106	0.064	0.164	0.289	0.141	0.089
HVAT4	0.377	0.141	0.659	0.510	-0.019	0.020	0.126	0.201	0.061	0.090
HVAT5	0.144	0.019	0.547	0.498	0.174	0.175	0.249	0.213	0.215	0.131

APPENDIX V (Continued)

	ED	EH	F	NF	FLOW	EMPINV	JIT	PULL	SETUP	SPC
IEPT1	0.196	0.154	0.526	0.598	0.030	0.196	0.306	0.133	0.178	0.082
IEPT2	0.045	0.114	0.434	0.493	0.003	0.187	0.316	0.028	0.122	0.085
IEPT3	0.195	0.185	0.452	0.542	-0.045	0.088	0.261	0.024	0.019	0.066
IEPT4	0.234	0.158	0.547	0.571	-0.033	0.145	0.300	0.100	0.043	0.065
IEPT5	0.269	0.030	0.530	0.559	0.099	0.203	0.245	0.109	0.137	0.172
IEPT6	0.285	0.158	0.536	0.533	0.080	0.208	0.217	0.029	0.114	0.146
IEPT7	0.197	-0.036	0.452	0.392	0.201	0.172	0.238	0.219	0.236	0.178
LVAT1	0.154	0.033	0.448	0.304	0.213	0.142	0.211	0.128	0.129	0.138
LVAT2	0.172	0.010	0.490	0.326	0.156	0.140	0.236	0.118	0.130	0.155
LVAT3	0.192	-0.020	0.527	0.416	0.156	0.180	0.293	0.125	0.099	0.129
LVAT4	0.240	-0.004	0.519	0.414	0.212	0.120	0.220	0.169	0.158	0.185
PD1	0.226	-0.040	0.572	0.434	0.179	0.149	0.196	0.219	0.145	0.091
PD2	0.118	-0.138	0.521	0.438	0.167	0.268	0.380	0.162	0.168	0.145
PD3	0.210	-0.114	0.573	0.444	0.146	0.245	0.318	0.156	0.134	0.171
PRODEV1	-0.430	-0.467	0.168	0.068	0.536	0.567	0.402	0.286	0.488	0.586
PRODEV3	-0.314	-0.357	0.195	0.132	0.558	0.599	0.459	0.251	0.566	0.533
PRODEV4	-0.182	-0.356	0.297	0.162	0.598	0.573	0.541	0.262	0.533	0.467
PROEFF1	-0.357	-0.281	0.208	0.242	0.585	0.633	0.455	0.253	0.588	0.525
PROEFF2	-0.375	-0.288	0.133	0.098	0.629	0.630	0.474	0.253	0.575	0.510
PROEFF3	-0.279	-0.290	0.105	0.123	0.600	0.596	0.514	0.291	0.597	0.526
PROEFF4	-0.239	-0.324	0.200	0.159	0.535	0.601	0.560	0.278	0.590	0.507
PROEFF5	-0.403	-0.280	0.179	0.154	0.615	0.580	0.612	0.327	0.577	0.525
PROEFF6	-0.472	-0.384	0.050	0.015	0.594	0.546	0.489	0.292	0.495	0.492
CAPCHA1	0.054	-0.142	0.315	0.316	0.153	0.284	0.191	0.243	0.296	0.233
CAPCHA2	-0.251	-0.307	0.208	0.166	0.542	0.565	0.388	0.332	0.578	0.489
CAPCHA3	-0.297	-0.287	0.181	0.052	0.539	0.519	0.328	0.260	0.497	0.390
CAPCHA4	-0.296	-0.351	0.206	0.237	0.459	0.564	0.401	0.302	0.567	0.464

APPENDIX V (Continued)

