THE EFFECT OF LEAN MANUFACTURING ON OPERATIONS PERFORMANCE AND BUSINESS PERFORMANCE IN MANUFACTURING COMPANIES IN INDONESIA

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ABSTRACT

The purpose of this mixed methods sequential explanatory study was to understand the effect of lean manufacturing on operations performance and business performance in the context of manufacturing companies in Indonesia. In the first phase, a quantitative research was conducted to investigate the relationship among the variables. 174 large manufacturing companies were involved in the quantitative phase. Structural equation modeling (SEM) approach was applied to test all the hypotheses. The findings of the quantitative data analysis indicate that all the lean manufacturing practices are highly correlated and interdependent. The results provide evidence that lean manufacturing should be implemented holistically, because the practices are mutually supportive and complement each other. Lean manufacturing is also positively related with operations performance and business performance. More importantly, operations performance complementary mediates the relationship between lean manufacturing and business performance. A qualitative research based on a case study method was conducted in Toyota Indonesia to explain, elaborate, and triangulate the quantitative findings. The outcomes of the qualitative research are consistent and supporting the quantitative results. This study provides a deeper insight regarding the relationship between lean manufacturing, operations performance, and business performance. Therefore, this study could expand the boundary of the existing literature, and contributes to the body of knowledge related to the effect of lean manufacturing theoretically, practically, and methodologically.

Keywords: lean manufacturing, operations performance, business performance, mixed methods sequential explanatory study, Indonesia

ABSTRAK

Kajian kaedah campuran penerangan berjujukan ini adalah bertujuan untuk memahami kesan amalan pengilangan kejat terhadap prestasi operasi dan prestasi perniagaan dalam konteks syarikat pembuatan di Indonesia. Dalam fasa pertama, penyelidikan kuantitatif telah dijalankan untuk menyiasat hubungan antara pemboleh ubah. Sebanyak 174 buah syarikat pembuatan besar telah terlibat dalam fasa kuantitatif ini. Pendekatan pemodelan persamaan berstruktur (SEM) telah digunakan untuk menguji kesemua hipotesis dalam kajian ini. Penemuan analisis kuantitatif menunjukkan bahawa semua amalan pengilangan kejat adalah berhubung kait dan saling bergantungan antara satu sama lain. Dapatan kajian menunjukkan bukti yang menyokong amalan pengilangan kejat perlu diterapkan secara holistik. Hal ini kerana semua amalan tersebut saling menyokong dan melengkapi antara satu sama lain. Di samping itu, pengilangan kejat juga mempunyai hubungan yang positif dengan prestasi operasi dan prestasi perniagaan. Lebih penting lagi, prestasi operasi berperanan sebagai pemboleh ubah pengantara separa dalam hubungan antara pengilangan kejat dengan prestasi perniagaan. Suatu penyelidikan kualitatif berdasarkan kaedah kajian kes telah dijalankan di Toyota Indonesia yang bertujuan untuk memberi penerangan, menghurai dengan lebih mendalam, dan melakukan triangulasi terhadap penemuan kajian kuantitatif. Penemuan kajian kualitatif ini adalah konsisten dan menyokong dapatan kajian kuantitatif. Kajian ini memberi pemahaman yang mendalam mengenai hubungan antara pengilangan kejat, prestasi operasi, dan prestasi perniagaan. Justeru, penyelidikan ini dapat meluaskan sempadan literatur yang sedia ada dan menyumbang kepada pengetahuan berhubungan dengan kesan pengilangan kejat secara teoritikal, praktikal, dan metodologikal.

Kata kunci: pengilangan kejat, prestasi operasi, prestasi perniagaan, kaedah campuran penerangan berjujukan, Indonesia

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You are that kind of woman whom the prophet refers to. You are simply one wife too many. You are my true partner in this life. I reserve the most heartfelt thanks for you. I could not have completed my study without your love, encouragement and patience. Finally, my lovely kids; Rafifa Mumtaza Elya, Muhammad Faheem Mumtaz, and Fatimah Az-zahra Gusman, you gave your father admirably spirit and wonderful inspiration to finish this journey quickly. I love you all. To my father and mother in law, Yoserizal and Milawati, they always give me the prayer and encouragement. My thanks and gratitudes are addressed for them.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABV	Activity-based View
AMOS	Analysis of Moment Structures
AVE	Average Variance Extracted
BC Bootstrap	Bias-corrected Bootstrap
BPS	Biro Pusat Statistik (Central Bereau of Statistics)
CEV	Component Export and Vanning
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CMV	Common Methods Variance
COPQ	Cost of Poor Quality
CR	Composite Reliability
df	Degree of Freedom
EDI	Electronic Data Interchange
GDP	Gross Domestic Product
GOF	Goodness-of-Fit
ISIC	International Standard of Industrial Classification
JIT	Just-in-time
NNFI	Non-Normed Fit Index
OMDD	Operations and Management Development Division
QCC	Quality Control Circle
RBV	Resource-based View
RMSEA	Root Mean Square Error Approximation
ROI	Return on Investment
S-C-W	Stop-Call-Wait
SEM	Structural Equation Modeling
SMED	Single-Minute Exchange of Die
Sigma CT	Sigma Cycle Time
SOP	Standard Operating Procedure
SPSS	Statistical Package for the Social Science
SRMR	Standardized Root Mean Square Residual

TAM	Toyota Astra Corporation
TMC	Toyota Motor Corporation
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQM	Total Quality Management
VIF	Variance Inflation Factor
VRIN	Valuable, Rare, Inimitable, Non-substitutable
WIP	Work in Process

CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Originated from the shop floors of a Japanese auto industry, in particular, Toyota Motor Corporation (TMC) in the late 1950s to early 1960s (Monden, 1983; Ohno, 1988), lean manufacturing has recently received much attention all over the world. In its history, Papadopoulou and Özbayrak (2005) stated that the term *"lean"* was first invented by Krafcik (1988) to pronounce a production system that uses fewer resources compared to mass production system. Further, to represent the same aim, the term was again used in a seminal book *"The Machine that Changed the World"* authored by Womack, Jones, and Ross (1990).

According to Papadopoulou and Özbayrak (2005), lean manufacturing is merely an Americanized version of the Toyota Production System (TPS) or equally the Just-in-Time (JIT) manufacturing. Thanki and Thakkar (2014) stated that lean manufacturing referred to a production system pioneered by Toyota, which is branded as TPS. Similarly, Arif-Uz-Zaman and Ahsan (2014) stated that foundation of lean manufacturing is TPS, which is based on JIT. The concept and practices of lean manufacturing, TPS, and JIT are similar (Heizer & Render, 2011), and the three terms are often used interchangeably in recent literature (Taj, 2008). However, the term lean manufacturing becomes more prevalent (Russell & Taylor, 2008). Thus, it is subsequently used in the present research to cover all the related techniques and approaches.

The success of the TMC in implementing lean manufacturing attracted other Japanese manufacturers since the year 1973 as Toyota gained huge profits, since others suffered because of several losses (Monden, 1983). This encouraged other Japanese manufacturers to implement the same principles to enhance their performance. Remarkably, sparked by superiority of lean manufacturers in Japan, starting from the early 1980s, principles of lean manufacturing were actively imported by the US and European manufacturers in attempting to copy the success of its implementation in the Japanese automobile industries (Taj, 2008). Surprisingly, as written by Furlan, Dal Pont, and Vinelli (2011a), lean manufacturing has influenced meaningfully to the achievement of the US and European manufacturing companies. Even, Krafcik (1989) acknowledged that high performance depends on generating a lean manufacturing system. Hofer, Eroglu, and Hofer (2012) acknowledged lean manufacturing as a gold standard of modern operations management. Recently, lean manufacturing has proven its value far beyond its original industry; it is now applied in a wide variety of industries, not only manufacturing industries but also service industries (Boyle & Scherrer-Rathje, 2009; Furlan et al., 2011a).

Nowadays, the success of lean manufacturers in Japan, US, and Europe in becoming world-class manufacturers inspired manufacturers all over the world to adapt and emulate lean manufacturing principles. In the past three decades, experiences on lean manufacturing mainly came from developed countries such as US, UK, and Japan (Chang & Lee, 1995; Flynn, Sakakibara, & Schroeder, 1995; Huson & Nanda, 1995; Nakamura, Sakakibara, & Schroeder, 1998; Sakakibara, Flynn, Schroeder, & Morris, 1997). However, there are a significant increasing number of industries employing these principles in the developing countries, such as China (Chen & Tan, 2011; Taj & Morosan, 2011), India (Singh & Ahuja, 2014; Thanki & Thakkar, 2014), Malaysia

(Agus & Hajinoor, 2012; Nordin, Deros, & Wahab, 2010), and Indonesia (Susilawati, Tan, Bell, & Sarwar, 2011).

1.2 Manufacturing Companies in Indonesia

Indonesia, the largest archipelago in the world with more than seventeen thousand islands, is located in the Southeastern Asia; between the Indian Ocean and the Pacific Ocean. Indonesia has been well known as a country with plenty of natural resources. With its abundant natural resources, as most developing countries, in the early stage of development (i.e., before 1980), Indonesian economic was built by exploiting the primary products such as agriculture, mining, forestry, and fishery. In this stage, the role of secondary products as resulted from manufacturing sector was relatively insignificant. For example, as cited by Margono and Sharma (2006) from World Bank (2003), in the year 1960, agriculture sector contributed about 51.50% of total gross domestic products (GDP), whereas manufacturing sector was only 9.20%. Starting from 1990s, the economic structure of Indonesia changed; the policies shifted towards the manufacturing sector. Nowadays, the manufacturing sector contributes meaningfully to the Indonesian economic structure. As conveyed by BPS-Statistics Indonesia (2014a), although its contribution to the total GDP tended to decline from 2010 to 2014; compared with other sectors, manufacturing sector gave the highest contribution during that time period. Recently, in the first semester of the year 2014, it contributed 23.66%. This contribution is the greatest among all other sectors, such as agriculture (14.92%), trade, hotel and restaurant (14.52%), mining (10.97%), services (10.34%), construction (9.80%), finance and real estate (7.67%), transportation and communication (7.27%), and electricity gas, and clean water (0.85%).

Based on the data provided by BPS-Statistics Indonesia (2010), medium and large manufacturing companies in Indonesia are conquered by food and beverage (23.99%); textile, wearing apparel and leather products (22.26%); wood products, furniture and fixtures (14.86%); non-metallic mineral products (6.98%); plastic and rubber (6.73%); metal and metal product (4.70%); chemical (4.31%); and tobacco products (4.27%); besides industrial machinery, electronic, electrical equipment, instrumentation and motor vehicle (6.44%). BPS-Statistics Indonesia (2012) reported that production growth of large and medium manufacturers in Indonesia tended to increase significantly from 2001 to 2011. Based on Figure 1.1, although a negative growth was happened in 2006, a substantial growth of 5.57% was observed in the year 2007. In the subsequent years, production cultivated rapidly from 1.34% in 2009, 4.45% in 2010, and 5.56% in 2011. Subsequently, BPS-Statistics Indonesia conveyed the substantial production growth at the level of 4.12% in 2012 (BPS-Statistics Indonesia, 2013), 5.64% in 2013 (BPS-Statistics Indonesia, 2014b), and 4.74% in 2014 (BPS-Statistics Indonesia, 2015).

Although the manufacturing sector subsidized expressively to the economics of Indonesia, lack of technical efficiency (Margono & Sharma, 2006; Margono, Sharma, Sylwester, & Al-Qalawi, 2011; Prabowo & Cabanda, 2011) was highlighted as one of the major weaknesses encountered by manufacturers in Indonesia. Margono and Sharma (2006) and Margono et al. (2011) noted that enhancement in technical efficiency drove the growth of manufacturing companies positively. It is expected that lean manufacturing implementation would assist manufacturers in Indonesia to augment better technical efficiency and companies' performance.

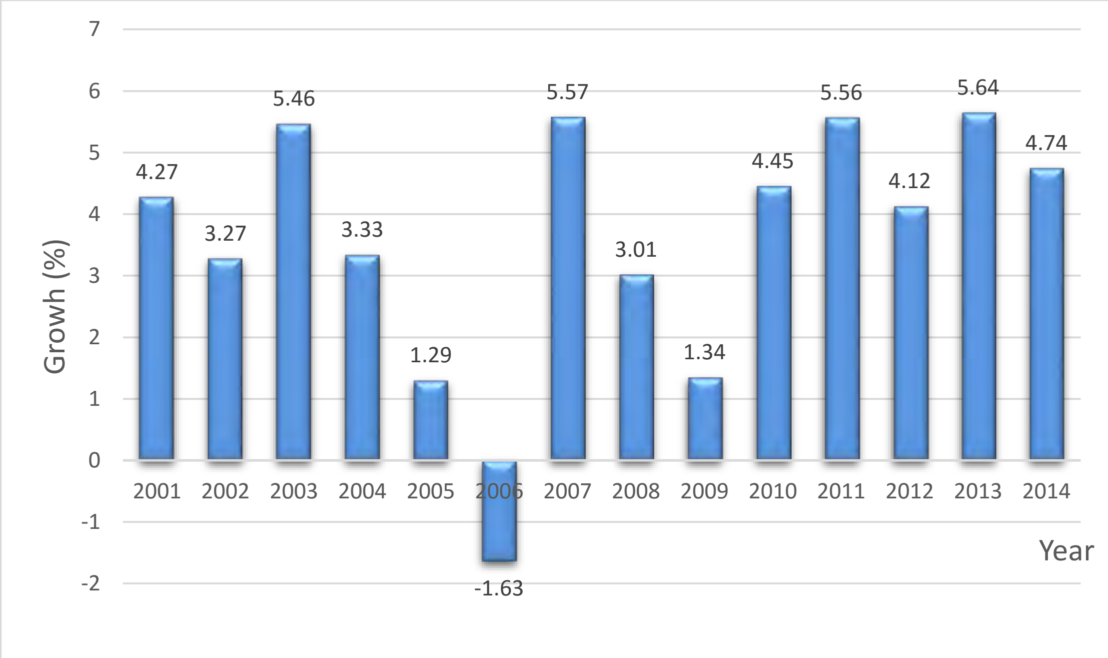

Figure 1.1
Production Growth of Large and Medium Industries in Indonesia (2001-2014)
Note. The growth from 2001 to 2011 was adapted from "Berita Resmi Statistik" by Badan Pusat Statistik, p. 2. Copyright 2012 by BPS-Statistics Indonesia. The growth from 2012 to 2014 was summarized from "Berita Resmi Statistik" by Badan Pusat Statistik, Copyright 2013, 2014, and 2015 by BPS-Statistics Indonesia.

Nowadays, at a certain level, lean manufacturing is applied in numerous manufacturers in Indonesia (Nakamura, 1999; Nugroho, 2007; Susilawati et al., 2011). However, most of the studies tend to be based on individual company's experiences (such as Fahmasari (2009), Yarsan (2009) and Rainyta (2009)), only a few studies have been conducted to investigate the level of lean manufacturing implementation involving the large number of companies. Hence, empirical studies aiming to investigate the effect of lean manufacturing on companies' performance in Indonesia are still very limited.

1.3 Problem Statement

Lean manufacturing with its practices was claimed as a powerful approach to enhance companies' performance. Nowadays, it is widely implemented in many different countries and industries (Bhamu & Sangwan, 2014; Rahman, Laosirihongthong, & Sohal, 2010). Although its power is indisputable, lean manufacturing was not beyond reproach, and its effects on performance remain much debate. Prior studies, such as Dal Pont, Furlan, and Vinelli (2008), Hallgren and Olhager (2009), Khanchanapong et al. (2014), Matsui (2007), Rahman et al. (2010), and Singh and Ahuja (2014), highlighted a positive and significant impact of lean manufacturing on operations performance. On the other hand, Kannan and Tan (2005), Nahm, Vonderembse, Rao, and Ragu-Nathan (2006), and Yang, Hong, and Modi (2011) postulated its positive effects on business performance in terms of market performance and financial performance. This remains a critical question, *"why some scholars claimed that lean manufacturing helped to improve operations performance, while others claimed that lean manufacturing improved business performance?"*

Considering the question above, an extensive literature review leads to the preliminary conclusion that the fundamental objective of lean manufacturing is to increase operations performance through waste elimination (Bartezzaghi & Turco, 1989; Chen & Tan, 2011; Singh & Ahuja, 2014). Operations performance was well defined as the performance that is influenced by operating conditions. It characterizes performance of each production resource level, and indicates internal properties of a production system (Chang & Lee, 1995; Jeyaraman & Leam, 2010). In addition, the wastes (e.g., over-production, over-processing, defects, delay, unnecessary inventory, unnecessary movements, and transportation) are more likely existed at the operations level rather than at the business level. Again, this raises a substantial question; *"if the underlying objective of lean manufacturing is to improve operations performance, how does it affect business performance?*" Meanwhile, Kannan and Tan (2005) claimed; manufacturing strategy like lean manufacturing is not only addressed to increase operations performance, but also to use the operations performance improvement to drive indicators of business performance. Nevertheless, it was evidenced that lean manufacturing practices interdependently affect operations performance, how the practices interact with one another and affect business performance (e.g., financial performance, sales, etc.) are still not well-understood. It becomes more questionable as Kaplan and Norton (1992) stated, *"the alleged linkage between operating performance and financial success is actually quite tenuous and uncertain."*

Furthermore, even though a number of studies have presented empirical evidence that lean manufacturing improved companies' performance, many of the studies considered very limited practices and performance measures (Furlan, Vinelli, & Dal Pont, 2011b). Only a few studies attempted to investigate simultaneous synergistic implications of multiple aspects of lean manufacturing on both operations performance and business performance concurrently (Bartezzaghi & Turco, 1989; Chang & Lee, 1995; Jeyaraman & Leam, 2010). In addition, lean manufacturing and performance were frequently assessed in limited subsets of measurement, instead of considering more comprehensive measures. This occasionally produced misleading information and misconceptions (Ahmad, Schroeder, & Sinha, 2003; Callen, Fader, & Krinsky, 2000; Fullerton & Wempe, 2009). The use of limited measures of manufacturing strategy and performance was also confuted by Ketokivi and Schroeder (2004) who claimed that multi-dimensional measures are more appropriate for studying practices and performance relationships.

Equally important, a number of previous studies highlighted that in order to succeed in implementing lean manufacturing; its practices should be applied holistically, because all the practices are interdependent (Dal Pont et al., 2008; Furlan et al., 2011a; Furlan et al., 2011b; Shah & Ward, 2003). In other words, adoption of one practice could be related to the adoption of other practices. On the top of that, Furlan et al. (2011a) and Furlan et al. (2011b) offered the idea of complementarity practices because of synergistic effect among lean manufacturing practices. A set of practices are complementary when implementation of one augments the marginal returns of others and vice-versa (Furlan et al., 2011a). Although its synergistic effects on companies' performance are widely believed, Dal Pont et al. (2008) and Furlan et al. (2011b) noted that most of the studies focused on the relationship between individual practices and performance rather than considering improvement resulted from implementation of a set of lean manufacturing practices. Hence, literature indicated the lack of studies on seeking simultaneous and synergistic effects of lean manufacturing on performance. Thus, in attempting to fill this gap, the present study investigates the simultaneous and synergistic effects of comprehensive practices of lean manufacturing on multi-dimensional measures of operations performance and business performance.

In addition, most of the researchers examined implications of lean manufacturing implementation in the context of developed countries such as Japan, Germany, USA, Canada, Italy, Australia, Spain, and UK. Chen and Tan (2011), Jasti and Kodali (2014), Khanchanapong et al. (2014), and Mazanai (2012) hinted that not much attention had been paid to examine the lean manufacturing-performance relationship in the developing countries. It is suspected that implementations of lean manufacturing across countries are varied. A comparative study conducted by Phan and Matsui (2010) highlighted that the lean manufacturing-performance relationship tended to be contingent on national context. In order to present more comprehensive view regarding the lean manufacturing, this study tries to identify the role of lean manufacturing practices in the context of manufacturing companies in Indonesia.

This study becomes more important because it was evidenced that one of the major problems in manufacturing sector in Indonesia was lack of technical efficiency (Margono & Sharma, 2006; Margono et al., 2011), while efficiency is one of the central objectives of a manufacturing system (Gupta, Acharya, & Patwardhan, 2013; Holweg, 2007). According to van Dijk and Szirmai (2006), technical inefficiency is related to inability of a plant to achieve maximum possible outputs from any combinations of inputs and resources. Therefore, it is closely related to poor operating condition, which is possibly one of the important sources of under-performance. Achieving the better technical efficiency may require several changes in technical aspects of operations such as methods and procedures. Lean manufacturing has a role to play here as it is addressed to eliminate non-value added activities; and at the same time, to maximize utilization of value added activities (Abdel-Razek, Elshakour, & Abdel-Hamid, 2007; Gupta et al., 2013). Hence, it potentially has an impact on the way in which firms combine resources and activities to enhance technical efficiency. Subsequently, it could improve organizational performance (Chavez, Gimenez, Fynes, Wiengarten, & Yu, 2013; Chen & Tan, 2013; Dal Pont et al., 2008; Khanchanapong et al., 2014; Rahman et al., 2010; Singh, Garg, Sharma, & Grewal, 2010b). Nowadays, there are still very limited investigations that have been accomplished to provide empirical evidence in favor of lean manufacturing implication on organizational performance. Therefore, in-depth investigations are still substantially required (Belekoukias, Garza-Reyes, & Kumar, 2014; Chavez et al., 2013; Chen & Tan, 2011; Shah & Ward, 2007).

To fill the gap of the lacking empirical evidence in favor of the effects of lean manufacturing on organizational performance, this study attempted to examine the extent of lean manufacturing implementation comprehensively by using nine practices compiled from a number of recent studies. The comprehensive practices were linked to organizational performance, which was assessed integrally in two levels of hierarchy of objectives; operations performance and business performance. Operations performance was assigned as a mediating variable on the relationship between lean manufacturing and business performance (Bartezzaghi & Turco, 1989; Chang & Lee, 1995). On eventually, the results were corroborated, explained, and triangulated qualitatively through a case study approach. This is important to reach a deeper understanding about how lean manufacturing leads to the better organizational performance.

1.4 Research Question

Based on the research background and problem statement discussed in the preceding sections, a major concern of this study is *"how does lean manufacturing lead to better organizational performance?"* To guide the author to obtain the understanding regarding the concern, the study was conducted in two phases. In the first phase (i.e., quantitative phase), the author attempted to look at statistical relationships among the variables (i.e., lean manufacturing practices, operations performance, and business performance). Accordingly, the four major research questions as below guided the first phase of the study;

1. What is the relationship between lean manufacturing and operations performance?
2. What is the relationship between lean manufacturing and business performance?
3. What is the relationship between operations performance and business performance?
4. What is the interrelationship between lean manufacturing, operations performance, and business performance?

In the second phase, the author was interested to understand deeper, explain further, and triangulate the findings of the quantitative phase in a qualitative stance. In general, the qualitative phase was guided by the following research question, *"how does lean manufacturing affect the business performance?*" This general research question was detailed into several specific research questions based on the results of the quantitative phase. The specific questions guided the author to go deeper into the phenomena under investigation.

1.5 Research Objective

The intent of this two-phase mixed methods study was to understand the impact of lean manufacturing practices on organizational performance in both quantitative and qualitative perspectives. In the first phase, in the context of manufacturing companies in Indonesia, the quantitative research was addressed to:

1. Investigate the relationship between lean manufacturing and operations performance.
2. Investigate the relationship between lean manufacturing and business performance.
3. Investigate the relationship between operations performance and business performance.
4. Examine the interrelationship between lean manufacturing, operations performance, and business performance.