	SUPP	CUSTINV	TPM	HVAT	IEPT	LVAT	PD	PRODEV	PROEFF	CAPCHA
ED1	-0.114	-0.110	-0.210	0.079	0.073	0.087	-0.016	-0.336	-0.343	-0.326
ED2	-0.020	-0.066	-0.190	0.251	0.317	0.231	0.181	-0.370	-0.377	-0.274
ED3	0.002	-0.174	-0.305	0.254	0.213	0.172	0.239	-0.211	-0.283	-0.088
ED4	-0.132	-0.221	-0.190	0.256	0.169	0.174	0.258	-0.148	-0.283	-0.068
EH4	-0.015	-0.170	-0.235	-0.028	-0.020	-0.049	-0.214	-0.245	-0.225	-0.163
EH6	0.123	0.158	0.323	0.165	0.195	0.102	0.052	-0.039	0.062	0.008
EH7	0.011	-0.185	-0.234	-0.026	0.120	-0.006	-0.054	-0.509	-0.437	-0.398
F1	0.424	0.128	0.068	0.686	0.544	0.555	0.611	0.196	0.085	0.248
F2	0.542	0.175	0.121	0.674	0.543	0.618	0.629	0.260	0.201	0.225
F3	0.435	0.084	0.110	0.506	0.449	0.474	0.519	0.198	0.209	0.170
F4	0.368	0.112	0.116	0.442	0.458	0.385	0.475	0.212	0.140	0.258
F5	0.321	0.026	0.100	0.471	0.482	0.360	0.409	0.215	0.112	0.195
NF1	0.351	0.068	0.060	0.526	0.546	0.409	0.431	0.071	0.083	0.105
NF2	0.341	0.103	0.021	0.381	0.499	0.345	0.362	0.064	0.104	0.126
NF3	0.275	0.066	0.122	0.410	0.477	0.282	0.313	0.062	0.138	0.173
NF4	0.516	0.267	0.182	0.371	0.446	0.242	0.352	0.176	0.223	0.217
NF5	0.420	0.131	0.180	0.413	0.480	0.305	0.421	0.168	0.073	0.211
FLOW1	0.342	0.444	0.570	0.086	0.075	0.147	0.149	0.598	0.630	0.490
FLOW2	0.279	0.559	0.513	0.051	0.011	0.136	0.073	0.464	0.501	0.370
FLOW3	0.341	0.507	0.608	0.132	0.092	0.196	0.180	0.495	0.582	0.432
FLOW4	0.405	0.645	0.572	0.143	0.082	0.160	0.210	0.538	0.609	0.397
FLOW5	0.399	0.581	0.455	0.142	0.013	0.248	0.161	0.680	0.695	0.535
EMPINV1	0.516	0.512	0.629	0.175	0.307	0.157	0.237	0.600	0.634	0.596
EMPINV2	0.480	0.504	0.705	0.205	0.191	0.218	0.295	0.642	0.657	0.503
EMPINV3	0.494	0.552	0.666	0.112	0.169	0.212	0.235	0.591	0.669	0.441
EMPINV4	0.350	0.432	0.728	0.032	0.068	-0.016	0.092	0.537	0.577	0.539
JIT1	0.387	0.382	0.359	0.171	0.193	0.160	0.234	0.274	0.380	0.280
JIT2	0.513	0.520	0.592	0.056	0.203	0.177	0.203	0.483	0.574	0.375
JIT3	0.366	0.189	0.339	0.153	0.250	0.170	0.231	0.288	0.305	0.145
JIT4	0.457	0.342	0.569	0.243	0.247	0.267	0.281	0.565	0.583	0.364
JIT5	0.327	0.256	0.262	0.240	0.210	0.196	0.250	0.295	0.305	0.191
JIT6	0.340	0.207	0.397	0.263	0.350	0.224	0.267	0.330	0.427	0.294

APPENDIX V (Continued)