Results obtained from the first phase were discovered further in the second phase (i.e., qualitative phase). In this phase, a case study method was used to probe the quantitative results through an exploration on how the lean manufacturing implementation affects the business performance. The reason for following up with qualitative stance in the second phase was to understand deeper, explain further, and triangulate the quantitative findings.

1.6 Significance of Study

Specifically, this study attempted to ascertain the linkage between the practices of lean manufacturing, operations performance and business performance. It was hoped; the study may enlarge the knowledge and theories on how lean manufacturing practices lead to organizational performance. This study tried to provide the view of integrative and holistic practices of lean manufacturing and comprehensive approach of performance measurement. Desirably, the present study also gave evidence to the importance of operations performance as a mediator between lean manufacturing and business performance. There were other studies on lean manufacturing area that have investigated the relationship between lean manufacturing and performance in various settings, which did not include the simultaneous performance measurement on both operations performance and business performance; for instance, Yang et al. (2011), Cua, McKone, and Schroeder (2001), Dal Pont et al. (2008), Kannan and Tan (2005) and so forth. Several scholars, such as Brown, Squire, and Blackmon (2007) and Ketokivi and Schroeder (2004), suggested that multi-dimensional measures were more appropriate for studying the practices-performance relationship. Moreover, by indicating the existence of significant direct and indirect effects of lean manufacturing on business performance, this study could provide clear evidence that lean employment is essential in enhancing companies' performance.

More importantly, in relation to the body of knowledge, this study hoped to contribute significantly to the body of knowledge in the process of examining implications of lean manufacturing practices by looking into the resource-based view (RBV), activity-based view (ABV), and complementarity theories. The RBV focuses on selecting the resources that can be strategically important for companies' performance and competitive advantages (Barney, 1991). However, the RBV suffered from at least three factors; they are lack of the link relating the resources and value creation (Priem & Butler, 2001), lack of the concept of activities (Sheehan & Foss, 2007), and lack of the concept of complementarity between the resources (Chan, Shaffer, & Snape, 2004). The first and second limitations would be overcome by using ABV theory, whereas the complementarity theory would overwhelm the third limitation. As a result, employing the three theories could strengthen the theoretical framework used in this current study.

This study provided a detail analysis of lean manufacturing, operations performance and business performance in manufacturing sector of Indonesia. In the context of Indonesia, very few studies have investigated the implication of lean manufacturing on companies' performance. Majority of the studies tended to be case study based on a single manufacturing company experience, such as Fahmasari (2009) and Yarsan (2009). There were only very few studies such as Nugroho (2007) and Nawanir, Othman, and Lim (2010) that have investigated the lean manufacturing implementation using the information provided from a large number of companies. Equally important, these studies did not include any consideration of the mixed methods; quantitative and qualitative, in examining the linkage between lean manufacturing, operations performance and business performance. Whereas, combining the two approaches seems to contribute significantly to the body of knowledge by reaching a much deeper understanding of the research problem. Therefore, the present study would fill the gap by assessing the linkage on both quantitative and qualitative perspectives.

From the practical perspective, this study could offer several suggestions to practitioners and managers in the area of operations management, especially lean manufacturing. Practically, utilization of the RBV, ABV and complementarity theories would strengthen the company to achieve the better performance and significant competitive advantages. Furthermore, it was hoped; the present study allowed practitioners and managers to gain deeper knowledge and understanding about lean manufacturing itself and more importantly its potential benefits that lean manufacturing can convey if implemented properly. In addition, any suggestions and ideas given through this study would help practitioners and managers in steering their companies towards being more competitive.

1.7 Scope of Study

The study emphases on investigating the linkage between lean manufacturing, operations performance, and business performance quantitatively and qualitatively. It was assumed that implementation of lean manufacturing significantly improves operations performance and subsequently leads to business performance. The contribution of all the nine lean manufacturing practices (i.e., flexible resources, cellular layouts, pull system, small lot production, quick setups, uniform production level, quality control, total productive maintenance, and supplier networks) on operations performance measures (i.e., quality, manufacturing flexibility, lead time reduction, inventory minimization, productivity, and cost reduction) and business performance measures (i.e., profitability, sales, and customer satisfaction) were investigated. In addition, the role of operations performance in mediating the relationship between lean manufacturing practices and business performance was examined. Therefore, the independent variable of the study was lean manufacturing; the mediating variable was operations performance; and the dependent variable was business performance.

Contextualized in a developing country, Indonesia, the quantitative study concerned to large manufacturing companies and discrete process industries. Large manufacturers were selected because they tended to implement lean manufacturing more frequently than do small and medium manufacturers (Fullerton & McWatters, 2001; Shah & Ward, 2003, 2007; Susilawati et al., 2011). In addition, according to Shah and Ward (2003), lean manufacturing was commonly implemented in the discrete part industries rather than continuous process industries. Therefore, respondents of the quantitative study are as follows, textiles; wearing apparel; tanning and dressing of leather; wood and products of wood except furniture and plaiting materials; machinery and equipment; electrical machinery and apparatus; radio, television and communication equipment and apparatus; medical, precision and optical instruments, watches and clocks; motor vehicles, trailers and semi-trailers; other transport equipment; and furniture.

In the qualitative phase, a case study method was held at Toyota Indonesia. This selection was because Toyota was the pioneer of lean manufacturing and had been implementing the lean manufacturing system since it was established. The study was conducted in four plants, namely stamping plant, engine production plant, component export and vanning plant, and vehicle assembly plant. The four plants were selected because of different characteristics of each plant. Thus, it may contribute to the rich and comprehensive findings.

1.8 Definition of Key Terms

To clarify the language used in the present study, the key terms were defined as follows:

Lean manufacturing

Lean manufacturing is an approach synergistically addressing to improve operations performance and business performance through waste elimination.

Lean manufacturing practices

Lean manufacturing practices are a set of integrated strategic resources used to achieve a set of goals of lean manufacturing implementation.

Operations performance

Operations performance comprises actual outputs of operations strategies employed, which is influenced by operating conditions (such as quality, manufacturing flexibility, lead time, inventory, productivity, and costs) and represents some internal properties of manufacturing system (Bartezzaghi & Turco, 1989; Chang & Lee, 1995).

Business performance

Business performance comprises actual outputs of an organization looking at an organization as a whole instead of at the operational level. Business performance may be viewed as a higher level in the hierarchy of objectives, with operations performance plays a role of mediating variable and represents the lower level (Bartezzaghi & Turco, 1989; Chang & Lee, 1995).

1.9 Organization of Research Report

This report is divided into seven chapters. The first chapter introduces the study. In the second chapter, literature reviews on lean manufacturing, operations performance and business performance are presented. In addition, inter-relationship among lean manufacturing practices, operations performance and business performance is also discussed. Based on the literature review; theoretical framework, related theories used in the study, and research hypotheses are presented in Chapter Three. Subsequently, in Chapter Four, research methodology is discussed thoroughly. This chapter includes discussion on philosophical justifications, mixed methods, and quantitative and qualitative research designs. Chapter Five presents the result of quantitative data analysis as well as its preliminary discussion. Following Chapter Five, Chapter Six thoroughly shows evidence from the qualitative study as an in depth explanation of quantitative findings. Finally, the last chapter (i.e. Chapter Seven) converses and interprets findings of both quantitative and qualitative phases. On eventually, research implication, limitation, suggestions for future research, and conclusion are presented.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The success of the Japanese and western companies in becoming world-class manufacturers with amazing performance has inspired manufacturers throughout the world to adapt and emulate lean manufacturing principles. Nowadays, it receives much attention all over the world. There is no doubt; implementation of lean manufacturing has a much deeper impact on companies' performance. This chapter reviews the existing literature with regards to overview of lean manufacturing, lean manufacturing in Indonesia, practices of lean manufacturing, organizational performance, and impact of lean manufacturing on both operations performance and business performance. Finally, the inter-relationship among the three variables are discussed thoroughly.

2.2 Lean Manufacturing Overview

There was a little confusion among academicians and practitioners in operations management regarding the terms of just-in-time (JIT), Toyota Production System (TPS), and lean manufacturing. Slack, Chambers, and Johnston (2010) revealed similarity between lean manufacturing and JIT. Schonberger (2007) stated that practices under lean manufacturing were same as JIT's. According to Heizer and Render (2011), there was a little difference between TPS, JIT and lean manufacturing in practice, as a result, the terms TPS, JIT and lean manufacturing were often used interchangeably. However, the present study strongly agrees with the postulation provided by Chavez et al. (2013) stating that lean manufacturing refers to a manufacturing system founded by Toyota, which is recognized as TPS. This was also supported by Arif-Uz-Zaman and Ahsan (2014) who stated that the foundation of lean manufacturing is TPS, which is based on JIT. Due to the TPS principles have been widely spread to any other companies throughout the world, not only automotive manufacturers but also other industries; then the term lean manufacturing is preferable instead of TPS. In this study, the term lean manufacturing is subsequently used to encompass all the related approaches and techniques, due to the similarity among the three terminologies.

2.2.1 Definitions and General Concept of Lean Manufacturing

In line with the postulation from Heizer and Render (2011), Schonberger (2007), and Slack et al. (2010) as mentioned earlier, although definitions of lean manufacturing were continuously expanding, widening, and evolving as the lean manufacturing concept is being more globally accepted (Goyal & Deshmukh, 1992), there was a consensus that the fundamental objective of lean manufacturing is to enhance organizational performance through waste elimination. Examples of definition of lean manufacturing from a number of well-known studies are as follows:

a. Lean manufacturing is a philosophy, approach, technique and integrated management system that synergistically addressed improvement of operations performance in a production system (Bartezzaghi & Turco, 1989).

b. Lean manufacturing is a manufacturing philosophy, which encompasses of having the right items of the right quality and quantity in the right place and at the right time, in such a way, it is related with higher productivity, better quality, lower costs, and higher profits (Cheng & Podolsky, 1993).

c. Lean manufacturing is a holistic approach to continuous improvement based on the notion of eliminating non-value added activities in a production system (Sakakibara et al., 1997).

In line with the definitions from the previous studies, the present study defined lean manufacturing as *"an approach synergistically addressing to improve operations performance and business performance through waste elimination."* In short, lean means producing without waste. In Russell and Taylor (2008), Eiji Toyoda (former president of TMC) defined waste as *"anything other than the minimum amount of equipment, materials, parts, space and time, which are essential to add value to the products."* The waste extends not only within a company but also along its supply-chain networks, within and across companies (Shah & Ward, 2007). Hence, it primarily focuses on eliminating the consumption of resources that adds no value to products and processes. As originally presented by Ohno (1988), there are seven types of waste, which lean manufacturing aims to reduce. They are over productions, unnecessary inventory, defects (or poor quality), unnecessary motions (movement), over processing (i.e., doing more work on a part than necessary), waiting (delay), and transportation. In addition, Womack and Jones (2003) introduced another type of waste, which is known as behavioral waste. This type of waste is related to unused creativity and underutilized human capital (intelligence and intellect). These eight types of waste are all attempted to be eliminated through the deployment of lean manufacturing.

2.2.2 Benefits of Lean Manufacturing

Nowadays, the concept of lean manufacturing is constantly evolving as well as expanding the scope and focus (Marodin & Saurin, 2013; Papadopoulou & Özbayrak, 2005). As the concept widened in scope and focus, it was widely acknowledged that lean manufacturing improves company's performance admirably, not only operations performance but also business performance. In the operations level, Schonberger (1996) presented empirical evidence that lean manufacturing companies have successfully eliminated the waste. Lead times were drastically cut; inventories were substantially reduced; asset turnover was effectively increased, and quality was admirably improved.

Davis and Heineke (2005) further highlighted several companies' experiences in eliminating waste with lean manufacturing; reduction in average inventory of about 50%; reduction in throughput time of 50% to 70 %; decrease in setup times of 50% without major investment in plant, machines, and equipment; increase in productivity of between 20% and 50%; and average payback time for investment is less than nine months. Subsequently, the fantastic achievement gained in operations level influences business performance in terms of profitability (Fullerton & McWatters, 2001; Fullerton, McWatters, & Fawson, 2003; Green & Inman, 2007; Olsen, 2004), sales (Green & Inman, 2007; Maiga & Jacobs, 2008; Yang et al., 2011), and customer satisfaction (Bhasin, 2008; Chong, White, & Prybutok, 2001; Rahman et al., 2010).

2.2.3 Issues Related to Investigation of Lean Manufacturing Effect on Organizational Performance in Previous Studies

A review on literature indicated that although a large body of empirical studies, for example, Chen and Tan (2011), Furlan et al. (2011b), Hofer et al. (2012), Mackelprang and Nair (2010), and Mazanai (2012), highlighted the significant and positive effect of lean manufacturing on organizational performance, a few studies found different findings. For example, Sakakibara et al. (1997), Olsen (2004), Ahmad, Mehra, and Pletcher (2004), and Belekoukias et al. (2014). A review the literature revealed a number of methodological issues that may lead to different findings as follows;

1. The use of indicators that are not relevant to lean manufacturing. As lean manufacturing is aimed to eliminate waste in a production system, all the practices should be relevant to this aim. Irrelevant lean manufacturing indicator such as value stream mapping (VSM) was observed in the study of Belekoukias et al. (2014), since the VSM is not a method used to eliminate waste but the method to identify waste. The researchers also classified takt time as a tool of JIT. This classification is inappropriate. Takt time was widely defined as an interval at which a product is moved ahead to next workstation, which is calculated by dividing available production time per day with production volume per day. At a final process, it reflects the rate at which a finished product is completed. Thus, it is used as an input of synchronizing production rate and demand rate. Furthermore, shorter takt time can be an output of lean manufacturing implementation. Hence, even though Belekoukias et al. (2014) found a strong relationship between JIT tools and operations performance, the presence of takt time is not operationally appropriate.

   Inappropriate indicator was also observed in Ahmad et al. (2004). The researchers included electronic data interchange (EDI) as one indicator of lean manufacturing. The study found that EDI had no significant relationship with operations performance and financial growth. In line with this finding, in-depth literature review indicated that emphasizing EDI as a practice of lean manufacturing did not frequently appear in literature. However, instead of using a general term like EDI, the term like e-kanban (electronic kanban) may be more appropriate. In addition, an exploratory factor analysis grouped kanban as one of the supplier strategy factors, while there was a consensus among researchers and practitioners emphasizing kanban as a practice implemented not only in the relationship with suppliers, but also in the production process (Matsui, 2007; Shah & Ward, 2007). Hence, it seems that the result of exploratory factor analysis in this study was not practically rationalized. The improper grouping of the practices may raise problematic results.

2. Even, if the methods or tools are relevant to lean manufacturing, it is not proper to measure the level of its implementation based on a limited number of practices. Dal Pont et al. (2008) and Furlan et al. (2011b) noted, although its synergistic effects on companies' performance are widely believed, most of the empirical studies focused on the relationship between individual practices and performance rather than considering improvement resulted from implementation of a set of lean manufacturing practices. The use of limited indicators to assess lean manufacturing and performance in a plant may not capture its actual condition. This was found in a number of studies. For example, Fullerton and Wempe (2009) who assessed lean manufacturing practices only in terms of quality improvement, setup time reduction, and cellular manufacturing. Even though the study concluded a significant relationship between lean manufacturing, non-financial and financial performance measures, the practices did not represent the lean manufacturing as a whole.

   Similarly, the study of Sakakibara et al. (1997) found insignificant effects of lean manufacturing (in terms of setup time reduction, schedule flexibility, maintenance, equipment layout, kanban, and JIT supplier relationship) on manufacturing performance (in terms of cycle time, inventory turnover, on-time delivery, and lead time). The researchers justified; the insignificant relationships were caused by the narrowness of lean manufacturing practices defined in the study. This justification makes sense, because there are some important practices of lean manufacturing that were not included in the analysis, such as small lot production and uniform production level. Interestingly, the researchers placed some of the important activities of lean manufacturing (e.g., process control, supplier quality involvement, and flexible workers) under another variable of the study (i.e., infrastructure practices). Not surprisingly, the study revealed that combination between the lean manufacturing and infrastructure practices significantly affected manufacturing performance. In conclusion, it seems that the limited measures may occasionally produce misleading information and misconceptions (Ahmad et al., 2003; Bartezzaghi & Turco, 1989; Fullerton & Wempe, 2009; Ramarapu, Mehra, & Frolick, 1995).

3. Partial implementation of lean manufacturing in a company. Review on literature summarized that lean manufacturing should be implemented in a full set of practices. Piecemeal adoption possibly caused the failure of a company in realizing potential benefits of its implementation (Khanchanapong et al., 2014; Mehra & Inman, 1992; Shah & Ward, 2007). Several studies emphasized a synergic effect of lean manufacturing on organizational performance measures, such as Furlan et al. (2011a), Khanchanapong et al. (2014), and Shah and Ward (2003). They tended to postulate that the effect of collective practices of lean manufacturing on organizational performance was higher than its individual practice. Hence, full adoption of lean manufacturing may lead to better organizational performance.

4. Different set of lean manufacturing practices may affect different benefits. As observed in a number of previous studies (see Mackelprang and Nair (2010)),

different practitioners and academicians offered different set of lean manufacturing practices. At the same time, measuring the implementation of lean manufacturing with a different set of measures may also produce different assessment results. This is in line with the statement from Shah and Ward (2007) stating that different lean manufacturing practices contribute to different performance. In other words, the performance outcomes are practice dependence. This was also supported by Combs, Crook, and Shook (2005) and Ray, Barney, and Muhanna (2004) who stated that different processes or activities within companies have a different effect on organizational performance.

5. The main objective of lean manufacturing is to eliminate the waste in a production system. Indicators of performance should reflect its operating conditions (Bartezzaghi & Turco, 1989). Therefore, operations performance indicators is more related to lean manufacturing, instead of business performance. The business performance may be regarded as a higher level in the hierarchy of objectives looking at business as a whole instead of operations level. Thus, operations performance should mediate the relationship between lean manufacturing and business performance (Bartezzaghi & Turco, 1989; Venkatraman & Ramanujam, 1986). Mixing operations performance and business performance indicators under the same variable may not be appropriate, because of the different level of the performance.

6. In addition, the use of multiple regression analysis in examining the effect of lean manufacturing on organizational performance may not be appropriate. This is because one of the basic assumptions of multiple regression is no significant correlations among the independent variable, while several studies noted that lean manufacturing practices complement each other. This complementarity reflects high

significant correlations among the practices. By using multiple regression analysis, the high correlations may produce multicollinearity among the practices that will be likely to confound its individual effect on performance measures (Agus & Hajinoor, 2012). In addition, as Hair, Black, Babin, and Anderson (2010) stated that direct measures of multicollinearity are variance inflation factor (VIF) and tolerance. High degrees of multicollinearity are reflected by high VIF and low tolerance. The use of 10 as the threshold value for VIF and .10 for tolerance to judge multicollinearity may not be appropriate for social studies, because it is difficult to achieve the correlation coefficient of .90 and above in social studies. Thus, as suggested by Miles and Shevlin (2001) and Quresh, Akbar, Khan, Sheikh, and Hijazi (2010), the thresholds of 4 for VIF and .25 for tolerance seem to be more suitable to judge multicollinearity in social studies.

Hence, applying SEM seems to be more suitable to assess the effect of lean manufacturing on company's performance. With these methods, the strong correlations among the practices provide an ideal situation for combining or parceling them into a single latent construct. In addition, as postulated by Dion (2008), since multicollinearity is an issue in multiple regression analysis; in SEM, it can be modeled and further assessed.

2.3 Lean Manufacturing in Indonesia

Nowadays, manufacturing companies in Indonesia have widely recognized lean manufacturing concepts. At the same time, they have implemented lean manufacturing practices in a certain level (Nakamura, 1999; Nugroho, 2007; Susilawati et al., 2011). Nakamura (1999) examined the extent to which lean manufacturing principles have been implemented in Indonesia by applying the work organization approach and utilizing the data provided by Toyota Astra Motor (TAM), a Japanese joint venture manufacturing company operating in Indonesia for about fifty years. Nakamura (1999) provided evidence how well lean manufacturing functioned in Indonesia, especially at TAM. This study stated that before the year 2000, to some extent, lean manufacturing practices such as *heijunka* or flexible leveled production (e.g., uniform work load, mixed model production, and repetitive production), flexible resources (e.g., multi-skilled workers, and employee involvement in problem-solving and employee empowerment), quality control (e.g., quality circle, quality at the source, process control, and *pokayoke*) were functioned at TAM. The implementation of these practices brought several benefits in terms of better quality, higher flexibility, lower cost, and shorter takt time.

Nugroho (2007) assessed to what extent lean manufacturing had been rooted in 56 manufacturing companies in Indonesia, particularly those located in the Central Java. The study suggested that the practices, such as focused factory, group technology, setup time reduction, TPM, multi-functional workers, uniform work load, product and process improvement, kanban, and JIT purchasing; have been implemented among the surveyed companies. In addition, the study found the significant difference of the degree of lean manufacturing implementation between companies that used job order production and companies that used mass production system. The degree of implementation in job order production system is higher than the mass production system.

Investigation on the degree of lean manufacturing implementation in Indonesia was also done by Susilawati et al. (2011). The study involved 260 manufacturers, consisting of 182 large companies and 78 small and medium. An analysis using fuzzy logic based method revealed that lean manufacturing had been applied in manufacturing companies in Indonesia. However, medium and small companies tended to implement it in a lesser extent than large companies due to lack of education on lean manufacturing. The study encouraged small and medium companies to implement lean manufacturing holistically in order to obtain a significant improvement in performance.

Other studies, such as Fahmasari (2009) and Yarsan (2009), employed case study approach focusing on an individual company. The implementation level of lean manufacturing was investigated by Fahmasari (2009) in a chicken meat processing industry (the name of company was not disclosed, because of confidentiality). The study led towards the conclusion that lean manufacturing has not been fully implemented within the company. In other words, its implementation tended to be partial and thus, suggesting improvement in order to gain probable benefits from its implementation. In addition, the effect of pull system, kanban system, kaizen, and visual control tools on lead time reduction and inventory minimization was assessed by Yarsan (2009) at PT. Chuhatsu Indonesia, a supplier of automotive part. The study concluded that lean manufacturing reduced manufacturing lead time by 50% and inventory level by 76%.

More recently, a number of studies were conducted in the area of lean six sigma in Indonesia (Manurung, 2014; Purba, Ichtiarto, & Basuki, 2012). However, none of them discussing the effect of lean six sigma on comprehensive measures of company's performance. Again, the investigations focused on experience of a single company; none of the studies involved large number of sample companies.

The empirical studies mentioned earlier provide evidence that in a certain level, lean manufacturing has been implemented in manufacturing companies in Indonesia.

However, the degrees of the implementation were varied; some of the companies have been implementing lean manufacturing in a holistic manner, but some of them are still partial. As results, some companies realized its potential benefits in terms of inventory minimization, quality improvement, lead time reduction, productivity improvement, etc. The studies tended to suggest that lean manufacturing should be applied holistically in order to grab more advantages from its implementation. In the subsequent section, a review on the literature of lean manufacturing practices will be presented.