	SUPP	CUSTINV	TPM	HVAT	IEPT	LVAT	PD	PRODEV	PROEFF	CAPCHA
PULL1	0.342	0.213	0.022	0.080	0.008	0.095	0.090	0.068	0.048	0.105
PULL2	0.387	0.199	-0.037	0.285	0.096	0.189	0.261	0.008	-0.012	0.103
PULL3	0.431	0.199	0.042	0.321	0.137	0.212	0.257	0.084	0.118	0.198
PULL4	0.458	0.436	0.529	0.140	0.087	0.053	0.090	0.443	0.490	0.392
SETUP1	0.506	0.462	0.659	0.134	0.049	0.102	0.085	0.563	0.620	0.493
SETUP2	0.541	0.438	0.648	0.208	0.151	0.162	0.232	0.634	0.624	0.566
SETUP3	0.444	0.439	0.666	0.301	0.196	0.263	0.313	0.608	0.597	0.577
SETUP4	0.355	0.278	0.447	0.134	0.213	0.074	0.048	0.301	0.439	0.382
SETUP5	0.360	0.368	0.500	0.012	0.030	-0.015	-0.021	0.378	0.533	0.393
SPC1	0.259	0.196	0.576	0.267	0.188	0.138	0.124	0.373	0.386	0.381
SPC2	0.408	0.318	0.576	0.238	0.130	0.187	0.193	0.523	0.434	0.338
SPC3	0.320	0.432	0.629	0.113	0.057	0.139	0.118	0.550	0.541	0.396
SPC4	0.394	0.536	0.642	0.032	0.136	0.107	0.091	0.563	0.616	0.474
SPC5	0.408	0.425	0.609	0.101	0.106	0.157	0.118	0.505	0.546	0.387
SUPP1	**0.663**	0.295	0.255	0.387	0.490	0.302	0.364	0.339	0.241	0.346
SUPP2	**0.683**	0.398	0.256	0.183	0.219	0.257	0.295	0.371	0.344	0.216
SUPP4	**0.821**	0.471	0.252	0.104	0.066	0.047	0.100	0.385	0.295	0.166
SUPP5	**0.886**	0.409	0.219	0.280	0.199	0.159	0.246	0.379	0.270	0.267
SUPP6	**0.580**	0.377	0.241	0.190	0.263	0.167	0.261	0.205	0.200	0.208
CUSTINV4	0.529	**0.669**	0.282	0.163	0.147	0.202	0.222	0.362	0.327	0.271
CUSTINV5	0.337	**0.828**	0.216	0.226	0.208	0.239	0.287	0.342	0.422	0.381
CUSTINV6	0.328	**0.819**	0.245	0.114	0.091	0.070	0.099	0.284	0.335	0.324
CUSTINV7	0.425	**0.779**	0.500	-0.070	-0.091	-0.083	-0.040	0.503	0.488	0.389
TPM1	0.154	0.245	**0.813**	-0.017	-0.039	-0.051	0.049	0.522	0.482	0.406
TPM4	0.386	0.450	**0.874**	0.176	0.211	0.204	0.210	0.444	0.532	0.429
HVAT1	0.235	0.129	0.115	**0.788**	0.433	0.698	0.710	0.272	0.253	0.290
HVAT2	0.298	0.172	0.172	**0.880**	0.494	0.674	0.719	0.336	0.267	0.321
HVAT3	0.263	0.091	0.023	**0.850**	0.536	0.645	0.572	0.113	0.090	0.127
HVAT4	0.217	0.030	0.034	**0.858**	0.560	0.630	0.615	0.162	0.068	0.163
HVAT5	0.312	0.112	0.097	**0.877**	0.564	0.757	0.707	0.224	0.215	0.205

APPENDIX V (Continued)