2.4 Lean Manufacturing Practices

In attempting to relate lean manufacturing and its potential benefits after its implementation, it is important to differentiate between practices and performance. Following Flynn et al. (1995), this study defined practices as a combination of activities or approaches done to achieve a set of goals (e.g., certain type of performance). While, performance was defined as a set of achievement gained after implementing a set of practices. Hence, borrowing terminology of system theory, practices are inputs, whereas performance is output resulted from processing a set of practices. Thus, the ultimate result expected from manufacturing practices implementation is performance.

For lean manufacturing to perform well in eliminating everything that does not add value to product, process and service; some fundamental practices must be in place. The triumph of lean manufacturing depends on the employment of its practices (Ramarapu et al., 1995). Bartezzaghi and Turco (1989), Chen and Tan (2011), Mackelprang and Nair (2010), and Shah and Ward (2007) revealed that although many studies have been addressed to identify fundamental practices of lean manufacturing, there was lack of agreement among the scholars regarding the significance of each lean manufacturing practices. These differences are the reason why practitioners and researchers offered different set of practices to cover lean manufacturing concept. The practices varied widely based on the researchers' background and the different collection of features (Ramarapu et al., 1995).

As the concept that is constantly evolving and widening, it is not easy to formulate the consistent practices of lean manufacturing. However, based on the literature review, several researchers strongly agreed that potential benefits of lean manufacturing cannot be fully realized until all the practices are implemented integrally and holistically (Cheng & Podolsky, 1993; Goyal & Deshmukh, 1992; White & Prybutok, 2001). Even, Mehra and Inman (1992) and Shah and Ward (2007) noted that lean manufacturing must be applied as a total system, implementation of any part of them will not be successful to convey a company to an outstanding position. Borrowing the terms used by Ramarapu et al. (1995), piecemeal adoption will only create *"island of lean manufacturing"* but would not significantly contribute to the company-wide improvement that increases its competitiveness. These implied that all the practices should be implemented in order to achieve its potential benefits in terms of outstanding organizational performance. These may have motivated several scholars in lean manufacturing, such as Dal Pont et al. (2008), Furlan et al. (2011b), and Shah and Ward (2003, 2007), to formulate the concept of lean manufacturing bundles, suggesting that the whole practices must be implemented as a bundle, instead of in isolation.

Through an in-depth literature review, this study attempts to produce the bundle of lean manufacturing practices those have been proven as effective practices to enhance companies' performance. A number of previous conceptual and empirical studies have identified and been used to develop lean manufacturing practices by considering its significant effect on performance. The practices of lean manufacturing are listed in Table 2.1. In selecting the practices, the common practices from the previous studies were compiled by listing down them in a spreadsheet. Subsequently, the practices were regrouped based on their similarity into nine related practices. The practices are flexible resources, cellular layouts, pull system, small lot production, quick setups, uniform production level, quality control, TPM, and supplier networks. Even though this study does not comprise some of the practices discussed in previous studies as separated components, many were incorporated into related practices. The next sections will thoroughly discuss the lean manufacturing practices listed in Table 2.1.

Table 2.1
Practices of Lean Manufacturing

Lean Practices	Literature
Flexible resources	
Training for multiple tasks	1, 3, 4, 7, 9, 10, 13, 19, 20, 22, 23, 24, 25
Multi-skilled workers	2, 4, 5, 6, 7, 8, 23, 24, 25, 26
Multi-functional machines and equipment	2, 9, 11
Cellular layouts	
Cellular manufacturing/Group technology/JIT Layout	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 25, 26
Kanban/Pull system	
Kanban system	1, 2, 4, 5, 7, 8, 10, 11, 12, 13, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
Pull system	1, 6, 10, 11, 14, 18, 20, 23, 24, 25, 26
Small lot production	
Small lot production/Lot size reduction	1, 2, 3, 6, 9, 11, 13, 17, 18, 21, 22, 23, 24, 26
Quick setups	
Setup time reduction	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
Training for quick setup	3, 4, 10, 11, 12, 13, 16, 19, 20, 21
Uniform production level	
Daily schedule adherence (JIT scheduling)	1, 2, 7, 11, 13, 14, 18, 21, 22, 23, 24, 25, 26
Repetitive production	2, 4, 11, 12, 14, 18, 21, 24, 26
Uniform workload	2, 4, 5, 8, 11, 12, 23, 24, 26
Quality Control	
Quality at the source	2, 3, 4, 5, 8, 10, 13, 16, 17, 22, 23, 24, 25, 26
Statistical quality control	2, 3, 4, 5, 8, 10, 13, 19, 22, 24, 25
Training for quality control	3, 4, 9, 10, 13, 19, 20, 21
Quality circle	2, 3, 4, 20, 24, 25

Table 2.1 (continued)

Lean Practices	Literature
Total Productive Maintenance	
Preventive maintenance	1, 2, 3, 4, 6, 9, 10, 12, 17, 18, 19, 23, 24, 26
Training for maintenance activities	3, 4, 10, 13, 19, 20, 21
Supplier Networks/JIT Purchasing	
JIT delivery by suppliers	1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 18, 19, 21, 22, 23, 24, 25, 26
Supplier involvement	2, 3, 4, 5, 7, 8, 9, 10, 15, 21, 23, 24, 25
Supplier development program	2, 3, 4, 5, 8, 9, 10, 15, 23, 24, 25
Long term agreement with suppliers	2, 3, 4, 5, 8, 9, 10, 11, 23, 24, 25

Note. 1 = Sakakibara, Flynn, and Schroeder (1993); 2 = Lee and Paek (1995); 3 = Ramarapu et al. (1995); 4 = Callen et al. (2000); 5 = Fullerton and McWatters (2001); 6 = Shah and Ward (2003); 7 = Ahmad et al. (2003); 8 = Fullerton et al. (2003); 9 = Kannan and Tan (2005); 10 = Shah and Ward (2007); 11 = Matsui (2007); 12 = Abdallah and Matsui (2007); 13 = Dal Pont et al. (2008); 14 = Hallgren and Olhager (2009); 15 = Jayaram, Vickery, and Dröge (2008); 16 = Fullerton and Wempe (2009); 17 = Rahman et al. (2010); 18 = Mackelprang and Nair (2010); 19 = Taj and Morosan (2011); 20 = Yang et al. (2011); 21 = Furlan et al. (2011a); 22 = Furlan et al. (2011b); 23 = Chen and Tan (2011); 24 = Marodin and Saurin (2013); 25 = Khanchanapong et al. (2014); 26 = Belekoukias et al. (2014).

2.4.1 Flexible Resources

Resources are often recognized as an essential determinant factor of enhancing performance and competitive advantage. Chauhan and Singh (2013) stated that sustainable competitive advantage could be established through the implementation of flexible resources. An extensive literature review indicated that manufacturing flexibility could be achieved through the use of multi-skilled workers, and multi-functional machines and equipment. However, the use of multi-skilled workers and multi-functional machines and equipment should be supported by trainings to perform multiple tasks (Wafa & Yasin, 1998). It seems that multi-skilled workers, multi-functional machines, and training are critical factors in a lean manufacturing system.

Human resources take important roles at all aspects of an organization. One of the fundamental aspects for the success of an organization is the power of its workers. In the context of lean manufacturing, Krafcik (1989) stated that the roles played by workers differentiate between lean and non-lean systems. In a lean system, workers must be able to perform multiple tasks, which is less important in a non-lean system.

So that, workers can be involved in a broad number of manufacturing activities. Fullerton and Wempe (2009) and Koufteros, Vonderembse, and Doll (1998) characterized workers' involvement as a critical factor for the success of lean manufacturing.

Optimum deployment of resources can be accomplished through flexible workers (Chauhan & Singh, 2013). Thus, to enhance workers' flexibility, they must undergo several trainings in order to be able to perform multiple jobs and possess redundant capabilities (Rahman et al., 2010). Wafa and Yasin (1998) stated that the better results of lean manufacturing implementation depend on having well-trained workers. In similar opinion, Bonavia and Marin-Garcia (2011) stated that lean plants were characterized by greater use of training. Thus, companies that implement most of the lean practices are those that take care to train workers in employing the practices.

Literature had different expressions for the training, such as cross-functional training (Cua et al., 2001), multi-functional training (Furlan et al., 2011b), and multiple task trainings (Dal Pont et al., 2008). However, the basic idea is to keep multiple abilities of workers and to maintain their high-skill level (Sakakibara et al., 1993). Previous studies had different terms to express multiple abilities of employees, such as cross-functional workforce (Shah & Ward, 2003), and multi-functional workers (Matsui, 2007). Although they expressed differently, it implied that development of multi-skilled workers has established in several studies. By employing multi-skilled workers, the contents of individual tasks could be enriched. They can engage on several different jobs. Ultimately, wastes caused by under-utilization of human resources are eliminated.

Besides human resources-related activities, lean manufacturing also concerns to maintain multi-functional machines and equipment to increase manufacturing flexibility (Bartezzaghi & Turco, 1989; Boyle & Scherrer-Rathje, 2009). Ohno (1988) noted; by employing multi-functional machines and equipment, waste of movement to other machines, setting up machines, and waiting would be eliminated admirably.

2.4.2 Cellular Layout

Literature emphasized the importance of this practice in attempting to increase flexibility in a shop floor. Several expressions were used to represent this practice, such as cellular layout (Yang et al., 2011), cells manufacturing (Jayaram et al., 2008; Shah & Ward, 2007), equipment layout (Mackelprang & Nair, 2010; Matsui, 2007), group technology (Fullerton et al., 2003) and cellular manufacturing (Wang, 2011).

Finch (2008) stated that this practice combined flexibility of process layout with efficiency of product layout based on the concept of group technology. By occupying cellular layouts, dissimilar machines are grouped into workstations that process families of parts with similar requirements such as sizes, shapes, routing, processing, or demand (Fullerton & Wempe, 2009; Hofer, Hofer, Eroglu, & Waller, 2011). In other words, in applying this practice; workstations, machines and equipment are arranged in a sequence in order to support smooth flow of materials with minimum transport and delay. Based on an extensive literature review, cellular layout in lean manufacturing is attractive because of the following reasons:

1. This practice arranges workstations and machines in relation to each other. This arrangement minimizes transportation, handling of materials, and part storage (Hirano, 1989; Matsui, 2007).

2. The machines are laid out in close proximity to each other (Matsui, 2007; Sakakibara et al., 1993). This abridges workers to handle multiple operations. Thus, workers have broad responsibility, instead of very narrow tasks.

3. Cells tend to utilize small-scale equipment (Finch, 2008). Thus, layout is easily relocated to adapt to variations in volume, design, or product developments. Hence, it increases the ability to adjust to demand change.

4. Cellular layouts virtually eliminate material movements that are often a waste in transportation through distance reduction, because cellular layouts reduce travel distance, inventory and space required (Matsui, 2007; Sakakibara et al., 1993).

Flexible layouts would support other practices such as quick setup, small lot production, pull system as well as kanban system. Even, Sakakibara et al. (1993) included this practice as a major driving force that improves company's performance. In the same vein, Matsui (2007) noted that cellular layouts had a strong effect upon the competitive position of manufacturing plants. Therefore, this practice contributes significantly in improving organizational performance.

2.4.3 Pull System

The terms "*push*" and "*pull*" are often used to differentiate between two approaches for operations and material movements in a production process. In a traditional process, push system is used; when a process is completed in a workstation, the material is then pushed to the subsequent workstation for the next processes. In case of final process, finished products will be pushed to storage. Practically, in a push system, each workstation pushes out the work without considering the readiness of the subsequent workstation to work (Koufteros et al., 1998). Hence, the processes are performed based on passing of goods from the preceding workstation. In addition, another characteristic of a push system is that production is performed based on schedule prepared in advance (Sakakibara et al., 1993). As consequences, it causes idle and queue time, excess inventory, and poor quality (Jasti & Kodali, 2014).

Conversely, in a pull system, a workstation pulls material from previous workstation as it is needed. The basic idea of a pull system is to produce only when requested, move to where it is needed just as it is needed (Chen & Chang, 2013). In case of final process, finished products are pulled by customer demand (Shah & Ward, 2007). Hence, customer demand acts as a trigger for production and material movement (Forrester, Shimizu, Soriano-Meier, Garza-Reyes, & Basso, 2010). If there is no demand, then there is no production and material movement. In this system, production and material movement are performed just as needed, in the right quality, right quantity (not too much or too little), right time (neither too early nor too late), and precisely where required. In short, the pull system is a customer order-driven production system according to actual demand, instead of forecasting.

In order to maintain the discipline of pull system, kanban is used to authorize production and material movement (Rahman, Sharif, & Esa, 2013). Kanban is the Japanese word for a card. It refers to the work signaling system to trigger actions (Chen & Tan, 2011). It is to control production flow through the factory. Hence, if there is no kanban, then there is no production and material movement. Furthermore, a kanban is also used to specify material order points, how much it is required, from where it is ordered, and to where it should be delivered (Slack et al., 2010). In addition, a kanban as well contains a number of information such as kanban number, part number, brief description of the product, type of container, quantity per kanban, supplier, preceding, and subsequent workstation (Russell & Taylor, 2008).

Nowadays, to ease operation, kanban has been modified in many forms, depending upon the context where it is used. So that, albeit it is named as kanban, a card itself does not exist. In other cases, verbal signals (e.g., empty container, electronic message, golf ball rolled down a tube, flag, or rag) are frequently used as alerts that it is time to perform a production process or to transfer materials (Rahman et al., 2013).

Kanban is also employed to release orders from suppliers. This type of kanban is called as supplier kanban (Aziz & Hafez, 2013). It contains instructions that request suppliers to deliver parts and materials. As having warehouses is not preferable in a lean manufacturing system, therefore, receiving place must be clearly stated in the kanban. In other words, suppliers deliver parts and materials directly to its point of use in the factory. Recently, barcode and e-kanban have widely used to facilitate interaction between factory and suppliers (Monden, 2012; Powell, 2013). By using e-kanban, the manufacturer does not pass any kanban cards manually to the handlers who are responsible for moving parts and materials, but uses information technology to send order information to suppliers electronically (Powell, 2013).

According to Sakakibara et al. (1993), pull system and supported by application of kanban (or e-kanban) is an extremely important practice in lean manufacturing. By applying the pull system, overproduction could be prevented; only necessary quantities are produced, which are defined by shop floor operation, not by schedule prepared in advance. Hence, inventory is eliminated admirably.

2.4.4 Small Lot Production

Lot size (or batch size) was defined as a quantity of items that are produced together (Agus & Hajinoor, 2012). There are pros and cons regarding lot size appropriately implemented within a production system. Traditional paradigm always suggested operating in large lot size as an effort to maximize utilization of machines. By producing in large lot sizes, although it can reduce variable costs, it may generate additional or hidden costs. Large lot size tends to accumulate inventory; once a finished product is completed, it must be warehoused. It is required storage space, additional costs, workers to maintain it, etc. Hence, inventory comes a great deal of costs.

Recently, the traditional paradigm has been shifted. In a lean manufacturing system, small lot size is preferable to match production to demand rate (Finch, 2008) as well as to achieve the ideal lot size of one (Agus & Hajinoor, 2012). Literature named this practice in several different expressions, such as small batch production (Finch, 2008), lot/batch size reduction (Rahman et al., 2010; Shah & Ward, 2003), small lot size (Chen & Tan, 2011; Mackelprang & Nair, 2010), and one-piece flow production (Wang, 2011). Besides production lot size, lean manufacturing also emphasizes reducing purchasing lot size (Bartezzaghi & Turco, 1989; Bartezzaghi, Turco, & Spina, 1992). Mehra and Inman (1992) called it as vendor lot size. The ability of suppliers to deliver their products on the JIT basis (i.e., small lot size, frequent delivery, in the right quality, quantity, and time) is important to support lean manufacturing system.

Many researchers, such as Chen and Tan (2011), Furlan et al. (2011b), and Yang et al. (2011), categorized small lot production as a key practice of lean manufacturing. It potentially brings companies to enjoy the following benefits:

1. It reduces lead time, consisting of five components; processing time, moving time, waiting time, queuing time, and setup time (Fullerton & McWatters, 2001).

2. It improves quality because quality problems are easier to detect, and workers have fewer tendencies to let poor-quality passes (Fullerton & McWatters, 2001).

3. It reduces the inventory level (Chen & Tan, 2013; Lee & Paek, 1995), because the average level of inventory is a function of quantity produced in a batch.

4. It enhances manufacturing flexibility, in terms of flexibility to change product design, production volume, routing, and layouts (Fullerton & McWatters, 2001). Consequently, responsiveness to customer demands could be increased.

2.4.5 Quick Setups

Quick setup, which is frequently called as quick changeover (Rahman et al., 2010; Shah & Ward, 2003) and setup time reduction (Jeyaraman & Leam, 2010; Mackelprang & Nair, 2010), was defined as a technique of eliminating times it takes to setup or changeover a process from running one specific product to another (Chen & Tan, 2011). It was defined as an effort to reduce the time involved in changing tools and other aspects required in moving from processing one product to another (Fullerton et al., 2003). Hence, based upon the definitions provided by the literature, it can be highlighted that the basic objective of this practice is to reduce setup time, and ultimately enable a company to respond to changes in customer demand quickly.

A lean manufacturing system, which is characterized by mixed model production in small lot size, should anticipate demand variances throughout the day. Production in smaller lot sizes requires frequent setups (Chen & Tan, 2013; Fullerton & Wempe, 2009). Small lot size production can only be realized as long as setup time is quick. Any setups between product models being produced must be performed quickly. Therefore, reducing setup time is critical to smooth production processes. In attempting to reduce setup time, Shigeo Shingo developed a technique that can be applied to any factory, any machine and any type of setup. This technique was recognized single-minute exchange of die (SMED). According to Moxham and Greatbanks (2001), the basic idea of SMED is to separate internal setup and external setup activities, and subsequently aggressively working to lower setup time by converting most of the internal setups to external setups. Therefore, most of the setup processes are performed while the machine is still running.

In addition, Hirano (1989) and Fynes and Voss (2002) also highlighted the importance of waste elimination of searching tools by keeping them in normal storage location. Therefore, production workers do not have any troubles in finding the tools. Other than that, due to the importance this practice, training for quick setup is essential to ensure the setup process can be performed appropriately. This was highlighted by a number of studies, such as Dal Pont et al. (2008) and Matsui (2007).

As shown in Table 2.1, prior studies indicated that quick setup is the most frequently selected practice and deemed to be critical in lean manufacturing. Agus and Hajinoor (2012) summarized the effects of performing quick setup as follows, (1) it enables the shop floor to changeover a process in producing dissimilar products in the most efficient way, (2) it reduces total costs, (3) it shortens lead times, (4) it reduces inventory, (5) it increases productivity, (6) it increases flexibility to adapt to demand variations, and (7) it allows mixing of product without incurring higher costs.

2.4.6 Uniform Production Level

The basic objective of uniform production is to reduce variability at the production level caused by fluctuations in customer demand. Variability may cause greater incidence of creating waste. In other words, it is addressed to ensure schedule stability (Moreira & Alves, 2008). In the TPS, this attempt is called "*heijunka*", which means leveling. By applying *heijunka*, Toyota manages its production system by leveling and smoothing production by volume and product type to guard against variability of demand (Chase, Jacobs, & Aquilano, 2004; Coleman & Vaghefi, 1994; Jones, 2006). It is truly critical to create the lean system because it is the key of achieving stability to the manufacturing system.

Through an extensive literature review, prior studies proposed several activities addressed to reduce variability as follows:

1. Uniform workload. This refers to balance daily flow of work through a production system (Fullerton et al., 2003), aiming to reduce fluctuation and variability of everyday workload. Uniform workload could be achieved through line balancing, level schedule, steady cycle rate, and market-pace final assembly rate (Fullerton & McWatters, 2002; Fullerton et al., 2003). According to White and Prybutok (2001), due to uniform workload gives a steady workload; it supports the implementation of the pull system in a shop floor.

2. Repetitive production. This refers to the extent of the use of a repetitive level daily production schedule (Sakakibara et al., 1993). In the same view point, Mackelprang and Nair (2010) stated that repetitive production is aimed to ensure consistency of daily production schedule; not only product types/models, but also production volumes. Repetitive production positively leads to outstanding performance in terms of inventory, quality, and manufacturing flexibility.

3. Daily schedule adherence. It refers to the ability to meet daily production schedule (Ahmad et al., 2003). Mackelprang and Nair (2010) and Matsui (2007) defined daily schedule adherence as the extent to which a plant meets each day's schedule, including consideration of time buffers for unexpected stoppages.

In line with prior studies mentioned earlier, Russell and Taylor (2008) provided three methods in order to achieve the uniform production level as follows:

1. Increase accuracy of forecast. Taking a smart practice from Toyota, production planning is usually arranged by considering the results of marketing surveys conducted twice a year by involving ten thousand people to estimate customers' demand. Monthly production schedules are drawn up from forecast of two months in advances. The planning is evaluated one month in advance and finally, ten days beforehand. Daily production schedules are finalized four days before production is started. By implementing this practice, Toyota has an accurate and flexible forecast.

2. Smoothing demand. Monthly demand is divided into daily and spread out as evenly as possible. Therefore, the same amount of each item is produced each day, and items produced are mixed throughout the day in small quantities.

3. Mixed-model production. This suggests producing several different models of the products daily. Daily production is prepared in the same ratio as monthly demand. Hence, at least some quantity of each item is produced every day, and manufacturer always keeps some quantity of items to respond demand variances.

In addition, implementing this practice may encourage relatively steady production, increase flexibility, and support the implementation of pull/kanban system. Moreover, uniform production level enables a predictable process as well as a smooth flow of products throughout the processes with minimum inventory.

2.4.7 Quality Control

Quality is a main priority of a production system. Employment of this practice is an integral element of establishing both process and product quality. In a lean manufacturing system, quality must be ensured at the very beginning of each process. It is important to guarantee that only good quality of product can be passed to subsequent workstation, no defect, no reject, and conforms to the required specification. This is totally contrasted from the traditional quality control approach, whereby the work was passed to next workstation without ensuring the quality; inspection is done in large lot size at the end of a production process.

To ensure the quality (both processes and products), lean manufacturing system includes quality at the source as one of the main activities. The importance of this activity was noted in several recent studies (Meybodi, 2013; Ringen, Aschehoug, Holtskog, & Ingvaldsen, 2014), in which in case of abnormality happens, machines can be automatically stopped. Quality at the source can be successfully implemented as long as production in small lot size is performed (Fullerton & McWatters, 2001). High quality can be ensured if small lot size principles are applied (Agus & Hajinoor, 2012; Sangwan, Bhamu, & Mehta, 2014). Source of the problem can be detected accurately. At the same time, it avoids from producing defects. Consequently, each process supplies no defect unit to subsequent processes (Shah & Ward, 2007).

To support quality at the source, visual control systems are used to make any problems and abnormalities observable (Karim & Arif-Uz-Zaman, 2013). So that, immediate corrective actions could be performed. For this purpose, visual control tools (such as *pokayoke*, standard operating sheets, *andons*, control charts, cause-effect diagrams, etc.) are used to assure that abnormalities are noticeable and visible (Karim & Arif-Uz-Zaman, 2013; Rymaszewska, 2014). Other than visual control, in attempting to monitor the outputs and to control the processes, lean manufacturing requires statistical quality control (Ahmad et al., 2003; Hallgren & Olhager, 2009; Nakamura et al., 1998; Shah & Ward, 2007; Zelbst, Green Jr, Abshire, & Sower, 2010). This technique supports a consistent quality of product conformance with predetermined specifications (Hallgren & Olhager, 2009). The use of this technique would encourage production workers to deal with early signals of quality problems (Nakamura et al., 1998). Hence, it ensures that each process supplies defect-free units to subsequent processes (Shah & Ward, 2007).

To support the implementation of quality at the source and statistical quality control, quality control circle (QCC) plays important roles. As a quality focused team, it was proven effective to assist manufacturers to increase quality (Callen et al., 2000; Fullerton et al., 2003; Lee & Paek, 1995; Monden, 2012). By meeting regularly, quality problems can be arisen; strategies of problem solving can be designed accurately, and some suggestions can be addressed to management as an attempt to acquire superior quality. More importantly, to support the quality control activities, production workers should undergo a number of trainings related to quality control (Cheng & Podolsky, 1993; Kaynak, 2002).

2.4.8 Total Productive Maintenance

Explained by Ahuja and Khanba (2007), maintenance was traditionally perceived as reactive activities related to replacement of parts and repairs malfunctioning equipment. This perception impressed that maintenance is a non-value added activity. However, Bamber, Sharp, and Hides (1999) refused this traditional perception by arguing that maintenance plays important roles to support the entire production activities by targeting the efficient and effective use of equipment. Lazim and Ramayah (2010) acknowledged that maintenance activities support a production system to achieve the desired performance through reducing adverse effects of breakdown, maximizing machines' availability, and ensuring efficient use of equipment. These aims can be achieved through total productive maintenance (TPM).

The TPM was originated from Japan, advocated by the Japan Institute of Plant Maintenance (JIPM) and particularly, promoted by Seiichi Nakajima (Bamber et al., 1999). Maintenance system is addressed to support and sustain the lean manufacturing system, since the availability and efficient use of equipment are pre-requisite of lean manufacturing implementation (Ahuja & Khanba, 2007). Following Nakajima (1988), the word *"total"* refers to total effectiveness, total maintenance system, and total participation of employees. At the same perspective, Imai (1986) cited the aim of TPM from the JIPM as *"... maximizing equipment effectiveness with a total system of* *preventive maintenance covering the entire life of the equipment involving everyone in all departments and at all levels, it motivates people for plant maintenance through small-group and voluntary activities.”* Based on the idea from Nakajima (1988) and Imai (1986), preventive maintenance is a main element of TPM, which involves periodic inspections and services to identify any potential failures and make minor adjustments to prevent major operating problems and breakdown. There is a strong consensus that preventive maintenance programs were critical to lean manufacturing success (Abdallah & Matsui, 2007; Chen & Tan, 2011; Cua et al., 2001; Matsui, 2007; Taj & Morosan, 2011). This is because losing any machines or equipment due to unexpected downtime will stop the production line.

Nakajima (1988) postulated the following attributes of TPM; (1) it establishes a total planned maintenance system consisting of preventive maintenance and improvement-related maintenance, (2) it aims at getting the most efficient use of equipment, (3) it involves total participation of all workers at every management level, (4) it implements planned maintenance based on autonomous and small-group activities.

To ensure the total workers involvement in the maintenance activities, they must be familiar with both production and maintenance activities (Nakamura et al., 1998). To become well-known with these activities, training related to maintenance tasks is absolutely required. Bakerjan (1994) noted the lack of sufficient training as a major cause of failing in the TPM implementation because workers do not have complete understanding on TPM goals and practices. Therefore, training is considered as an important activity to support the success of TPM.

Past studies (Ahuja & Khanba, 2007; Cua et al., 2001; Olsen, 2004) noted that TPM had strong positive effects on multiple aspects of companies' performance. Imai (1986) presented several expected benefits from the TPM implementation such as the increase in labor and machine productivities, equipment operating ratio, and the inventory turnover ratio. At the same time, it decreases the number of equipment breakdowns, tools replacement time, and cost of defectives.

2.4.9 Supplier Networks

Lean manufacturing activities are not only related to internal properties of a production system, but also to entire supply chain networks, within and across companies. Externally, extensive literature review indicates supplier networks (or often called as JIT partnership and JIT purchasing) as a critical factor for lean manufacturing success (Fynes & Voss, 2002; Matson & Matson, 2007). Close relationships with suppliers are indispensable for the triumph of lean manufacturing. Nowadays, practitioners give much attention to the role of suppliers to support a company to enhance its performance (Green & Inman, 2007; So & Sun, 2010).

Literature review indicates that lean manufacturing system requires buyer and suppliers to work together as a strategic collaborator with a goal of eliminating waste and cutting down costs for mutual benefits. Supplier networks play important roles to enhance the following purposes (Heizer & Render, 2011); (1) to eliminate unnecessary activities, such as receiving, incoming inspection, invoicing and payment, (2) to eliminate in-transit inventory by encouraging suppliers to locate nearby, providing frequent shipments and applying consignment technique (placing goods in the hand of the purchaser, but retaining ownership until the goods used), (3) to improve quality and reliability through long-term agreement and cooperation, and (4) to eliminate in-plant inventory by delivering in a small lot directly to the housing unit just as it is required.

One of the most important requirements of the lean manufacturing system is on-time delivery. Suppliers must be able to deliver the products as promised, just as it is needed, in the right quantity at the right time to the right place (Shah & Ward, 2007). To enhance suppliers' ability to fulfill this requirement, the buyer must design a transportation system compatible with JIT delivery (Singh et al., 2010b). According to Singh et al. (2010b), the buyer must design delivery times, types of carriers, routing decisions, and shipping processes. These facilitate the suppliers to deliver their products as promised (on-time delivery) and faster (fast delivery). Ultimately, the buyer could depend upon on-time delivery from suppliers. Nowadays, due to the importance of JIT delivery by suppliers, it is considered as a key activity of lean manufacturing (Furlan et al., 2011b; Mackelprang & Nair, 2010; Matsui, 2007; Shah & Ward, 2007).

Lean manufacturing system requires suppliers' involvement in a production system. Ahmad et al. (2003) noted that it could contribute substantially to process enhancement and variance reduction. The involvement is very important to encourage suppliers to develop their capabilities in terms of product quality, product design, product development (Papadopoulou & Özbayrak, 2005) and continuous improvement (Schroeder, Bates, & Junttila, 2002). To ensure their involvement, supplier development programs should be regularly conducted by lean manufacturers (Jayaram et al., 2008; Kannan & Tan, 2005; Shah & Ward, 2007). Kaynak (2002) stated that lack of training for suppliers was a major obstacle to the employment of lean manufacturing. Hence, through supplier development programs, suppliers can be more involved in many parts of focal company's activities.

Another characteristic of supplier networks is long-term relationship with suppliers (Ahmad et al., 2003; Bayo-Moriones, Bello-Pintado, & Merino-Dı´az-de-Cerio, 2008; Boyle & Scherrer-Rathje, 2009). Several researchers proposed different expression for this practice, such as the long-term contract (Anand & Kodali, 2009; Anand & Ward, 2004; Bartezzaghi & Turco, 1989), long-term arrangements with suppliers (Flynn, Schroeder, & Flynn, 1999; Sakakibara et al., 1993), long-term commitment with suppliers (Matson & Matson, 2007), and long-term agreement with suppliers (Abdallah & Matsui, 2007; Matsui, 2007). Lean manufacturing requires a steady production system. Therefore, manufacturer (or buyer) needs to select reliable suppliers to ensure superior quality of product as well as to keep lower costs.

Several scholars, such as Matson and Matson (2007), Rahman et al. (2010), Shah and Ward (2007), and Kannan and Tan (2005) suggested to maintain long-term relationship with a small number of suppliers that have been proven credible, certified for quality, and high performance. In line with this suggestion, Forza (1996) recommended that manufacturer (buyer) should consider whether the suppliers are certified for quality or not. In other words, suppliers should be selected based on quality standards. Through this activity, buyer can ensure high quality of product without performing any inspection. This could be realized because suppliers can assure that quality specifications have been met before the products are delivered (Singh, Garg, & Sharma, 2010a). Other than that, long-term relationship with a smaller number of suppliers can result in a better channel of communication, require less paperwork, and operate at lower coordination costs (Matson & Matson, 2007). Moreover, Kaynak (2002) described that several aspects, such as enhanced quality of incoming materials, improved product quality, reduced delivery lead time, and increased productivity, are important benefits of long-term relationship with fewer suppliers.

Based on the discussion above, there are nine important practices of lean manufacturing proposed in this study. All the practices and its related activities may contribute to the success of its implementation to enhance organizational performance. The next section discusses possible interaction among the practices.

2.5 Interrelationship among Lean Manufacturing Practices

Lean manufacturing was conceptualized as a combination of manufacturing practices, which are attempted to eliminate waste in a production system. Several researchers, such as Dal Pont et al. (2008), Furlan et al. (2011b), Hofer et al. (2012), and Shah and Ward (2003, 2007), noticed that the distinct practices of lean manufacturing should work together as a system. When all practices work together, they would contribute significantly to performance. Feld (2001) explained the concept of holistic implementation of lean manufacturing practices. According to him, the holistic implementation implies inter-connectivity among the practices. Hence, the practices should be implemented holistically to realize its benefits.

More importantly, Dal Pont et al. (2008), Furlan et al. (2011a), and Furlan et al. (2011b) intensively investigated the concept of lean manufacturing bundles. They found lean manufacturing practices are mutually supportive. In other words, the total effect of the practice as a set is higher than piecemeal adoption. In short, simultaneous implementation of the practices is preferable, instead of implementing them separately or in limited subsets. Recently, Hofer et al. (2012) empirically examined the synergic effect of lean manufacturing bundles on inventory leanness and financial performance. The finding of the study supported the evidence that concurrent implementation of lean manufacturing practices leads to the superior performance, instead of piecemeal adoption or partial implementation.

After establishing the lean manufacturing practices, the next section will discuss organizational performance and its common measures.

2.6 Organizational Performance

Implementation of lean manufacturing practices is addressed to achieve a set of goals (e.g., certain type of performance). Performance itself was defined as a set of achievement gained after implementing a set of practices. Measuring performance means assessing achievements resulted from implementation of a set of practices (Neely, Gregory, & Platts, 2005). In other words, performance measurement is a process in assessing progress towards achieving predetermined objectives. Through the measurement, a company evaluates and improves its production processes. Assessing the achievements appropriately is a critical aspect within a company. Inappropriate performance measures may affect not only to undermine but also to misrepresent company's efforts (Upton, 1998).

In its history, performance measurement system underwent revolution, as explained by Neely et al. (2005) and Ghalayini and Noble (1996), from a purely financial emphasis to comprise more comprehensive business characteristics. According to Ghalayini and Noble (1996), development of performance measurement was divided into two phases. The first phase purely emphasized financial performance measures such as profit, return on investment (ROI), price variances, return on sales, and sales per employee. Shop floor performance was formally reported as financial outcomes (Abdel-Maksoud, Dugdale, & Luther, 2005). Argued by Schonberger (1996), financial data were not the best measures of manufacturing company strength and prospects. As non-financial indicators (such as quality, flexibility, etc.) cannot be quantified accurately, financial performance measures may produce misleading information that could undermine achievement of a company's strategic objectives (Bhasin, 2008). Thus, it does not suit for strategic decisions. In other words, financial performance may not be relevant to practices, because it is attempted to quantify performance in financial terms, since most of the improvements in the shop floor are unsuitable to be quantified in dollars (Ghalayini & Noble, 1996). Hence, traditional performance measures may not support continuous improvement efforts in a plant.

In the second phase of its revolution, after 1980s, various scholars, most notably Kaplan and Norton (1992) claimed that weaknesses of the traditional performance measurement system can be overwhelmed with a balance set of measures, including four perspectives namely financial (how does a firm look at its shareholder?), internal business (what must a firm excel at?), customer (how do customers see a firm?), and innovation and learning (how can a firm continue to improve and create values?). This technique was well-known as *"balanced scorecard"*. It seems that the balanced scorecard can provide a more comprehensive method to performance measurement (Neely et al., 2000). They stated that although the importance of non-traditional measures had been taken into account, there was no single opinion regarding how the performance should be measured, little guidance on how proper indicators can be recognized, introduced and eventually used to manage the business, since there is a need to manage company's performance in more effective and accurate ways.

In attempting to formulate dimensions to measure organizational performance, a number of studies related to organizational performance were reviewed, such as Combs et al. (2005), Venkatraman and Ramanujam (1986), Chang and Lee (1996), Bartezzaghi and Turco (1989), Arif-Uz-Zaman and Ahsan (2014), etc. The studies tended to suggest a distinction between operations performance and business performance. In other words, operations performance is a separate construct from business performance. Operations performance and business performance as a whole was defined by Bartezzaghi and Turco (1989), Chang and Lee (1995) and Jeyaraman and Leam (2010). They defined operations performance as achievement that is influenced by operating conditions (such as lead time, quality, productivity, cost, inventory and flexibility) and represents performance at each production resource level, or reflects some internal properties of the production system. Whereas, business performance may be regarded as a higher level in the hierarchy of objectives looking at business as a whole instead of operations level. In other words, operations performance may be an antecedent to business performance (Combs et al., 2005).

Pertaining to lean manufacturing, Chang and Lee (1996) and Upton (1998) noted that its implementation would have a profound effect on an organization. Major operational changes will occur after its implementation. As mentioned earlier, lean manufacturing practices are more frequently implemented in shop floors. It is associated to production processes. Thus, it seems that the use of operations performance measures is more useful in lean manufacturing environments. Achievement in operations performance influences performance at the business level. Hence, operations performance may intervene or mediate the relationship between resources (e.g., manufacturing strategies like lean manufacturing practices) and business performance (Bartezzaghi & Turco, 1989; Combs et al., 2005; Ray et al., 2004).

Several studies have been conducted by practitioners and academicians to investigate the effect of lean manufacturing on performance. Based on the previous empirical studies, various performance measures have been chosen to measure the performance gained after lean manufacturing implementation. Following Bartezzaghi and Turco (1989), Chang and Lee (1995), Combs et al. (2005), and Ray et al. (2004), this study divides the performance into two levels; operations performance and business performance. These variables mainly implied when discussing lean manufacturing performance. The measures such as quality, manufacturing flexibility, lead time reduction, inventory minimization, productivity and cost reduction were commonly used in recent studies as indicators of operations performance. Profitability, sales, and customer satisfaction are the most frequently selected measures of business performance. Subsequently, indicators of each performance variable are presented.

2.6.1 Measures of Operations Performance

As earlier explained, this study defined operations performance as achievement that is influenced by operating conditions and characterizes achievement at each production resource level. Hence, it reveals some internal properties of a production system. Even though several studies have attempted to investigate the profound effect of lean manufacturing on operations performance, each study offered different set of operations performance measures. Thus, consensus regarding the indicators to be used to assess performance at operations level is still lacking. Considering this fact, this study summarized measures used in a number of previous studies, and compiled them into a set of common operations performance measures, as presented in Table 2.2. Each measure will subsequently be expounded.

Table 2.2
Measures of Operations Performance

Performance Measures	Literature
Quality	
Quality of product conformance	2, 3, 7, 10, 14, 15, 17, 24, 25, 28
Defective product at the final assembly	1, 4, 6, 12, 16, 22, 26, 28
Scraps	1, 4, 5, 6, 12, 19, 22
Reworks	1, 5, 6, 12, 19, 22
Customer complaints and claims	1, 6, 11, 12, 28
First-pass quality yield	9, 10, 26
Manufacturing flexibility	
Volume flexibility	1, 2, 3, 11, 12, 14, 15, 17, 20, 22, 24, 25, 26, 28
Product mix flexibility	1, 2, 7, 10, 12, 14, 15, 16, 17, 20, 22, 25, 26, 28
Flexibility in work assignment to workers	4, 5, 6, 7, 8, 11, 12, 15, 21, 22, 28
Routing flexibility	9, 11, 18, 19, 22, 26
Supply flexibility	7, 11, 14, 15, 22, 28
Flexibility in work assignment to machines	18, 19, 22, 26
Lead time reduction	
Processing time	1, 3, 4, 5, 6, 9, 10, 11, 12, 14, 15, 16, 19, 22
Machine setup time	1, 3, 4, 5, 6, 10, 19, 22, 26
Transportation time	1, 3, 4, 5, 6, 10, 19, 22
Waiting time	1, 3, 4, 5, 6, 10, 19, 22
Delivery time to customers	12, 18, 22, 26
Delivery from suppliers	11, 14, 17, 18
Inventory minimization	
Inventory turnover	3, 10, 14, 15, 16, 19, 22
WIP inventory level	1, 2, 5, 6, 16, 22, 28
Raw material inventory level	1, 2, 4, 5, 6, 16, 22
Finished goods inventory level	1, 2, 4, 5, 6, 16, 22
Storage space requirement	8, 13, 14, 18, 20, 26
Over productions	11, 14, 24
Productivity	
More efficient setup processes	4, 5, 7, 8, 13, 14, 15, 17, 18, 19, 22, 26, 28
Higher production worker flexibility	4, 5, 6, 7, 8, 11, 12, 15, 21, 22, 28
Reduced inputs	5, 7, 13, 15, 21, 23, 26, 27
Shorter processing times	5, 6, 11, 12, 14, 19, 28
More efficient production processes	5, 6, 8, 11, 15, 20
Fewer interruptions by the machine breakdown	14, 15, 26, 28
Higher equipment flexibility	18, 19, 22, 26
Cost reduction	
Unit cost of manufacturing	3, 6, 7, 10, 15, 16, 17, 21, 22, 23, 24, 25, 28
Internal failure costs	9, 10, 16, 21
External failure costs	9, 10, 16, 21
Inventory costs	11, 15, 23
Labor costs	4, 11, 28

Note. 1 = Lee and Paek (1995); 2 = Chang and Lee (1995, 1996); 3 = Sakakibara et al. (1997); 4 = Callen et al. (2000); 5 = Fullerton and McWatters (2001); 6 = Chong et al. (2001); 7 = Ahmad et al. (2003); 8 = Fullerton et al. (2003); 9 = Shah and Ward (2003); 10 = Ahmad et al. (2004); 11 = Olsen (2004); 12 = Abdel-Maksoud et al. (2005); 13 = Kannan and Tan (2005); 14 = Abdallah and Matsui (2007); 15 = Matsui (2007); 16 = Bhasin (2008); 17 = Dal Pont et al. (2008); 18 = Jayaram et al. (2008); 19 = Fullerton and Wempe (2009); 20 = Hallgren and Olhager (2009); 21 = Jeyaraman and Leam (2010); 22 = Mackelprang and Nair (2010); 23 = Rahman et al. (2010); 24 = Furlan et al. (2011a); 25 = Furlan et al. (2011b); 26 = Taj and Morosan (2011); 27 = Yang et al. (2011); 28 = Chen and Tan (2011).

2.6.1.1 Quality

Recently, manufacturing environment has been substantially changed; cost minimization is not the only one factor should be in manufacturer's mind. Nowadays, quality is increasingly becoming a major issue for today's business, not only in manufacturing companies but also service companies. It has been one of the most discussed topics in literature to measure companies' operations performance. Several studies (see Table 2.2) linked lean manufacturing with quality performance. Quality of product conformance was one of the popular quality measures used in the past studies. It is not surprisingly as Neely (2007) defined quality in terms of conformance to pre-determined specification. It refers to how consistent a product meets the pre-determined specifications (Flynn et al., 1999). More specific, it describes compliance of every single product with design specification (Bartezzaghi & Turco, 1989).

Following Bartezzaghi and Turco (1989) and Chong et al. (2001), in this study, it is important to assess the quality of product conformance both in the house (defects occurring in the plant, in terms of defect/reject, scrap, rework) and in the field (defects occurring after sale but within the warranty period, in terms of customer complaints and warranty claims). Chong et al. (2001) used the terms internal quality and external quality to express these quality performance measures. In addition, the present study also assesses quality performance in terms of yield (Ahmad et al., 2004; Shah & Ward, 2003; Taj & Berro, 2006; Taj & Morosan, 2011). Yield refers to the percentage of products that pass final inspection the first time. It is quantified as the sum of the percentage of products started in a process that will turn out to be good quality plus the percentage of the defects that are successfully reworked (Russell & Taylor, 2008).

2.6.1.2 Manufacturing Flexibility

Other than perfect quality, firms are currently seeking alternative sources of competitive advantage (i.e., flexibility). Russell and Taylor (2008) commented; *"flexibility has become a competitive weapon."* Recently, there have been a significant increasing number of companies concentrating to increase flexibility in order to survive in worldwide competition. Generally, Stevenson (2012) defined flexibility as an ability to respond to change. Change may be related to product, volume, routing, equipment, labor and supply. It may also reflect firm's agility, adaptability, and responsiveness.

In the operations level, achieving greater manufacturing flexibility is one of the critical target areas of lean manufacturing implementation. However, it seems that there was no consensus regarding the element of manufacturing flexibility attempted to be achieved from lean manufacturing implementation. Furlan et al. (2011b) assessed flexibility performance in terms of flexibility to change product mix and flexibility to change volume. Cheng and Podolsky (1993) also stated that organization could consider flexibility on four levels; adjustment to change volume, modification of the product mix, equipment flexibility, and employee flexibility. Furthermore, concern to the manufacturing flexibility, Rogers (2008) included six components constituting flexibility, namely product mix flexibility, routing flexibility, equipment flexibility, labor flexibility, volume flexibility, and supply flexibility. Following Rogers (2008), this study chose six elements as indicators of manufacturing flexibility. This decision was because the practices of lean manufacturing proposed in this study tend to affect all the selected indicators of manufacturing flexibility as follows:

1. Volume flexibility. It refers to a capability to change production volume/capacity.

2. Product mix flexibility. This is a capability to switch between products. It includes an ability to quick and easy changeover between current products, modification of the products, and newly designed products.

3. Routing flexibility. It is the capability to reroute the production flow for better workload balance and to handle disturbance.

4. Flexibility in work assignment to machines. It refers to the ability of assigning different types of operations/jobs to the machines.

5. Flexibility in work assignment to production workers. It means the ability of assigning different jobs to production workers.

6. Supply flexibility. It is related to the ability of suppliers to alter order quantities without increasing lead times and costs. It includes their ability to deliver frequently as well as expediting orders without considerably increasing lead time and costs.

2.6.1.3 Lead Time Reduction

Lead time was recognized as an important measure of operations performance. Tersine (1994) stated that lead time can take on different meanings depending on the range of activities included in the interpretation. It may apply to particular operations, individually or collectively. Lead time may refer to flow time (Feld, 2001), throughput time (White & Prybutok, 2001; Zelbst et al., 2010) and cycle time (Olsen, 2004; Tersine, 1994). Christiansen, Berry, Bruun, and Ward (2003) assessed lead times in three different categories, namely purchasing lead time, manufacturing lead time, and delivery lead time (lead time to customers). Purchasing/procurement lead time was defined as the times between placing an order to supplier and receiving purchased items from the supplier (Jayaram & Vickery, 1998). Manufacturing lead time is the times that particular item spends on the production line from its first entrance until its completion (Singh et al., 2010b). In other words, it is the total manufacturing time needed to perform all necessary operations exclusively in the plant, from the start of the earliest to the completion at the last (Tersine, 1994). Delivery lead time is the times between the finished goods picked up from manufacturer and delivered to customers (Wu, 2003). Considering the types of lead time covers the cumulative lead times as defined by Gaither and Frazier (2002). It was defined as the amount of time to get the materials in from suppliers, produce all the parts and assemblies, and delivered to customers (Gaither & Frazier, 2002).