	SUPP	CUSTINV	TPM	HVAT	IEPT	LVAT	PD	PRODEV	PROEFF	CAPCHA
IEPT1	0.393	0.119	0.088	0.364	**0.835**	0.367	0.408	0.021	0.089	0.157
IEPT2	0.295	0.072	0.116	0.404	**0.854**	0.392	0.418	0.121	0.176	0.214
IEPT3	0.254	0.082	0.026	0.381	**0.891**	0.445	0.418	0.013	0.056	0.095
IEPT4	0.274	0.072	0.079	0.390	**0.841**	0.373	0.440	0.091	0.116	0.139
IEPT5	0.226	0.080	0.147	0.655	**0.877**	0.664	0.652	0.159	0.159	0.282
IEPT6	0.211	0.015	0.134	0.640	**0.867**	0.649	0.632	0.071	0.085	0.178
IEPT7	0.300	0.147	0.056	0.731	**0.623**	0.650	0.640	0.212	0.197	0.191
LVAT1	0.165	0.111	0.035	0.702	0.473	**0.880**	0.657	0.251	0.223	0.124
LVAT2	0.216	0.097	0.088	0.713	0.604	**0.926**	0.715	0.261	0.247	0.180
LVAT3	0.236	0.021	0.109	0.665	0.594	**0.883**	0.846	0.226	0.229	0.230
LVAT4	0.263	0.216	0.133	0.758	0.554	**0.849**	0.689	0.251	0.233	0.207
PD1	0.286	0.177	0.080	0.721	0.594	0.731	**0.876**	0.227	0.155	0.190
PD2	0.337	0.164	0.196	0.577	0.546	0.702	**0.908**	0.339	0.287	0.337
PD3	0.299	0.118	0.166	0.694	0.580	0.784	**0.914**	0.346	0.285	0.312
PRODEV1	0.444	0.444	0.465	0.140	0.018	0.193	0.226	**0.861**	0.709	0.603
PRODEV3	0.386	0.386	0.514	0.235	0.167	0.209	0.264	**0.907**	0.767	0.673
PRODEV4	0.384	0.475	0.506	0.303	0.135	0.330	0.391	**0.851**	0.742	0.626
PROEFF1	0.255	0.393	0.486	0.258	0.256	0.263	0.245	0.685	**0.860**	0.701
PROEFF2	0.253	0.428	0.514	0.219	0.166	0.280	0.264	0.734	**0.903**	0.702
PROEFF3	0.308	0.451	0.532	0.285	0.142	0.301	0.301	0.727	**0.839**	0.618
PROEFF4	0.324	0.425	0.526	0.241	0.179	0.261	0.300	0.748	**0.831**	0.705
PROEFF5	0.380	0.472	0.502	0.075	0.059	0.169	0.158	0.659	**0.819**	0.592
PROEFF6	0.353	0.453	0.480	-0.036	-0.042	0.043	0.067	0.725	**0.796**	0.603
CAPCHA1	0.320	0.316	0.147	0.221	0.241	0.202	0.238	0.453	0.444	**0.706**
CAPCHA2	0.291	0.411	0.543	0.214	0.150	0.181	0.238	0.681	0.748	**0.920**
CAPCHA3	0.238	0.410	0.421	0.199	0.110	0.150	0.242	0.664	0.693	**0.877**
CAPCHA4	0.292	0.376	0.504	0.257	0.278	0.199	0.336	0.652	0.732	**0.893**

APPENDIX VI – Mediation confidence interval calculation (Bootstrapping)

Calculation Method (Hayes, 2013)

1. With n = 85 , generate a bootstrap sampling of indirect distribution a and b
2. Estimate $a*b$ in the bootstrap sample, where a and b are from #1
3. Repeat the process over and over, 5000 times
4. Sort from lowest to highest value
5. For ci% of 95% , BootLLCI = 5000 x 2.5% ; BootULCI=5000 x 97.5%
6. At CI of 95% , a normal distribution curve sorted then at point 125 (2.5%) and 4875(97.5%) out of k = 5000
7. P < 0.05 if a 95% CI does not include zero

K=5000	a1b1(LM)	a2b2(SF)	a3b3(MT)
125	-0.1253	0.1001	0.0391
4875	-0.0415	0.1943	0.1374