Related to manufacturing lead time, the present study considers it as the cumulative of times from the beginning until the completion of the processes. Tersine (1994) and Cheng and Podolsky (1993) divided this lead time into five elements, namely setup time, processing time, waiting time, move time, and queuing time. Similarly, Russell and Taylor (2008) considered lead time constituting four elements. They are setup time, processing time, moving time, and waiting time. All the components of lead time are defined as below:

1. Setup time; the time required in preparing equipment, materials and workstations for an operation. It can be reduced by conducting most of the setup activities externally that can be done while equipment is in operation.

2. Processing time; the time required to perform productive/value added operations. This can be shortened through reducing the number item processed and increasing efficiency of equipment and workers.

3. Waiting time; the time waiting for a part to be moved to the subsequent operation. It can be decreased through well scheduling of materials, equipment, and workers.

4. Moving time; the time required for transportation from storage to storage, or between workstations. Moving time reduction is possibly achieved if the machines are located closer together, movement is simplified, routing is customized, and layout can be reconfigured easily.

This study attempts to measure manufacturing lead time in terms of setup time, processing time, move time and waiting time. In addition, to have the more comprehensive analysis on the lead time, the present study adds two measures of lead time, namely (1) purchasing lead time, referring to the times between placing order and receiving purchased items from suppliers (Stevenson, 2012), and (2) delivery lead time, comprising the time required to move finished goods from the plant to customers (Angelis, Conti, Cooper, & Gill, 2011; Rogers, 2008; Wu, 2003).

2.6.1.4 Inventory Minimization

One of the strategic goals of lean manufacturing implementation is to minimize waste incurred by existence of inventory. There are certain indicators used in the previous studies to measure inventory performance, such as inventory turnover (Fullerton & Wempe, 2009; Mackelprang & Nair, 2010) and inventory levels (Bhasin, 2008; Claycomb, Dröge, & Germain, 1999). Taj (2005, 2008) also postulated inventory level and inventory turnover as two common measures of inventory performance. Inventory level was frequently explained in terms of raw materials, WIPs, and finished goods.

Inventory turnover refers to cycle of using and replacing goods in inventory (Tersine, 1994). In other words, it is the ratio of average cost of goods sold to average inventory investment (Stevenson, 2012). This ratio shows how many times a year the inventory sold. The ratio is expected to be high, because the higher the inventory turnover ratio, the more efficient the inventory. However, according to Stevenson (2012), inventory turnover depends on types of industry and profit margin of the item. The higher the profit margin, the lower the expected inventory turnover of the items, and vice-versa. In addition, the items that require long time to manufacture, or long time to sell, tend to have low inventory turnover rate. Cumulatively, inventory turnover can be measured as ratio of annual cost of goods sold and average aggregate inventory value (Tersine, 1994). Costs of goods sold are costs incurred to make a product, including direct labor, direct material, and factory overhead. Aggregate inventory value is defined as the accumulated monetary value (in dollar) for the year of all categories of inventory (operating supplies, raw materials, WIPs, and finished goods).

Other than inventory level reduction (in terms of raw material, WIP, and finished goods inventory) and inventory turnover as discussed earlier, it is essential to include other measures to indicate inventory performance, such as reduction in overall inventory level (Balakrishnan, Linsmeier, & Venkatachalam, 1996; Claycomb et al., 1999), reduction in storage space requirement (Gurumurthy & Kodali, 2009), and reduction in over production (Garbie, 2010; Wong, Wong, & Ali, 2009).

2.6.1.5 Productivity

Revolution on the performance measurement system from purely financial in the traditional approach to the balancing between non-financial and financial measures in the non-traditional approach has trapped productivity into a problematic performance measure. Ahmad et al. (2004) argued that productivity tends to emphasize performance to a standard and may encourage overproduction through maximizing output from any one machine or operator. They tended to presume that productivity measure such as labor productivity and machine utilization may encourage production workers to work in short-time results and discourage process improvement and thus, may mislead from the objective of lean manufacturing (e.g., inventory reduction). Even, Chenhall and Langfield-Smith (2007) highlighted the importance of replacing the productivity measures (i.e., labor productivity and machine utilization) with other performance measures, such as quality and inventory reduction in new manufacturing environment.

Although productivity was often criticized, it is currently still maintained as one of the important measures to evaluate the success of lean manufacturing implementation (Fullerton & Wempe, 2009; Jeyaraman & Leam, 2010; Rahman et al., 2010; Shah & Ward, 2003). The importance of this measure was supported by Ahuja and Khanba (2007) by arguing that recent competitive era has been pushing manufacturers to concern on increasing productivity, resources utilization and equipment utilization. Furthermore, the ultimate benefit from a sound productivity is to enhance the outstanding profitability.

In general, productivity was defined as the ratio between two variables; system's outputs and its inputs. It indicates the relationship between quantity of outputs and its inputs. The high ratio is preferable because it indicates high efficiently of the use of inputs (e.g., workers, costs, materials, capital, technology, etc.) to produce outputs. Productivity is a measure of how effectively resources are used to produce various goods (Taj & Berro, 2006). Productivity is improved by producing more with the same amount of resources or fewer. Hence, if a company wants to increase productivity, it has to increase the outputs as well as decrease the inputs. Otherwise, it is necessary to increase the outputs if the inputs are still maintained constant. Another way, productivity can be increased by decreasing the inputs used to produce the outputs. The last option was reported by Ferdousi and Ahmed (2010) who stated that well-organized manufacturer (e.g., lean manufacturing company) should perform better in achieving higher productivity with fewer inputs and efforts. Relevant to lean manufacturing, which focuses on reducing the use of inputs in production processes, this study emphasizes to measure productivity related to inputs' usage minimization rather than to outputs' maximization.

In this study, several factors related to the input minimization are considered as determinations of production line productivity. Reduction in the machine breakdown, reduced inputs, more efficient setup processes (Lieberman & Demeester, 1999) and more efficient production processes (Agus & Hajinoor, 2012; Lewis, 2000) would increase the production line productivity. At the same time, improvement worker flexibility (Abdel-Razek et al., 2007; Rogers, 2008) will also subsequently increase productivity of the production line. By reducing machines break down; production line requires fewer workers, less equipment idleness, and higher machine utilization. Furthermore, reduction in inputs means that production line requires less material, labor, capital, and energy. More efficient setup processes would also lead to higher machine utilization, low labor cost, and shorter processing time. Efficient production processes cut operational costs as well as decrease the required resources. In addition, higher labor flexibility helps to decrease setup times, lead times, scraps, reworks, all types of inventory and costs. Subsequently, according to Rogers (2008), they are expected to increase worker productivity and machine utilization.

2.6.1.6 Cost Reduction

One of the determinant factors of company's sustainability is to produce at a minimum cost. It was frequently mentioned in previous studies as an indicator of successful of lean manufacturing implementation. Lean manufacturing as the collection of practices for eliminating waste would lead to the better cost's performance. Extensive literature review indicates that cost performance was commonly assessed in terms of unit manufacturing cost (Ahmad et al., 2003; Chen & Tan, 2011; Dal Pont et al., 2008; Matsui, 2007) and cost of poor quality (COPQ) (Gurumurthy & Kodali, 2009).

In the present study, unit manufacturing cost was defined as the total cost for producing the units divided by the quantity of units produced. Since, COPQ is defined as the alteration between what it essentially costs to produce a product and what it costs if there were no defects (Russell & Taylor, 2008). Literature (such as Chang and Lee (1995), Heizer and Render (2011), and Slack et al. (2010)) classified COPQ into internal failure costs and external failure costs. Internal failure costs are the costs related with process failure, rework, scrap, price reduction and downtime, whereas external failure costs are caused by returns, complaints, liability, warranty claims, and lost sales. In addition, to provide more comprehensive analysis, the present study also incorporated overall inventory cost (Rahman et al., 2010; Rogers, 2008) and labor cost (Hirano, 2009; Lieberman & Demeester, 1999) as indicators of cost reduction.

2.6.2 Measures of Business Performance

Business performance comprises actual outputs of an organization looking into an organization as a whole instead of at the operational level. Several studies linked lean manufacturing implementation with business performance. Table 2.3 lists favorable business performance measures compiled from a number of previous studies. They are profitability (Agus, Hassan, & Zainnuddin, 2011; Jayaram et al., 2008; Jeyaraman & Leam, 2010; Yang et al., 2011), sales (Agus & Hajinoor, 2012; Bhasin, 2008; Green & Inman, 2007; Yang et al., 2011), and customer satisfaction (Bhasin, 2008; Kannan & Tan, 2005; Rahman et al., 2010). In the following sections, the measures of business performance are discussed.

Table 2.3
Measures of Business Performance

Performance Measures	Literature
Profitability	
Net profit margin	1, 3, 4, 6, 8, 9, 12, 14, 16, 17
Overall financial performance	3, 6, 8, 9, 12, 14, 15, 16, 20, 21
Return on investment	5, 8, 9, 11, 12, 15, 20, 21
Profitability growth	12, 16, 17
Sales	
Sales achievement	3, 4, 6, 9, 12, 14, 15, 16, 21
Market share	9, 11, 12, 14, 17, 18, 21
Sales growth	1, 9, 12, 18, 21
Market share growth	9, 11, 12, 14
Customer satisfaction	
Satisfaction on overall quality of products	10, 11, 12, 14, 17, 19
Satisfaction on delivery lead time	7, 10, 12, 14, 19
Satisfaction on response to sales enquiries	4, 11, 12, 14, 19
Satisfaction on product's competitive price	10, 12, 14, 19
Satisfaction on after sales service	2, 8, 10, 13, 14

Note. 1 = Chang and Lee (1995, 1996); 2 = Sakakibara et al. (1997); 3 = Callen et al. (2000); 4 = Fullerton and McWatters (2001); 5 = Chong et al. (2001); 6 = Fullerton et al. (2003); 7 = Shah and Ward (2003); 8 = Ahmad et al. (2004); 9 = Olsen (2004); 10 = Abdel-Maksoud et al. (2005); 11 = Kannan and Tan (2005); 12 = Green and Inman (2007); 13 = Matsui (2007); 14 = Bhasin (2008); 15 = Jayaram et al. (2008); 16 = Fullerton and Wempe (2009); 17 = Jeyaraman and Leam (2010); 18 = Mackelprang and Nair (2010); 19 = Rahman et al. (2010); 20 = Taj and Morosan (2011); 21 = Yang et al. (2011).

2.6.2.1 Profitability

Prior studies have investigated how well a company in generating profits by using several criteria, such as net profit margin and ROI (Stratopoulos & Dehning, 2000). Following Stratopoulos and Dehning (2000), net profit margin measures income from current operations per dollar of sales, which is calculated by dividing net income from continuing operations (after interests and taxes) with total net sales. ROI measures profitability of the investment based on total investment, both debt and equity (Stratopoulos & Dehning, 2000), which specifies how efficient a company is at using its assets to create earnings (Finch, 2008). It is computed by dividing net income (after interests and taxes) with total invested capital (Stratopoulos & Dehning, 2000). These two measures were selected because lean manufacturing affected factors contributing the profitability measures such as sales (Green & Inman, 2007; Yang et al., 2011) as well as income. In addition, these measures were widely accepted as a measure of profitability (Stratopoulos & Dehning, 2000).

Besides net profit margin and ROI, this study was interested to assess profitability growth among the samples of the study. The rational of selecting this measure was because profitability growth is recognized as an objective of firms (Chenhall, 1997), each company attempts to have better profitability from year to year. Chenhall (1997) argued that profitability growth was a rigorous test as companies covered under study are involving in the global market competition.

It seems valuable as this study uses all the measures mentioned earlier (i.e., net profit margin, ROI, profitability growth, and overall financial performance) to assess profitability performance. These measures are hoped to provide a comprehensive view regarding the profitability of the companies under investigation.

2.6.2.2 Sales

One of the expected benefits of lean manufacturing implementation is superior sales performance. Numerous prior studies exerted market share, sales growth (Ahmad et al., 2004; Anand & Ward, 2004; Green & Inman, 2007; Olsen, 2004), sales turnover (Clark, 2007; Küster & Canales, 2011), average annual sales per product model (MacDuffie, Sethuraman, & Fisher, 1996; Rogers, 2008; White & Prybutok, 2001), and ability to achieve annual sales target (Kaynak, 2002) as the measures of sales performance.

Market share indicates a proportion of total obtainable market that is being served by a company, whereas sales growth refers to the increasing in sales over a specific period of time, which was often indicated by the average of the change in sales from previous year divided by sales in the previous year (Maiga & Jacobs, 2008). Hence, sales growth indicates performance with respect to increasing revenue over the previous year. Olsen (2004) stated that sales growth provided a sense of how well a company in enhancing market share over its competitors. Sales growth was commonly represented as sales volume growth and sales in dollar growth (Green & Inman, 2007; Rogers, 2008). As a sales performance indicator, sales turnover represents the total amount sold within a specific period (Clark, 2007). It suggests a company to achieve higher level of sales by doubling sales in the next time period, and of course, it encourages a company to work more intensively. In addition, average annual sales per product model tells ability to sell of each type of product.

2.6.2.3 Customer Satisfaction

To understand the customer satisfaction, it is necessary to distinct between customers' expectations and their perceptions. According to Ismail, Haron, Ibrahim, and Isa (2006), customers' satisfaction or dissatisfaction is resulted from experiencing services or products and comparing that experience with what they were expected.

Customers are satisfied when their expectation regarding services or products had been met or exceeded (Krajewski & Ritzman, 2005). In other words, if the products and services meet their expectation, then the customers are well satisfied. Satisfied customers tend to be more loyal and remain with the products and services for a long time, and more importantly; they will recommend new customers to buy and use the products and services. On the other hand, the unsatisfied customers tend to seek other alternatives from the competitors, and sometimes build bad image regarding the products and services.

A meta-analysis by White (1996) proposed a set of variables that influence customer satisfaction, including quality (product and service quality), delivery speed, delivery dependability, cost, flexibility and innovation. These variables seem to be antecedent to customer satisfaction. Chenhall and Langfield-Smith (2007) suggested that there is no specific way to measure customer satisfaction, it can be measured in various ways. According to Franceschini, Galetto, Maisano, and Mastrogiacomo (2008), the indicators used should have direct relationship with customer needs. Radnor and Barnes (2007) also revealed the important role of operations in achieving customer satisfaction. Thus, this study was interested to assess customer satisfaction related to overall quality of products, products' competitive price, responsiveness to sales enquiries, after-sales service, fast delivery, and on-time delivery.

2.7 Effect of Lean Manufacturing on Organizational Performance

Based on previous studies, the following sections will discuss potential effects of lean manufacturing on organizational performance. In order to obtain a more comprehensive viewpoint, review on literature regarding the effect of lean manufacturing on each measure of performance variables will also be elaborated.

2.7.1 Effect of Lean Manufacturing on Operations Performance

Several studies, such as Neely et al. (2000) and Abdel-Maksoud et al. (2005), highlighted the importance of operations performance measures in lean manufacturing environment. This is because by evaluating, controlling, and improving operational measures, companies will be able to improve their operational condition continuously. However, although many researchers have looked into the effect of lean manufacturing on performance, Chen and Tan (2011) noted that only few have examined its effect on operations performance, since Durden, Hassel, and Upton (1999) highlighted the importance of using operations performance measures as an integral component of the management control systems. In the same vein, Bartezzaghi and Turco (1989) stated that the main objective of operations strategy adoption (e.g., lean manufacturing), is to enhance operations performance instead of business performance, because improvement on operating condition may eventually increase business performance.

However, Fullerton and McWatters (2002) stated that there was an unclear specific link between lean manufacturing and operations performance. Hence, for the time being, still there is no single agreement regarding the aspects of operations performance that are potentially achieved after lean manufacturing implementation, it still remains much debate. The next sections explain the effects of lean manufacturing on each measure of operations performance based on evidence from recent literature.

2.7.1.1 Effect of Lean Manufacturing on Quality

The studies, such as Brown et al. (2007), Chen and Tan (2011), Mackelprang and Nair (2010), and Furlan et al. (2011b), have noted a positive significant effect of lean manufacturing on quality. It may be existed because it performs a stable manufacturing environment that allows for powerful quality control system. Furthermore, producing in a small number of items in each batch makes quality problems are easier to detect, and workers show fewer tendencies to let poor-quality pass (Fullerton & McWatters, 2001; Russell & Taylor, 2008).

More importantly, implementing quality control through quality at the source (e.g., visual control system, workers' authority to stop the production line, etc.), statistical quality control, and quality circle could directly affect quality performance. In addition, training on quality and employees involvement could enable companies to deliver high-quality improvement (Abdel-Maksoud et al., 2005). The ability of a company to deliver high quality of product is supported by the roles played by suppliers. Supplier selection should be emphasized on quality consideration, not only lead time and cost criteria. Ahmad et al. (2003) stated, working in mutually supportive and long-term relationship with suppliers is one of the best ways to achieve quality performance.

2.7.1.2 Effect of Lean Manufacturing on Manufacturing Flexibility

Nowadays, business environment is characterized by variations of customers' demand (Metternich, Böllhoff, Seifermann, & Beck, 2013). It is almost inevitable in today's volatile markets. Sometimes, a company may be challenged to cater for the product variety needed by customers. The manufacturers are indeed required to be flexible to respond to market changes, if they want to survive in the dynamic competition. According to Sangwan et al. (2014) and Hallgren and Olhager (2009), manufacturers must become flexible, adaptable, and responsive to market changes. In other words, it is crucial for manufacturers to enhance its ability to react to a changing demand; they must be able to adapt themselves to dynamic market situations.

As the goal of lean manufacturing is to become highly responsive to customer demand by reducing waste; through its implementation, it is expected that manufacturers could enhance its ability to respond to the changes (Stevenson, 2012). Implementation of lean manufacturing could help manufacturers to become more flexible (Hallgren & Olhager, 2009). Several studies engaged lean manufacturing practices and manufacturing flexibility. Most of them concluded that implementation of lean manufacturing significantly improves manufacturing flexibility (Agus & Hajinoor, 2012; Bayo-Moriones et al., 2008; Mackelprang & Nair, 2010). Bhamu and Sangwan (2014) and Chauhan and Singh (2013) revealed that lean manufacturers could grab benefits in terms of workers and machines' flexibility. Thus, the manufacturers are flexible in terms of assigning jobs to workers and machines. Taj and Morosan (2011) and Dal Pont et al. (2008) found a significant effect of lean manufacturing on flexibility, in terms of product mix and volume. Hence, it seems that there was a consensus that lean manufacturing leads to higher manufacturing flexibility.

2.7.1.3 Effect of Lean Manufacturing on Lead Time Reduction

Time-based competition had been coming (Koufteros et al., 1998). Shorter lead time has become a major source of competitive advantage for manufacturers across industries. Ability of a company in managing production time may determine a company's success in its competition. This ability may help a company to achieve higher profit, increase market share, improve customer satisfaction, and reduce risks (Koufteros et al., 1998). Due to the importance of the time performance, researchers such as Nahm et al. (2006) and Koufteros et al. (1998) have brought forward the idea of a time-based manufacturing system aimed to reduce the time required, not only in production processes but also in delivery to customers.

Lean manufacturing is aimed to ensure materials arrived just as needed, in the right quality, the right quantity, and the right time. There are several practices of lean manufacturing that could lead to the lead time reduction. Anand and Kodali (2009) concluded that shorter lead time can be achieved through uniform production level, especially workload balancing and standardize processes. Producing in small lot size also encourages shorter lead time, rather than producing in large lot size (Bartezzaghi & Turco, 1989). More importantly, reduction in setup time through the quick setups also resoundingly shortens the lead times (Callen et al., 2000). Other practices, such as the flexible resources, the use of cellular layouts, pull system, TPM, quality control, and supplier networks make sense to contribute to lead time reduction. This opinion was supported by several previous studies, such as Callen et al. (2000), Fullerton and McWatters (2001), Chong et al. (2001), Shah and Ward (2003), and Matsui (2007), who had confirmed the positive linkage between lean manufacturing and lead time.

2.7.1.4 Effect of Lean Manufacturing on Inventory Minimization

Inventory is viewed as one type of waste in a lean manufacturing system. Even, inventory can make other wastes invisible. *"Inventory is evil"*, this is a simple argument from Shigeo Shingo in Heizer and Render (2011). He further argued; *"if inventory itself* *is not evil; it hides evil at great cost."* These arguments gave a clue that inventories tend to hide problems and variability in the shop floor, and ultimately may incur the high costs. Several problems, such as lengthy setups, poor quality, process downtime, late delivery, inefficient layouts, and unreliable suppliers, are tolerated because of maintaining inventory in high level. Eliminating inventory exposes the hidden problems. When the problems are solved, manufacturing processes will run more smoothly without inventory, hidden problems, and variability. This was illustrated by Heizer and Render (2011) by the analogy of water flowing over a bed of rocks. Low inventory levels make a process more dependent on each other. Hence, it reveals problems in the shop floor more quickly and gives the worker opportunity to solve the problems.

Realize the importance of inventory minimization, it is well known that lean manufacturing emphasizes eliminating inventory. The primary effect of lean manufacturing is to increase inventory turnover (Fullerton & Wempe, 2009; Huson & Nanda, 1995; Mackelprang & Nair, 2010) as well as to reduce raw materials, WIPs, and finished goods (Bhasin, 2008; Claycomb et al., 1999). Balakrishnan et al. (1996) suggested that lean manufacturing adoption was commonly associated with reducing inventory levels and increasing inventory turnover leading to increase profitability.

Literature review indicates that inventory elimination can be achieved by ensuring all the required materials are produced just in time, in the right quality and quantity, not just in case. All practices of lean manufacturing proposed in the current study are believed to have a direct effect on inventory performance.

2.7.1.5 Effect of Lean Manufacturing on Productivity

Several studies concerning about implications of lean manufacturing on productivity have been conducted. Past studies, such as Ahmad et al. (2004), Bonavia and Marin-Garcia (2011), and Anand and Kodali (2009), supported that productivity was significantly affected by lean manufacturing practices. Furlan et al. (2011a) had shown the increasing productivity level after lean manufacturing implementation. Similarly, So and Sun (2010) revealed that by implementing lean manufacturing as daily practice, overall productivity could be increased. Reducing lot sizes enables a smooth production flow and allows faster replenishment of equipment and materials. It may shorten lead time and increase productivity (Wong et al., 2009).

Wong et al. (2009) and Ahuja and Khanba (2007) suggested that implementing TPM in a lean manufacturing system would lead to the better productivity because it prevents unexpected machine downtime. Furthermore, due to lean manufacturing attempts to increase manufacturing flexibility, according to Rogers (2008) and Dal Pont et al. (2008), once manufacturing flexibility increases, the labor productivity and machine utilization are also expected to increase. In addition, Agus and Hajinoor (2012) stated that reducing lead time, reducing storage space required may increase productivity. This is because lean manufacturing attempts to reduce lead time and storage space used for materials, WIPs, and finished goods.

2.7.1.6 Effect of Lean Manufacturing on Costs Reduction

In the competitive era, companies are striving to become a low-cost producer. Lean manufacturing as a collection of practices for reducing waste would lead to the better costs performance. It is possible, because cost reduction could be achieved through waste elimination and continuous pursuit of perfection. Not surprisingly, prior studies were interested to examine the relationship between lean manufacturing and costs reduction (Chen & Tan, 2011; Dal Pont et al., 2008; Jeyaraman & Leam, 2010; Mackelprang & Nair, 2010). The studies provided a strong consensus that there is a positive relationship between lean manufacturing and costs reduction.

Relevant to the consensus, Meredith (1992) argued, costs saving can be achieved easily through a number of ways, such as inventory reduction, producing superior product quality, less space required, and decrease labor hours. This argument was supported by Huson and Nanda (1995) who argued that efficient resources utilization may affect costs performance because it does not allow any waste existed within a production system. In the context of this study, all the nine lean manufacturing practices seem to have an effect on costs reduction.

2.7.2 Effect of Lean Manufacturing on Business Performance

As presented earlier, business performance comprises actual outputs of an organization viewing it as a whole, not just at operations level. A number of studies have assessed the effect of lean manufacturing on business performance, such as Agus and Hajinoor (2012), Losonci and Demeter (2013), Yang et al. (2011), and Moori, Pescarmona, and Kimura (2013). However, according to Agus and Hajinoor (2012) and Losonci and Demeter (2013), further investigations are still required in order to obtain a clearer picture about the relationship between the two variables. The next sections explain the effects of lean manufacturing on each measure of business performance.

2.7.2.1 Effect of Lean Manufacturing on Profitability

Achieving sustainable improvement in profitability is a goal of business activities. Several investigations have been conducted to ensure the effect of lean manufacturing implementation on the ability of companies to make a superior profit. The studies, such as Claycomb et al. (1999), Fullerton et al. (2003), Callen et al. (2000), and Green and Inman (2007), suggested a significant effect of lean manufacturing practices on profitability. Claycomb et al. (1999) found comparable results; lean manufacturing practices were positively associated with financial efficiency in terms of ROI, profitability, and profit margin. Somewhat similar, Agus and Hajinoor (2012) evidenced significant correlations between each indicator of lean manufacturing (i.e., continuous improvement program, pull system, shorter lead time, and small lot production) and profitability.

In addition, Mia (2000), Kinney and Wempe (2002), and Callen, Morel, and Fader (2005) compared profitability of lean and non-lean adopters. The studies provided scant evidence that lean adopters are more profitable than non-lean adopters. The evidence implied that companies those implemented lean manufacturing practices more comprehensive are more profitable. The higher the level of lean manufacturing implementation, the higher the profitability.

2.7.2.2 Effect of Lean Manufacturing on Sales

Nowadays, it is widely believed that superior performance in sales is a main driver and determinant factor of profitability. Several studies have scrutinized the effect of lean manufacturing on sales performance. Germain and Dröge (1997) linked lean manufacturing, especially JIT purchasing, to sales performance. The study provided evidence that lean manufacturing implementation increases sales volume and market share. Specifically, Agus and Hajinoor (2012) noted the significant correlations between each lean manufacturing practice (in terms of continuous improvement program, pull system, shorter lead time, and small lot production) and sales performance (in terms of market share and return on sales).

Regarding the positive effect of lean manufacturing on sales, Li, Ragu-Nathan, Ragu-Nathan, and Rao (2006) justified that lean manufacturers have a short time to market, quick product innovation, and fast delivery to market. Consequently, lean manufacturers could enjoy a higher market share and sales volume. This evidenced a consensus that lean manufacturing implementation significantly contributes to the higher sales performance.

2.7.2.3 Effect of Lean Manufacturing on Customer Satisfaction

In the global competitive market, one of the main objectives of companies is to satisfy the customers. Valmohammadi and Servati (2011) noted a positive relationship between customer satisfaction and market share. They found that increasing customer satisfaction led to increased purchases by customers, and subsequently led to increased market share. Ismail et al. (2006) also revealed that customer satisfaction on products and services delivered increased customer loyalty.

The companies implementing lean manufacturing should produce their products at lower costs and without compromising quality. At the same time, they are able to sell their products at competitive price, deliver the product quickly and on-time.

So that, according to Mia (2000), lean manufacturers could increase customer satisfaction. Subsequently, the companies can retain and increase sales performance and achieve financial objectives (Bhasin, 2008; Chenhall & Langfield-Smith, 2007). Empirically, a number of previous studies, such as Flynn et al. (1995), Sakakibara et al. (1997), Chong et al. (2001), and Green and Inman (2007), provided strong evidence that lean manufacturing significantly contributed to higher customer satisfaction. Hence, to enhance customer satisfaction, lean manufacturing is suggested to be well implemented.

2.7.3 Relationship between Operations Performance and Business Performance

To accommodate manufacturing strategies (e.g., lean manufacturing, TQM, flexible manufacturing and so forth), Chenhall and Langfield-Smith (2007) suggested to coordinate and combine operations performance and business performance measures within an integrative framework. Several studies have been conducted to clarify the relationship between operations performance and business performance. The study conducted by Said, HassabElnaby, and Wie (2003), van der Stede, Chow, and Lin (2006), Fullerton and Wempe (2009), and Agus et al. (2011), supported the contention that operations performance is significantly associated with business performance. The findings of the studies tended to support the idea that operations performance drives broader measures of business performance.

Agus et al. (2011) attempted to relate both of performance levels; operations performance and business performance. Operations performance was indicated by production effectiveness and production efficiency, whereas business performance was characterized by return on sales, return on assets, and profits. Applying SEM as the data analysis method, Agus et al. (2011) postulated that achievements in operations performance measures significantly contribute to the enhancement of business performance measures.

2.8 Interrelationship among Lean Manufacturing, Operations Performance and Business Performance

Several past studies, such as Agus and Hajinoor (2012), Fullerton and Wempe (2009), and Hofer et al. (2012), have examined the role of operations performance as a mediating variable of the relationship between lean manufacturing practices and business performance. Fullerton and Wempe (2009) provided substantial evidence that utilization of operations performance measures, such as equipment downtime, on-time delivery, inventory turnover, scrap, rework, labor productivity, setup time, manufacturing cycle efficiency, throughput time, and supplier performance (in terms of product quality and on-time delivery), mediate the relationship between lean manufacturing and profitability. The study indicated that there is no direct effect of lean manufacturing implementation on profitability; the effect does exist indirectly through operations performance as a mediating variable. The improved profitability may be driven by a measurement system that motivates behavior aligned with strategic objectives. This is possible, because lean manufacturing with its set of practice targets to achieve better performance through waste elimination. Lean manufacturing aims to reduce incidental works (non-value added activities) within a production system. Courtis (1995) stated that lean manufacturing strategy helped companies to increase net income and profitability through eliminating non-value added costs and increasing revenue. Costs reduction and revenue enhancement could be achieved through better operations performance measures, such as quality, manufacturing flexibility, productivity, inventory minimization and lead time reduction. Further, Fullerton and Wempe (2009) revealed that managers who implement lean manufacturing without utilizing supportive operations performance measures may experience disappointing financial results.

Equally important, a study by Agus and Hajinoor (2012) in the context of non-food manufacturing industries in Malaysia investigated the structural relationship between lean manufacturing supply-chain management practices, product quality, and business performance. Lean manufacturing (independent variable) was measured in terms of setup time reduction, continuous improvement programs, pull system, shorter lead time, and small lot size. Product quality performance (mediating variable) was assessed in terms of product conformance, product performance, product reliability, and product durability. In addition, profitability, market share, return on sales, and return on assets were assigned as business performance measures (dependent variable). The study revealed that lean manufacturing enabled the companies to enhance product quality performance and ultimately improve business performance.

Hofer et al. (2012) investigated the relationship among the three variables; inventory leanness as a mediator of the relationship between lean manufacturing and financial performance. Hofer et al. (2012) analyzed the relationship by combining both primary and secondary data. Lean manufacturing was assessed by using a survey questionnaire, whereas inventory data and financial performance were obtained from COMPUSTAT database (a database of financial, statistical and market information). They discovered that effect of lean manufacturing on business performance was partially mediated by inventory leanness. Lean manufacturing may affect business performance directly and indirectly (through inventory leanness as a mediator).

In the article attempting to investigate the effect of lean manufacturing, especially related to JIT purchasing, on sales and market share, Germain and Dröge (1997) stated that the increased sales and market share were because the market may reward the high quality of products, on-time delivery, lower and price. Similarly, Balakrishnan et al. (1996) highlighted the indirect effect of lean manufacturing on sales performance. They noted; the effect is because of the quality and processing time benefits. Balakrishnan et al. (1996) attributed the two benefits of lean manufacturing that concern to eliminate the waste in a production system.

In a similar perspective, Kaplan and Norton (1992) tended to suggest that companies could emphasize quality of products, lead time, delivery, and new-product introduction, which in turn, will lead to higher market share and sales, as well as lower operating costs. In addition, the company having a short time to market, rapid product innovation, and fast delivery to market, should enjoy a higher market share and sales volume (Li et al., 2006). From this perspective, it can be highlighted that improvement in operations performance (such as quality, manufacturing flexibility, lead time, productivity, and costs) provides a company a competitive advantage through increasing in sales and market share. In a similar vein, Parry, Mills, and Turner (2010), Ghalayini and Noble (1996), and Nahm et al. (2006) noted that better sales performance can be gained by improving production processes. Improved quality, flexibility, productivity, and reduced lead time and costs may provide opportunities to gain wider market share and better sales growth over the rivals who have poorer quality, flexibility, productivity, slower lead time, and higher costs. Finally, it allows the companies to compete more aggressive in global market and to gain superior sales and market share.

More importantly, related to customer satisfaction, reduction in lead time may influence other operations performance indicators, such as inventory level reduction, ability to deliver products to customers, and costs reduction. Subsequently, achievement in lead time performance would enable a company to respond rapidly to customer requests by shortening the time to make products and having them available to customers (Cheng & Podolsky, 1993). Thus, it will automatically increase responsiveness to customers' requirements (Bayo-Moriones et al., 2008). Afterward, it can increase customer loyalty and sales (Brown, Collins, & McCombs, 2006) and profitability (Balakrishnan et al., 1996). Afterward, it could sustain competitive advantage.

Based on the evidence presented earlier, it seems that there is a consensus regarding the effect of lean manufacturing practices on business performance. The effect tends to be indirectly through several factors related to the operations performance of a manufacturing system. The factors such as quality, flexibility, lead time, inventory, productivity, and costs may mediate the relationship between the two variables. Evaluating performance at the operational level could help a company to enhance its profitability, sales and customer satisfaction.

2.9 Chapter Summary

This chapter provided an extensive literature review on lean manufacturing, operations performance and business performance. First, this chapter was started with an overview on lean manufacturing. Researches on lean manufacturing in the context of Indonesia were subsequently explained. Next, core practices of lean manufacturing were reviewed. In attempting to relate the lean manufacturing and performance, measures of lean manufacturing performance, and the possible effect of lean manufacturing on both operations performance and business performance are discussed. Afterward, review on the relationships among the variables have also been carried out. On eventually, this chapter is summarized. The literature review provided a foundation to establish the theoretical framework as discussed in Chapter Three.

CHAPTER THREE
RESEARCH FRAMEWORK

3.1 Introduction

Literature review revealed that not much attention had been given to the linkages between lean manufacturing, operations performance, and business performance. This study attempts to understand the effect of lean manufacturing, not only on operations performance but also on business performance. The main objective of this chapter is to provide information about the concepts embedded in the study together with their definitions, set of indicators for measuring the concepts, theoretical framework, hypotheses, and related theories that are compatible with the study. For this aim, firstly, dimensions of each variable are explained. Secondly, the proposed theoretical framework is exhibited. Thirdly, the theories supporting the research framework are discussed. On eventually, research hypotheses are developed.

3.2 Operational Definition of Variables

Before measuring a variable, it must be ensured exactly what the variable is, because according to Creswell (2008), there are many possible definitions of the terms, such as dictionary definition. In research, researchers commonly used operational definitions to ensure a clear and concise detailed definition of measures. The definitions seem to be fundamental in all steps of the research, especially when preparing instrument, collecting data, and even in the step of data analysis and interpretation. Hence, operational definition is important in order to parry the chance of confusion and ambiguous meaning to the variables in a study that can be interpreted in different ways. In the context of this study, three major important concepts will be explained, namely lean manufacturing (independent variable), operations performance (mediating variable), and business performance (dependent variable).

3.2.1 Lean Manufacturing

This study defined lean manufacturing as an approach synergistically addressing to improve operations performance and business performance through waste elimination. To achieve its objective, a number of practices must be in place. Lean manufacturing practices refer to a set of strategic resources used to achieve goals of lean manufacturing implementation. Borrowing the argument of Goyal and Deshmukh (1992), Furlan et al. (2011a), Furlan et al. (2011b), Mehra and Inman (1992), and White and Prybutok (2001) as mentioned above, the potential benefits of lean manufacturing will not be grasped until its practices are implemented integrally. Considering the results of literature review as mentioned in Chapter Two, this study emphasized in measuring lean manufacturing by using nine practices as presented below:

1. Flexible resources. This is a lean practice addressed to increase flexibility in a manufacturing system through multi-skilled workers, multi-functional machines and equipment, and trainings for multiple tasks (Russell & Taylor, 2008).

2. Cellular layouts. Cellular layout is a practice aimed to increase flexibility by combining between flexibility of a process layout and efficiency of product layout based on the concept of group technology (Finch, 2008; Russell & Taylor, 2008).

3. Pull system. Pull system is a production concept in which production and material movement are performed when requested, and move to where it is needed just as it is needed, no less, and no more (Heizer & Render, 2011). This practice incorporates the use of kanban system to authorize production and material movement.

4. Small lot production. Small lot production is a practice addressed to produce in small quantity per lot. It aims to achieve the ideal lot size of one (Finch, 2008).

5. Quick setups. Quick setup is a practice aimed to reduce the time required to prepare machines or workstations to perform particular jobs (Cheng & Podolsky, 1993; Heizer & Render, 2011; Tersine, 1994). It ensures that shop floor can quickly perform setups if there is a change in process and its requirement. In addition, this practice also emphasizes trainings to perform quick setups.

6. Uniform production level. Uniform production level is a practice, which encompasses production leveling by volume and product types (Chase et al., 2004; Coleman & Vaghefi, 1994). It covers several activities, namely increasing accuracy of forecast, smoothing demand, mixed model production, and uniform workload.

7. Quality control. It comprises activities aimed to establish process and product quality (Fullerton et al., 2003) through identifying defects and drivers. It includes quality at the source, the use of statistical techniques, and trainings for quality control.

8. Total productive maintenance (TPM). TPM is a concept emphasized to maximize equipment effectiveness with a total system of preventive maintenance covering entire life of equipment involving everyone in all departments and at all

management levels (Imai, 1986). In addition, it also emphasizes trainings for maintenance activities.

9. Supplier networks. This refers to partnerships between manufacturers and suppliers with a goal of eliminating waste and reducing costs for mutual benefits (Heizer & Render, 2011). It includes JIT delivery by suppliers, suppliers' involvement, long-term relationship with suppliers, and supplier development program.

3.2.2 Operations Performance

Operations performance comprises the actual outputs of operations strategies employed, which are influenced by operating circumstances and represent or reflect internal properties of a manufacturing system (Bartezzaghi & Turco, 1989; Chang & Lee, 1995). A set of operations performance measures used in this study are as below:

1. Quality, in terms of quality of product conformance, defects, scraps, reworks, yield, warranty claims, and customer complaints.

2. Manufacturing flexibility, in terms of product mix flexibility, volume flexibility, routing flexibility, flexibility in work assignment to production workers, flexibility in work assignment to machines, and supply flexibility.

3. Lead time reduction, in terms of the times between placing order and receiving purchased items from suppliers, machine setup time, processing time, waiting time, moving time, and delivery time to customers.

4. Inventory minimization, in terms of inventory level (finished goods, WIPs, raw materials), inventory turnover, storage space requirement, and over production.

5. Productivity, in terms of overall productivity of production line, improvement in production line productivity due to fewer interruptions by machine breakdowns, shorter processing time, more efficient production processes, more efficient setup processes, reduced inputs (such as labor, material, and capital), more efficient setup, higher worker flexibility, and higher equipment flexibility.

6. Cost reduction, in terms of unit manufacturing cost, internal failure costs, external failure costs, overall inventory costs, and labor costs.

3.2.3 Business Performance

Business performance comprises the actual outputs of an organization looking at an organization as a whole. It is viewed as a higher level in the hierarchy of objectives, with operations performance as a mediating variable (Bartezzaghi & Turco, 1989; Chang & Lee, 1995). The following measures are examined in this study:

1. Profitability, in terms of net profit margin, ROI, profitability growth, and overall financial performance.

2. Sales, in terms of sales achievement, sales growth, and market share.

3. Customer satisfactions, in terms of overall quality of products, products' competitive prices, responsiveness, after-sales service, fast delivery time, and on-time delivery.

3.3 Theoretical Framework

Theoretical framework, as stated by Merriam (2009), is the underlying structure of a research. It informs concepts, expectations, and theories that support a research. Based on literature review and the above operational definitions, a mediation model was proposed in this study, including lean manufacturing as an independent variable, business performance as a dependent variable, and operations performance as a mediating variable. Specifically, the research framework suggested that lean manufacturing affects business performance directly and indirectly (through operations performance as a mediating variable. The related literature review led to a theoretical framework as displayed in Figure 3.1.

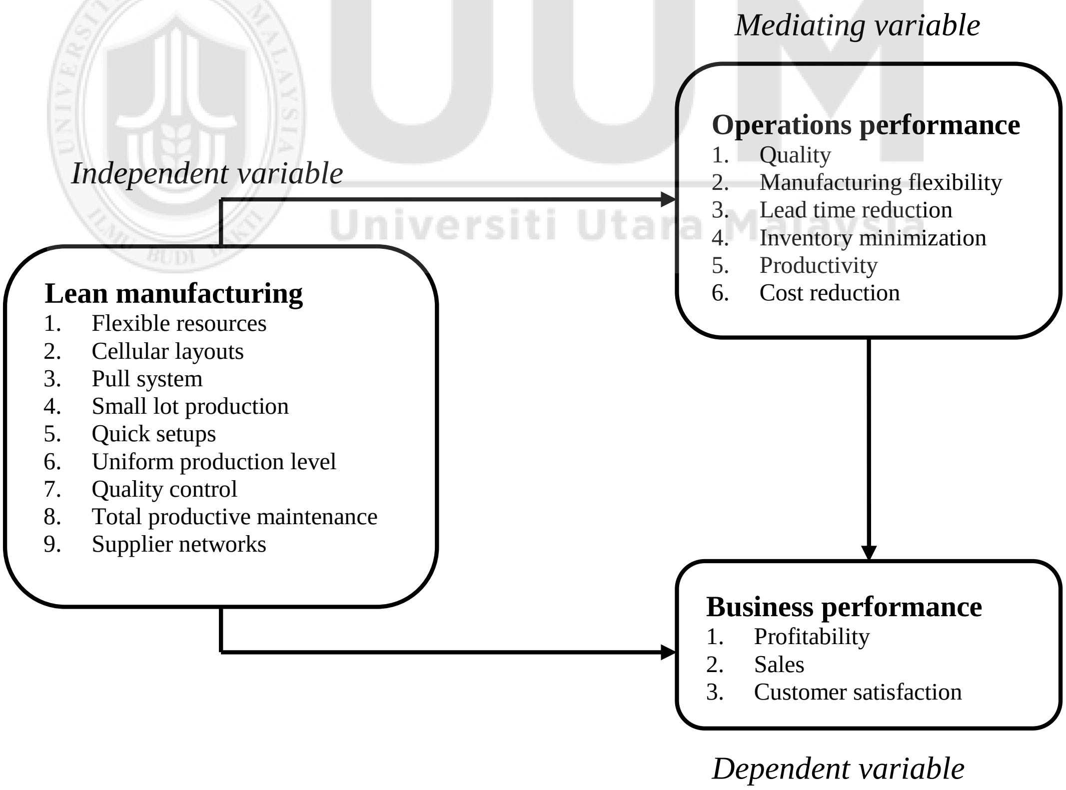

Figure 3.1
Theoretical Framework

3.4 Related Theories

Sekaran and Bougie (2009) postulated that a good research model should be based on a sound theory. A theory attempts to explain the logical linkage between the concepts/constructs in the research model, to guide the researcher to understand regarding the linkage between the concepts/constructs and how they affect with one another (Zikmund, Babin, Carr, & Griffin, 2010). At the same vein, Creswell (2009) well-defined a theory as *"an interrelated set of constructs (or variables) formed into propositions or hypotheses that specify the relationship among variables (typically in terms of magnitude or direction)."* Hence, a theory helps the researcher to explain and predict the relationship between the variables. In these attempts, the subsequent section discusses the related theories that underpin the model developed in the current study.

3.4.1 Resource-based View Theory

The reason why a company succeeds or fails to enhance the desired performance is perhaps related to the resources utilized by a company (Porter, 1991). Because of this reason, the resource-based view (RBV) theory emphasizes the resources as the fundamental determinant of competitive advantage. The RBV is a theoretical standpoint that endeavors to describe and predict how firms can achieve its sustainable competitive advantage through gaining of and control over internal resources (Barney, 1991; Wernerfelt, 1984). The RBV lies primarily in the application of superior resources and enables companies to maintain their resources' advantages and sustain their competitive advantages (Barney, 1991). More specific, as stated by Ramayah, Sulaiman, Jantan, and Ng (2004), the fundamental postulation of RBV is leveraging firms' resources and its core competencies to create a sustained competitive advantage, which in turn, interprets into better firms' performance.

Resources discussed within the RBV are not limited to only physical resources. Zahra and Das (1993) divided resources into tangible and intangible resources. Tangible resources are observable; their values can be determined accurately; such as machine, equipment, etc. Tangible resources include human, financial, informational, and technological resources. Conversely, intangible resources cannot be observed, including company's reputation, administrative skills, etc. More detail, Barney (1991) has summarized the possible resources possessed by a company by classifying them into three categories. They are; (1) physical capital resources, including all physical technologies used, plant and equipment, geographic location and access to raw materials; (2) human capital resources, including training, judgments, intelligence, relationship, experiences and insights of individual employees; and (3) company's capital resources such as company's structure, planning, controlling, coordinating systems, as well as informal relations among groups within a company and between a company and its environment.

Relevant to the RBV, to distinguish between strategic and non-strategic resources, Barney (1991) postulated the VRIN criteria as stated below as key characteristics of a strategic resource that will deliver a company to sustain its competitive advantage. They are:

1. Valuable. A resource is valuable when it enables a firm to apprehend of and apply strategies that increase its performance.

2. Rare. A resource cannot be possessed by other companies. If a company is implementing a value-creating strategy, the strategy cannot be simultaneously implemented by other companies.

3. Inimitable. A resource cannot be obtained and replicated by competitors that do not possess them. Valuable and rare resources can only deliver a company to achieve a short-term competitive advantage. Sustained competitive advantage can be achieved if the valuable and rare recourses are inimitable.

4. Non-substitutable. A resource must be no strategically equivalent valuable that enables competitors to implement the similar strategies.

However, Makadok (2001) recently argued the shifting paradigm regarding the mechanism of creating competitive advantage. The old mechanism of creating competitive advantage was by being more effective in selecting resources over competitors, whereas the latter mechanism was by being more effective at deploying resources. The former paradigm asserted that heterogeneity in performance is due to resources ownership that has differential productivity, and that competitive advantage can be generated by having superior resource-picking skills, which enable a company to predict the future value of the resources accurately. This paradigm was criticized by Mahoney and Pandian (1992) by introducing the new paradigm to achieve sustainable competitive advantage, namely capability building. According to Makadok (2001), the capability building was first introduced by Schumpeter (1950), which was the codification of dynamic capability view.

To obtain a better understanding regarding the resources and capabilities, it seems essential to differentiate between the two terms. Amit and Schoemaker (1993) and next followed by Makadok (2001) provided a clear distinction of the terms. They well-defined resources as stocks of available aspects that are possessed and controlled by a company, while capabilities refer to organization capacity to organize and exploit resources for achieving a particular result. In line with these definitions, Makadok (2001) provided a clear distinction to distinguish capabilities and resources. According to Makadok (2001), capabilities are embedded in organization and its processes. So that, capabilities are firm-specific, whereas resources are not. Because of the embeddedness, capabilities are inimitable and non-transferable. If a company is absolutely dissolved, then its capabilities may be lost, whereas its other resources can be existed for a long time on the hand of the new owner. Makadok (2001) simply cited as an example; if a company is completely dissolved, the company can easily transfer its resources (such as ownerships, plants, equipment, patents, locations, and so forth) to the new owner, but it cannot transfer its capabilities (e.g., skills, talents, and knowledge) in developing the next generation of products.

Similarly, Hoopes, Madsen, and Walker (2003) noted that a resource is observable (but not necessarily tangible) that can be traded and taken over by a new owner, whereas capability is unobservable and necessarily intangible that cannot be traded to any other owners. Based on the distinctions, borrowing the words of Makadok (2001), capabilities are organizationally embedded non-transferable company-specific resources aimed to deploy and exploit resources possessed by a company. From the definition, capabilities are aimed to enhance the productive value of the resources possessed by a company. Hence, the presence of capabilities enables the company to utilize its resources. Therefore, to sustain competitive advantage, capabilities are regarded as a more important factor than the resources *per se*. According to Grant (1991), capabilities are the source of heterogeneity among companies in an industry, because capabilities encourage a company to develop the specific and unique ways to exploit the resources possessed by a company. In the same vein, Hoopes and Madsen (2008) stated; the uniqueness of a company largely comes from its capabilities, instead of resources. Hence, capabilities are the more critical factors to enhance competitive heterogeneity rather than resources.

Winter (2000, 2003) defined capabilities as *"a high level of routine (or collection of routines) that, together with its implementation input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type."* Based on the definition, the major concern is the term *"routine"*, which was defined by Winter (2003) as *"behavior that is learned, highly patterned, repetitious, or quasi-repetitious, founded in part in tacit knowledge-and the specificity of objectives."* In line with Winter (2003), Schroeder et al. (2002) noted that capabilities are generated through routine-changing routines that transform knowledge into a production system. Hence, agree with Winter (2000, 2003) and Schroeder et al. (2002), capabilities are a function of knowledge construction within a company. In manufacturing context, capabilities are constructed through routine manufacturing activities within a plant.

Nowadays, manufacturing companies are focusing on continually improving capabilities of their manufacturing processes. At the same time, operations management research has also focused on selecting specific manufacturing practices that are intended to underpin company's performance (Brown et al., 2007; Ketokivi & Schroeder, 2004). Ketokivi and Schroeder (2004) stated that researchers on operations management have emphasized activities and how they can contribute to company's capabilities. More importantly, how the capabilities can contribute to the company's routine activities. By utilizing its capabilities, a manufacturing company continually improves and shapes its manufacturing practices over time. This makes the practices unique and difficult to imitate. Therefore, manufacturing practices are heterogeneous across companies, which finally, the heterogeneity gives a benefit for sustainable competitive advantage. Hence, the word *"capabilities"* answered the questions arisen by Hoopes and Madsen (2008), *"how do firms differ?"*

Although the RBV theory has been recognized as an excellent and powerful approach to determine the strategic resources that can significantly affect the performance, the theory is not without limitation. Several studies have critically reviewed regarding the limitation of the RBV. Based on the rigorous literature review, the RBV suffers from at least three factors. One is that the RBV lacks of the link relating the resources (and capabilities) and value creation (Priem & Butler, 2001). In other words, as the author noted, it was not clear how strategic/potential resources and capabilities contribute to value creation, since value is a fundamental component to determine the competitive advantages. If the value created by a company is greater than competitors', then the company can sustain its competitive advantage. Second, Sheehan and Foss (2007) further argued that the RBV lacks of the concept of activities because it is primarily a concern to recognize strategic resources that can yield competitive advantage, meanwhile it has not reached its full potential in the field of strategy and tends to be less transparent on how resources and capabilities lead to value creation.

Third, according to Chan et al. (2004), the RBV focuses on taking away any potential and strategic resources and capabilities rather than on complementarity among them, since a resource and activity hardly acts as a standalone in achieving a superior position. This reveals that there are inadequacy and limitation of the RBV in addressing the relationships or interactions between company's resources in enhancing the desired outcomes. Whereas, when resources have complementarities, it enhances their potential to increase company's performance and sustain competitive advantages (Furlan et al., 2011a). In order to overcome the deficiencies of RBV, this study attempts to adopt the activity-based view and complementarity theory as briefly discussed in the next sections.

3.4.2 Activity-based View Theory

The genesis of activity-based view (ABV) theory was introduced by Porter (1985) in his seminal book entitled *"Competitive Advantage: Creating and Sustaining Superior Performance."* Following Porter (1985), competitive advantage in this study is defined as ability or potential to create and generate more values over the competitors. Ability to sustain competitive advantage and to enhance organizational performance is depended on how to create more values (Priem, 2007). According to Porter (1985), value is created when there is a margin between price that buyers willing to pay and total cost of the required activities. Due to this reason, Porter (1985) postulated two strategies to enhance the competitive advantage over the rivals as follows:

1. To produce at minimum cost compared to competitors, while sustaining superior quality and competitive price. In short, this reflects cost leadership over competitors.

2. To induce customers' willingness to pay by increasing the value of the products and service that accompany of products. At the same time, by enhancing the product image. This reflects differentiation relative to competitors.

To produce at lower cost and to enhance values over the competitors, Porter (1985, 1991) argued that these enhancements can only be achieved by looking into activities performed in a company. Supporting this idea, Porter (1985, 1991) stated that firm's competitive potential is impossible to be understood by looking at a company as a whole, rather it should be determined at the level of activities. Hence, only by breaking a company into activities (such as manufacturing, designing, marketing, purchasing, etc.), the company can identify clearly the potential sources of competitive advantage.

To give the clear picture regarding how to achieve competitive advantage, Porter (1985) introduced the idea of the value chain. Sheehan and Foss (2009) defined value chain as *"a generic activity template that can be used to decompose the firm into individual activities it undertakes to create value."* In the Porter's point of view, selecting an activity should consider its effect on buyers' willingness to pay and/or cost. The increasing buyer willingness to pay and reducing cost determine the firm's position relative to its competitors. Practically, a company performs a huge number of activities in transforming inputs to outputs. Porter (1985) classified activities generally into two categories. They are primary and supporting activities. The primary activities are directly concerned with the creation or delivery of products and services. Porter (1985) grouped these activities into five main areas, including inbound logistics, operations, outbound logistics, marketing and sales, and services. The primary activities are linked to supporting activities, which support the primary activities in improving their effectiveness and efficiency. Supporting activities included procurement, human-resource management, technological improvement, and infrastructure. In the Porter's world view, by concerning to the activities to transform inputs to outputs, minimizing costs and maximizing values (increasing profit margin) can be achieved on eventually. Schematically, the basic model of the Porter's value chain is depicted in Figure 3.2.

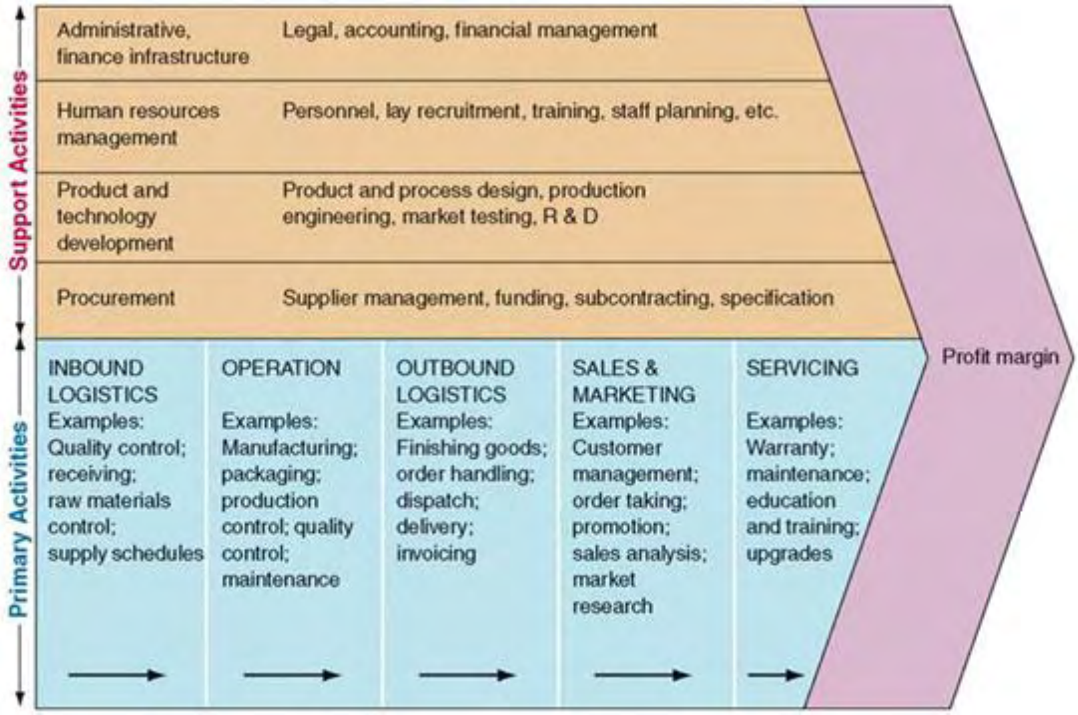

Figure 3.2
Basic Model of Porter's Value Chain
Note. Adapted and modified from "On Competition" by M. E. Porter, 2008, p. 75. Copyright 2008 by the Harvard Business School Publishing Corporation.

However, according to Porter (1985) and Sheehan and Foss (2007), activity level analysis may expose some strategic visions. Hence, to obtain the clearer picture regarding performance and competitive advantage, it is required to understand the driver of the activities. Activity drivers are underlying sources of competitive advantage that drive competitive advantage operational (Sheehan & Foss, 2007). Activity drivers are under management control, which in turn will affect cost incurred and value created from the activities (Porter, 1985). Porter (1985) further posited two types of drivers. They are cost and differentiation. Cost drivers minimize all types of costs caused by activities, whereas differentiation drivers influence customers' willingness to pay through increasing the values of products and services. Hence, activity drivers help the company to decrease costs and create more values, which in turn will help the company to enhance superior performance and sustain competitive advantage.

Nowadays, these ideas (value chain and ABV) are placed its deeper root in operations and manufacturing strategy researches, especially in terms of activity analysis. According to Sheehan and Foss (2009), the key characteristics of the ABV from the Porter (1985) are as below:

1. Activity is the unit of analysis. The firms are broken down into several activities. This will enable a company to ensure value added, and non-value added activities. In other words, it abridges a company to identify activities that incur large costs and that are accomplished differently from competitors.

2. A systemic view should be employed. The value chain attempts to enhance the whole company as a system, rather than individual business units.

3. There are two types of activities, namely primary and supporting activities. Primary activities are defined as the activities that improve customer values, while supporting activities are the activities that help a company to enhance and improve customer values resulted by primary activities.

4. It includes cost and value drivers. Porter (1985) defined driver as the factors that encourage, drive, and explain why costs or values generated by firm activities differ from its competitors.

Finally, in attempting to explore the roots of Porter's ABV, Sheehan and Foss (2009) concluded as follows, *"... activities are a key link between resources holdings and strategic positions; resources are only valuable when placed into activities, which generate lower cost or high value than rivals (Porter, 1991, 1994). It is when the activity-based view is integrated with the resource-based view that they together provide the most comprehensive explanation of firm value creation."* The conclusion provided by Sheehan and Foss (2009) leads to intellectual roots of ABV. The RBV and ABV complement each other. The two theories address different aspects of how internal factors contribute to superior performance and competitive advantage. The two perspectives provide comprehensive views how the resources belong to a company lead to superior competitive position over the competitors; it is through valuable activities.

However, collaboration between the RBV and ABV seems to become more powerful if a company pays attention on complementarity between the activities. Practically, one activity may complement any other activities. Complementarity theory proved that adoption of one activity will increase marginal returns of other activities and vice-versa. Hence, it is assumed that adoption the three theories in this study will give better insight as a comprehensive strategic framework on how company's activities lead to the superior competitive position. The following section will discuss the complementarity theory to support the RBV and ABV theories discussed above.

3.4.3 Complementarity Theory

As reported by Choi, Poon, and Davis (2008), Furlan et al. (2011a), and Milgrom and Roberts (1990, 1995), the concept of complementarity theory was first coined by Edgeworth (1881). He defined activities as complementarity as *"if doing (more of) any one of them increases the returns to doing (more of) the others."* This theory, according to Choi et al. (2008), assumes that separate practices cannot be independently fine-tuned to realize outstanding performance, and thus considering complementarities among the organizational practices are substantial from the perspective of their influence on company's performance.

Furlan et al. (2011b) highlighted; the two practices are complementary when adoption of one practice will subsequently increase marginal returns of another practice and vice-versa. Furthermore, Milgrom and Roberts (1990, 1995) reported that some organizational practices tended to be adopted together because they are complementary or mutually supportive with each other. In other words, one practice enhances the contribution of others. Hence, it is suspected that the total effect to ongoing improvement will be marvelously greater rather than adopting as standalone practice. Even, according to Milgrom and Roberts (1990, 1995) and Tanriverdi (2005), implementing single organizational practice without implementing the others may not produce the desired performance improvement; it may even reduce overall organizational performance.

Interestingly, in line with the complementarity concept, Lee, Venkatraman, Tanriverdi, and Iyer (2010) and Tanriverdi and Venkatraman (2005), provided idea of super-additive value and sub-additive cost. According to them, two business units (can be equated with manufacturing practices or activities) may enjoy super-additive value synergies if their joint value is greater than the sum of their individual values. Mathematically, it can be represented as the value (a, b) > value (a) + value (b). The super-additive value synergies may produce a super-modular return (Milgrom & Roberts, 1990, 1995).

Similarly, in terms of cost reduction, a company may enjoy sub-additive cost if the implementation of manufacturing practices (or activities) simultaneously reduces joint production costs in a greater extent than the sum of their individual cost reduction (Lee et al., 2010; Tanriverdi, 2005; Tanriverdi & Venkatraman, 2005). In short, cost reduction (a, b) > cost reduction (a) + cost reduction (b). Hence, the sub-additive cost synergies may produce sub-modular costs as presented by Milgrom and Roberts (1990, 1995).

In conclusion, based on the complementarity theory, complementarity among manufacturing practices may create super-modular return, and at the same time, generate sub-modular costs. Subsequently, a company could potentially improve its performance through super-modular return and sub-modular cost advantages. Even, according to Lee et al. (2010), companies those gain superior performance and competitive advantage through complementarity of organizational practices (or activities, assets, etc.) are expected to sustain the advantage over long periods of time.

3.4.4 Lean Manufacturing Practices as Strategic Resources

As discussed earlier, resources were classified by Zahra and Das (1993) into two categories, namely tangible and intangible resources. In a different perspective, Barney (1991) has also postulated three types of resources, namely physical, human, and organizational capital resources. Organizational practices (e.g., lean manufacturing practices) have largely been considered as resources that are owned and controlled by a company. Relying on the classification suggested by Zahra and Das (1993), lean manufacturing practices can be tangible as well as intangible. The uses of general-purpose machines and implementation of cellular layouts are considered as the tangible aspect in the lean system. Besides tangible, educational processes (such as training, supplier development programs, etc.) are considered as intangible resources.

Taking the idea from Barney (1991) into consideration, physical technology such as kanbans, general-purpose machines, easy moving equipment, and quality control systems are physical capital resources that are commonly used in a lean manufacturing system. Human capital resources, including training, human relationship, knowledge, experience and insight of managers and workers, are very crucial factors in implementing lean manufacturing. Implementation of lean manufacturing activities must be supported by such human capital resources. In addition, organizational capital resources, such as planning, controlling, and coordinating system; are embedded within a lean manufacturing system. In other words, lean manufacturing practices cannot be separated from organizational capital resources. Hence, based on this discussion, it can be understood that lean manufacturing practices can be considered as resources that are key inputs into production.

Lean manufacturing with a set of practices has been widely believed as a powerful manufacturing strategy to achieve competitive advantage concerning waste elimination in all parts within a production system, not only in manufacturing but also for entire supply chain networks, within and across companies. Hallgren and Olhager (2009) also argued that lean manufacturing was commonly implemented by plant managers to increase operations capabilities.

Some of the literature presented so far had shown that the RBV can complement lean manufacturing practices strongly in helping the company to enhance the performance and competitive advantage (Brown et al., 2007; Forrester et al., 2010; Lewis, 2000; Schroeder et al., 2002). The principles of RBV-lean manufacturing strategy serve as guidelines to help in understanding and determining the practices that can maximize company’s performance through its implementation. Hence, it is crucial in the current study to focus on the development and selection of the important lean manufacturing practices, which in turn, can improve company’s performance significantly. In determining the practices, the present study follows the criteria provided by Ketokivi and Schroeder (2004) as follows, (1) the practices are likely to satisfy the criteria for strategic resources; (2) the practices have been theoretically or empirically associated with one or more specific measures of companies' performance; and (3) the practices and performance measures have been linked in recent literature.

Based on several empirical studies (Ahmad et al., 2003; Forrester et al., 2010; Lewis, 2000; Schroeder et al., 2002), lean manufacturing practices fulfill the criteria for the strategic resources. Lean manufacturing practices are valuable as they contributed positively to the enhancement of company's performance, not only at the operational level but also at the business level. The ability of lean manufacturing practices to eliminate all types of waste has clearly been noted in numerous studies concerning organizational performance achieved after the lean manufacturing implementation (Bartezzaghi & Turco, 1989; Chang & Lee, 1995; Fullerton & Wempe, 2009). It can be observed in terms of better quality, greater flexibility, higher productivity, shorter lead time, lower inventory, lower costs, higher profit, higher customer satisfaction, better sales performance, and so forth.

Besides the valuable consideration, lean manufacturing is also considered rare or scarce. The practices and its implementation depend on the organizational context (Shah & Ward, 2003) as well as culture embedded inside the organization (Angelis et al., 2011; Nordin, Deros, & Wahab, 2011). As concluded by Shah and Ward (2003), contextual factors (e.g., size of company, unionization, and plant age) influenced the lean manufacturing implementation. In a similar vein, Nordin et al. (2011) noted several factors influencing lean manufacturing implementation. They are a difficulty in acquiring lean, lack of management support, capability of the implementer, insufficient training and communication, and employees' attitude. In addition, the potential benefits gained from lean manufacturing implementation also vary depending on the circumstances in which organization it is implemented. As a consequence, the configuration of the practices in each company will be unique. Hence, following the word of Escrig-Tena (2004), there is *"a path-dependent process"* that makes the lean implementation differs across the companies.

Continuous improvement and knowledge creation should be incorporated in every organization, not only in lean companies but also in non-lean companies. Knowledge is created through learning processes (Escrig-Tena, 2004). As postulated by Winter (2000, 2003) and Schroeder et al. (2002), capabilities are a function of knowledge construction within the company. In line with capabilities, manufacturing strategy and performance; concepts of internal learning, external learning and proprietary manufacturing processes have been developed and tested by Schroeder et al. (2002) and Ramayah et al. (2004). Internal learning includes training to improve manufacturing processes, such as training for multifunctional employees, training for quality control, training for maintenance activities, and incorporating employee suggestions into the manufacturing process. In the context of manufacturing plants, Schroeder et al. (2002) defined external learning as an inter-organizational learning through problem solving with stakeholders (including suppliers and customers) in attempting to get mutual benefits. They stated that customers and suppliers were important resources of a company. According to Russell and Taylor (2008) and Heizer and Render (2011), supplier supports, close relationship with suppliers, and trust between customer and suppliers are essential to the triumph of lean manufacturing implementation, which in turn, will improve company's performance. This concept can be applied through long term agreement with suppliers, engineering and quality management assistance, involvement in continuous improvement, and so forth.

Schroeder et al. (2002) highlighted that capabilities inherent in situated learning should result in excellent and continuously improved manufacturing practices. Hence, the learning processes encourage the company to create the unique and inimitable lean manufacturing practices. In addition, if the practices have been embedded in a manufacturing system, as mentioned earlier, lean manufacturing can be considered as a company's culture. According to Escrig-Tena (2004), it is difficult and almost impossible to describe what component making a company probable to sustain its outperformed performance. This is in line with the idea of causal ambiguity as stated by Barney (1991, 1995). According to Barney (1991), the causal ambiguity exists when there is a poorly understood link between resources (and capabilities) and performance as well as its competitive advantage. This condition creates difficulties for a company, which is attempting to imitate the lean manufacturing practices, to know which practices should be imitated.

Related to the causal ambiguity, a number of studies (such as such as Furlan et al. (2011a), Furlan et al. (2011b), Dal Pont et al. (2008), and Shah and Ward (2003)) revealed the importance of holistic approach in implementing lean manufacturing in order to enhance the desired performance. The holistic implementation of lean manufacturing may result in the substantial performance rather than piecemeal adoption. Holistic employment of lean manufacturing arising from complementarity practices is not easy to observe, competitors may face a nightmare to recognize the practices and activities combined into a bundle. Hence, the success of lean manufacturing implementation may depend on a series of mutually supportive practices, and it is not easy to identify the practices and activities contributing to the success. Again, it implies the difficulties of competitors to determine which practices contribute to the company's success, since all the practices are mutually supportive. In addition, inimitability of lean manufacturing practices may be shaped by anteceding factors as mentioned by Escrig-Tena (2004) in the context of TQM. The factors like infrastructure practices (Bayo-Moriones et al., 2008; Sakakibara et al., 1997), organizational support (Chong et al., 2001), and management commitment (Escrig-Tena, 2004) may contribute to the success of lean manufacturing implementation. These factors may create a conducive environment for lean manufacturing practices to be effective in a plant. These factors may generate inimitable competitive advantage.

More importantly, manufacturing practices and activities (e.g., lean manufacturing practices) can contribute to company's capabilities (Ketokivi & Schroeder, 2004), or vice-versa. As noted by Winter (2000, 2003), capabilities are created through routine-changing routine that transforms knowledge into a production system. Routine is continuously improved through learning process in the production system, and thus, routine changing is a function of knowledge construction. Therefore, the capabilities of a company are dynamic depending on knowledge generated within the company. The dynamic capabilities possess the characteristics needed to make them and manufacturing practices (e.g., lean manufacturing) difficult to imitate (Hoopes & Madsen, 2008; Ketokivi & Schroeder, 2004). This also implies that individual lean manufacturing practices are possible to imitate but lean manufacturing systems and routines, which are developed over time may be unique to a particular company, in other words, inimitable.

Barney (1991, 1995) stated the social complexity as constrain of ability of a company to imitate resources and capabilities possessed by another company. Lean manufacturing involved almost all part of organizational structure; top, middle, and lower management. All of them may contribute to the success of lean manufacturing employment. Achievement in performance may be based on such complex social phenomena. So that, the ability of other companies to imitate the lean manufacturing practices is significantly constrained.

Besides valuable, rare and inimitable, strategic resources must be non-substitutable. This criterion suggests that resources must be no opportunity to replace them with similar resources or with the totally different resources but with the same potential benefits (e.g., strategically equivalent). Nothnagel (2008) stated that if resources are inimitable, they tend to be non-substitutable as well. However, the idea of equifinality as stated by Barney (2001) should be taken into account. According to Barney (2001), equifinality refers to the ability of a company to achieve the same objectives through different ways. Considering the equifinality, it seems that the substitutability deals with ambiguities (Barney, 2001; Nothnagel, 2008), which provide a poorly understood link between resources and performance. Lean manufacturing is complex, as mentioned earlier, it has widely been considered as a culture embedded within a company. As it is difficult to describe what components contributing to performance, the ambiguities of lean manufacturing do exist. It was also suggested by Holweg (2007) who stated that cultural differences allow for more efficient production, which is difficult to replicate. Hence, because of the ambiguities, the lean manufacturing implementation is non-substitutable.

3.4.5 Compatibility between the Theories

To ensure compatibility between the theories used in this study, Sheehan and Foss (2007) provided guidance by relying on the objectives and underlying assumption of the theories. Sheehan and Foss (2009) strongly agreed that activities take the role in relating resources, capabilities and strategic position in the competitive world. They further revealed that a comprehensive view on value creation of companies can only be gained when the RBV and ABV point of views are integrated. At one side, RBV ensures the strategic and potential resources and capabilities, at another side ABV emphasizes valuable activities leading to the better performance and sustainable competitive advantage. However, facts and figures indicated that several activities are complemented among them; adopting one practice can increase marginal returns of another, or vice-versa. Therefore, when the RBV, ABV, and complementarity theory are integrated, the theories could provide a comprehensive strategic framework of company value creation and sustainable competitive advantage.

Based on the discussion earlier, it is clear that lean manufacturing meets the criteria of strategic resources, and it is a source of sustainable competitive advantage. Lean manufacturing practices add value to a company, are rare, inimitable, and non-substitutable. However, according to Sheehan and Foss (2007), the strategic resources and capabilities are only valuable when they are placed into activities to generate lower cost and higher values over competitors. The combination of the RBV and ABV together would provide the more comprehensive explanation of how the resources possessed by a company help it to enhance superior performance and competitive position; it is through valuable and value added activities. Appendix A.1 shows the lean manufacturing practices, and the containing activities proposed in this study.

Beyond the RBV and ABV, several studies have been conducted to assess the complementarity between activities or practices deployed in organizations. In the area of lean manufacturing, several studies such as Callen et al. (2005), Fullerton et al. (2003), Furlan et al. (2011a), Furlan et al. (2011b), and Shah and Ward (2003, 2007) investigated the complementarity idea among lean manufacturing practices. Their studies tend to support the complementarity theory by revealing that applying the practices simultaneously may significantly affect performance rather than applying lean manufacturing in separated practices. Bartezzaghi et al. (1992) also revealed that adoption of a single practice of lean manufacturing was less frequent. This why, single practice has a limited ability to enhance the competitive advantage (Ahmad et al., 2003), but the complementarity practices may positively affect performance in a greater extent. Hence, the bundle of lean manufacturing practices tends to work together, synergistically and mutually supportive each other.

Similar to Dal Pont et al. (2008), Shah and Ward (2003) highlighted that although the practices diverse, they tended to be complementary and inter-related to each other. More importantly, Shah and Ward (2007) again declared that complementarity and synergistic effects of the highly correlated lean manufacturing practices contributed to the superior ability to achieve multiple performance measures. Albeit each of distinct practice can contribute to certain performance; the holistic practices are able to enhance more comprehensive performance outcomes. The more the lean manufacturing practices are concurrently implemented, the more the performance measures may be achieved. Even though, the simultaneous implementation of lean manufacturing practices is difficult to be performed; it may increase the company's ability to compete through inimitable practices and capabilities.

Papadopoulou and Özbayrak (2005) also stated that the practices constituting under lean manufacturing, such as small lot production, quick setup, and pull system are complementary practices. They are inseparable parts of lean manufacturing to enhance the desired company's performance. Even, Papadopoulou and Özbayrak (2005) further revealed that the viability of lean manufacturing implementation depends on a number of complementary practices. In the current study, the author attempts to rely on the complementarity theory to provide useful and in-depth perspective to understand the relationship among the lean manufacturing practices. This theory provides the basis to understand how various practices in organization are interrelated (Milgrom & Roberts, 1990, 1995). Furthermore, the complementarity concept rigorously explains how a combination of synergistic and mutually reinforcing practices leads to the better performance and competitive advantage (Choi et al., 2008).

Related to competitive advantage, in the RBV perspective, as stated by Barney (2001), there are two ways to define the competitive advantage. They are:

1. With respect to the actions of other companies. In this perspective, a company possesses the sustained competitive advantage when it increases efficiency and effectiveness in ways that other companies are not.

2. With respect to return expectations of company's company's owner. In this view, a company sustains its competitive advantage when it can enhance the return exceeding its owners' expectations. This competitive advantage is called as economic rent.

With regards to the two perspectives, Barney (2001) postulated that the two company's levels of competitive advantage are closely related. A company can generate superior economic rent as long as it can maintain its efficiency and effectiveness in ways competitors cannot.

Relevant to the present study, lean manufacturing attempts to enhance the competitive advantage through waste elimination. Eliminating waste in the production system would increase its efficiency and effectiveness. Subsequently, the more efficient and effective the production, the more the return gained by a company. In line with this idea, Venkatraman and Ramanujam (1986) explained that performance can be measured either as business performance or as operations performance. Several studies, such as Bartezzaghi and Turco (1989), Chang and Lee (1995), and Ketokivi and Schroeder (2004), emphasized the use of multidimensional measures of performance. In the context of lean manufacturing, Bartezzaghi and Turco (1989) and Chang and Lee (1995) argued that operations performance was more relevant to plant-level strategic alignment because manufacturing strategy reflects and represents some internal properties of a production system, such as managing human resources, operations, maintenance, consolidating supplier networks, etc. Ketokivi and Schroeder (2004) suggested that operations performance measures are strategically important, and thus the measures must be priority. The performance achieved at the operations level will subsequently lead to performance at the business level, which views performance of organization as a whole, in terms of profitability, sales and customer satisfaction. Appendix A2 and A.3 respectively provide measurement items of each operations performance and business performance measures.

In summary, compatibility among the theories to support the research framework is exhibited in Figure 3.3. Based on the figure, lean manufacturing practices are treated as resources that fulfill all the VRIN criteria suggested by Barney (1991).

Due to the lack of concept of activities in RBV (Sheehan & Foss, 2007, 2009), and lack of link relating the resources and value creation (Priem & Butler, 2001), the ABV plays a role of translating the resources into activities. Translating resources into activities is very important because activities are a key link between resources and strategic position. Porter (1991, 1994) stated that strategic resources were only valuable when placed into activities. Through a reciprocal relationship between resources and capabilities, lean manufacturing practices and activities are continually improved and shaped. In other words, creation of capabilities through lean manufacturing practices and activities helps in deployment of company's unique competencies. At the same time, improvement in practices and activities would improve company's capabilities.

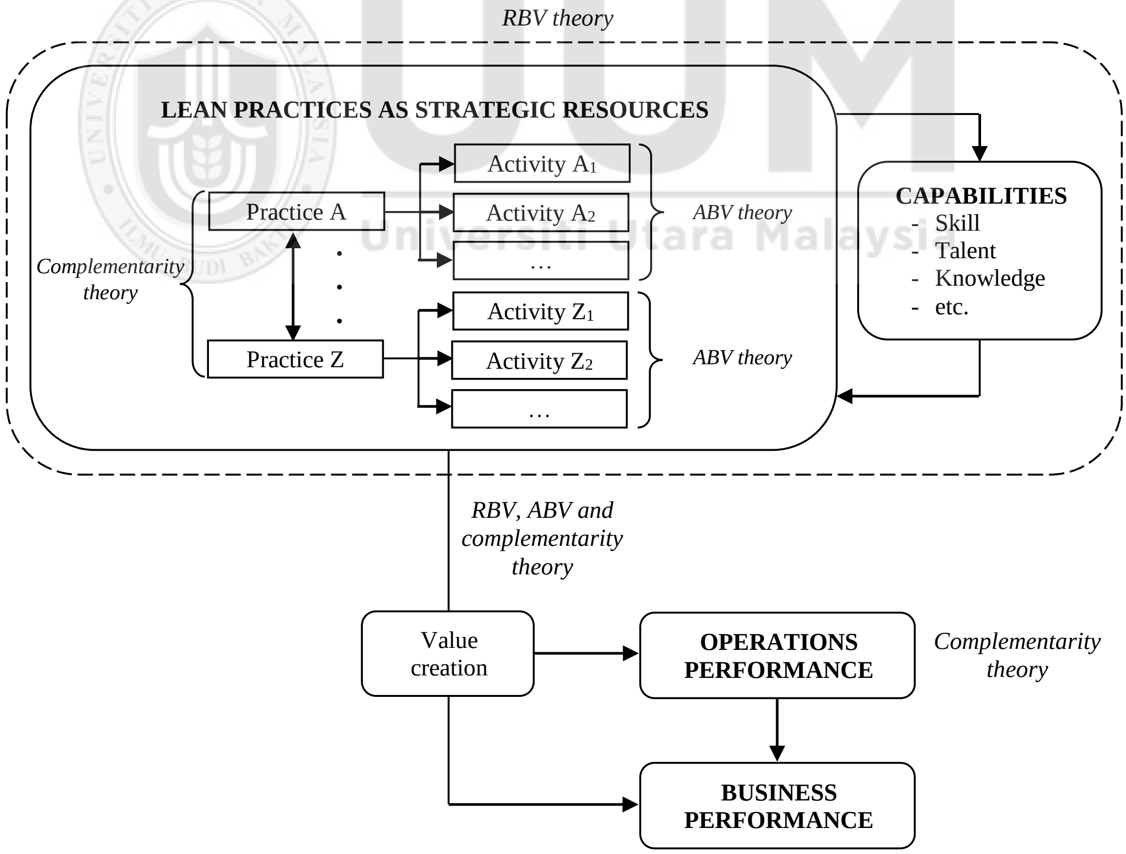

Figure 3.3
Related Theories and Variables of the Study

Subsequently, improvement in lean manufacturing practices and activities would lead to higher values (Porter, 1985, 1991, 1994), which in turn, improves operations performance and business performance (Sheehan & Foss, 2007, 2009). Finally, complementary among operations performance measures would positively affect business performance as suggested by Shah and Ward (2003, 2007), Furlan et al. (2011a), Furlan et al. (2011b), and Hofer et al. (2012).

3.5 Research Hypotheses

Based on the research questions, theoretical framework and related theories discussed earlier, this section discusses about the research hypotheses addressing quantitative phase of the study. Due to the strategy used in this mixed methods study is sequential explanatory, the series of propositions to guide the qualitative phase of the study will be established after the quantitative data analysis.

In conducting a quantitative research, one of the important considerations is hypotheses development. Following Kumar (2010), hypothesis was defined as *"a proposition that is stated in a testable form and that predicts a particular relationship between two (or more) variables."* According to Bailey (1978), if it is suspected that there is a relationship between two variables, a researcher first states it as hypotheses and then tests it. Based on the definition, hypotheses development is essential because they bring direction, clarity, specificity, focus to a research, and provide the basis of an enquiry (Kumar, 2010). This study tested several research hypotheses to analyze the question of whether lean manufacturing affects performance. These were structured by articulating the problem as a need to understand the relationship between three ideas; lean manufacturing practices, operations performance and business performance. Based on the research questions, related theories, and theoretical framework, four main hypotheses were posited.

Lean manufacturing practices are believed to have a positive relationship with operations performance (Abdel-Maksoud et al., 2005; Bartezzaghi & Turco, 1989; Chang & Lee, 1995; Fullerton & McWatters, 2002; Fullerton & Wempe, 2009; Hallgren & Olhager, 2009; Rahman et al., 2010) because lean manufacturing with its set of practices was widely considered to be a potential powerful approach to enhance better operations performance through waste elimination. After summarizing the literature, the results show that implementation of lean manufacturing provides several benefits, such as quality improvement (Abdallah & Matsui, 2007; Fullerton & Wempe, 2009), lead time reduction (Fullerton & Wempe, 2009; Matsui, 2007), costs reduction (Chen & Tan, 2011; Mackelprang & Nair, 2010), inventory minimization (Chen & Tan, 2011; Hofer et al., 2012; Mackelprang & Nair, 2010), manufacturing flexibility improvement (Furlan et al., 2011b; Taj & Morosan, 2011), and productivity (Jeyaraman & Leam, 2010; Rahman et al., 2010). This leads to the following hypothesis:

H_1: Lean manufacturing has a positive relationship with operations performance.

Besides its positive effect on operations performance, lean manufacturing would lead to higher business performance. In order to achieve outstanding business performance, various actions must be undertaken by a company involving manufacturing strategies. For instance, the company should produce and deliver the products in a small lot within short lead time, reduce setup times, make cellular layouts, increase flexibility of machines and workers, increase steadiness of machines and equipment through TPM, and so forth. Through the lean manufacturing practices, a company should be able to enhance business performance. A number of studies noted the positive effect of lean manufacturing on business performance in terms of profitability (Green & Inman, 2007; Olsen, 2004; Yang et al., 2011), sales performance (Green & Inman, 2007; Yang et al., 2011), and customer satisfaction (Abdallah & Matsui, 2007; Chong et al., 2001). The following hypothesis is posited.

H_2: Lean manufacturing has a positive relationship with business performance.

It is widely believed that operations performance had a positive relationship with business performance (Chang & Lee, 1995; Fullerton & Wempe, 2009; Kannan & Tan, 2005; Said et al., 2003; van der Stede et al., 2006). The better operating conditions, in terms of quality, manufacturing flexibility, productivity, lead time, inventory and costs, would increase the companies' ability to enhance business performance in terms of profitability, sales and customer satisfaction. More importantly, a number of previous studies (Fullerton & Wempe, 2009; Hofer et al., 2012; van der Stede et al., 2006) noted that organizational performance as a whole is aplenty determined by better operating conditions. In other words, it is believed that operations performance is a pre-determinant of enhancement in business performance. This leads to the following hypothesis:

H_3: Operations performance has a positive relationship with business performance.

Lean manufacturing practices are normally implemented in a shop floor. Thus, lean manufacturing could improve overall business performance through improvement in operations performance. It is suspected that lean manufacturing practices would affect business performance directly and indirectly through operations performance as a mediating variable. To some extent, several researchers (Bartezzaghi & Turco, 1989;

Chang & Lee, 1995; Fullerton & Wempe, 2009; Hofer et al., 2012) supported this assumption. In the present study, it is hypothesized that operations performance acts as a mediator in the relationship between lean manufacturing and business performance. The last hypothesis is then established as follows:

H_4: Lean manufacturing affects business performance directly and indirectly through operations performance as a mediating variable.

3.6 Chapter Summary

The extensive literature review was addressed to develop the research framework of the present study. The research framework was formulated by including nine practices of lean manufacturing, six operations performance measures, and three business performance measures. Furthermore, this chapter reviewed the related theories to explain the relationship among the variables and to support the research framework. Finally, to test the relationships, four hypotheses were developed in line with the research problem, research questions, research objectives, and theoretical framework. The next chapter provides the detail of research methodology employed in this study.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 Introduction

Research methodology was defined as a philosophical framework and fundamental assumptions of a research (Creswell & Plano Clark, 2011). According to them, the entire research procedures should be underpinned by philosophical justifications. Following the definition, this chapter will begin with philosophical justifications and stances, which drive all the decisions made by the author in the entire research processes. Subsequently, based on the philosophical justifications, research designs comprising plans and actions that relate the philosophical justifications to specific methods will be presented. Finally, this chapter will be summarized concisely.

4.2 Philosophical Justifications and Stances

A knowledge claim, according to Bloomberg and Volpe (2012), implies a certain justification about what and how a researcher will learn. A research design spans the decisions from broad assumptions or justifications to detailed methods of data collection and analysis. So that, all decisions in a research should be based on the knowledge claims or philosophical justifications (world views) that underpin overall decisions at every stage of a research. The world views represent the belief of researchers that guide inquiries (Creswell, 2009). In the same perspective, Morgan (2007) highlighted the world view as *"shared belief system"*, which influences the knowledge attempted to seek and how the researcher collects and analyzes the evidence.

Hence, in conducting a mixed methods research, world views are essential to direct the entire research efforts (Biesta, 2010; Creswell & Plano Clark, 2011).

Following Creswell and Plano Clark (2011) and Bloomberg and Volpe (2012), world views differ in its elements representing the beliefs of the research. They are the nature of reality (ontology), the relationship between researcher and that being researched (epistemology), the role of value (axiology), the language of the research (rhetoric), and the processes of the research (methodology). The next section will explain the world views that drive the entire research processes.

4.2.1 Ontological Justification

The first world view element is ontology. It is associated with nature of reality of the phenomena. Specifically, it is about the reality that is the object of research (Biesta, 2010). It guides the way of a researcher in viewing the phenomena. Ontological justification is commonly driven by research questions (Creswell & Plano Clark, 2011). The research questions of this study implied that discoveries of the phenomenon are both objective and subjective. On one hand, the first four research questions are objective and singular reality; on the other hand, the last research question is subjective and multiple realities. Hence, there was a need for combining objective dimensions and singular reality (quantitative stance) with subjective dimensions and multiple realities (qualitative stance) to provide a complete understanding to the research problem.

Based on the research questions, the most suitable method to acquire knowledge in this study was multi-phases mixed methods with sequential strands. The use of sequential strand required multiple worldviews to guide the research process.

Following Creswell and Plano Clark (2011), this study used different set of beliefs within each phase. Due to this study was started quantitatively, the author used perspective of post-positivism to develop instrument, select respondents, measure the variable, and analyze the data. When the author moved to the qualitative phase, dealing with subjective and multiple realities, the set of beliefs was shifted to constructivism. Hence, this study used multiple worldviews (i.e., post-positivist and constructivist) instead of using single world view.

More importantly, selection of multiple worldviews gave the researcher flexibility in conducting both the quantitative and qualitative methods. Onwuegbuzie, Leech, and Collins (2011) stated that ontological justification representing post-positivist researchers does not prevent them from using some qualitative analyses. Similarly, ontological justification representing constructivist researchers does not avoid them from using some quantitative analyses. Moreover, employing the two stances in a mixed methods study, according to Onwuegbuzie et al. (2011), is not only to enhance the more detail and deeper analyses but also to assess trustworthiness, dependability, conformability, transferability, and authenticity of the study.

4.2.1.1 Post-positivism

Quantitative studies have been widely driven by positivist ontology throughout this century. It believed in realism, objectivity, and value-free inquiry (Easterby-Smith, Thorpe, & Jackson, 2008). Miller (2000) stated that positivist deemed in absolute truth, unassailable foundation, and assumption of knowledge steady. However, several scholars rejected the positivism (Miller, 2000; Onwuegbuzie, Johnson, & Collins, 2009), not because of its realism, objectivity, and value-free inquiry, but because of its absolute truth belief. This belief does not open a room for straightening and amending the knowledge. While, scientific knowledge is historically and socially conditioned and not absolutely true but relative in character (Alvesson & Sköldberg, 2010).

In addition, the increasing number of scholars arguing theory-laden nature of observation has encouraged scientists to reject the positivist ontology (Miller, 2000). Theoretical perspective cannot be sometimes eliminated in any portion of research processes. Therefore, maintaining a clear distinction between the research process and theory is impossible, since this distinction was very essential to logical positivists (Miller, 2000). According to Easterby-Smith et al. (2008), positivists presupposed that human beliefs should be irrelevant. Nowadays, neglecting the theoretical statements in a social research becomes more impossible because most researches are conducted by using instruments, while the instruments are generated by considering a set of theories and literature. Miller (2000) underlined that positivism was detached from actual working of science. Theories came from developing and testing hypotheses; they can be modified, thrived and degenerated through research processes.

Suffered from the critiques; the positivism was demised by the middle of the 20^{th} century, and the post-positivism took place (Miller, 2000). Post-positivism is an amendment of positivism. Positivist assumes an objective external reality, and the results of hypotheses' verification are established as facts, laws and truths, whereas post-positivist also assumes the objective reality, but it does not believe in absolute truth; the results of hypotheses' testing are probable facts and laws (Guba & Lincoln, 1994). In other words, post-positivist believes that the finding is approximate truth; the reality is never fully apprehended. In addition, positivist uses data to develop a theory, whereas post-positivist uses it to test theory or theories. In conclusion, a term that precisely represents today's quantitative researchers is post-positivism, instead of positivism (Onwuegbuzie et al., 2009).

In relation to this study, it used post-positivist ontology to drive the entire decisions within the quantitative phase of the study. Adapted from Creswell and Plano Clark (2011) and Creswell (2009), Table 4.1 addresses the features of post-positivist world view. First, post-positivist held a deterministic paradigm, which is cause and effect oriented. Relevant to this study, it was needed to assess the lean manufacturing influencing organizational performance. Additionally, post-positivist uses theory to construct and relate the variables. Investigating the effect of lean manufacturing on performance indicated the appropriateness of adopting this ontology.

Table 4.1
Features of Post-positivist Ontology

Features of post-positivist	Features of quantitative phase of this study
Determinism (cause and effect oriented, and based on pre-determined theory)	1. Concerned to the effect of lean manufacturing on operations performance and business performance. 2. Used theories to construct and relate lean manufacturing, operations performance, and business performance.
Reductionism	Narrowed and focused on nine lean practices, six operations performance measures and three business performance measures.
Measurement	Emphasized on empirical data collection (i.e., survey).
Theory verification	Tested the framework generated from theories.

The second feature of post-positivist ontology is reductionism. It intends to reduce a big idea into a number of small ideas to test, such as a variable containing several dimensions. This is because post-positivist assured that the problems are better understood if they are reduced into the simplest possible elements. This study attempted to examine the relationships between three constructs, namely lean manufacturing, operations performance, and business performance. All the constructs consisted of small dimensions; lean manufacturing contains nine dimensions, operations performance covers six dimensions, and business performance comprises three dimensions. Additionally, all the dimensions consisted of several measurement items.

Third, the knowledge gained from the post-positivist world view is based on objective measurement and observations. In the first phase of this study, the author advanced the relationship among the variables and posed it in terms of hypotheses. Subsequently, the objective reality was assessed by using a set of the close-ended questionnaire. Finally, it was common in post-positivist world view; a research was begun with theory/theories, developed the research framework by using theory/theories, collected the data for testing theory/theories, and if possible, made necessary revisions and suggestions. Based on the features of post-positivist and its suitability with the features of this study, the application of post-positivist was appropriate.

4.2.1.2 Social Constructivism

The ontology adopted in the second phase of the study was constructivism. Table 4.2 depicts its features described by Creswell and Plano Clark (2011). According to Easterby-Smith et al. (2008) and Merriam (2009), if the researcher views the phenomena subjectively and based on external factors, the constructivist world view is appropriate. Hence, it seems that the essence of constructivist is that reality is determined by people rather than by the objective and external factors.

Using the constructivist world view, the author viewed the phenomena in a subjective view based on informants' experiences. The author looked for the complexity of views (i.e., lean manufacturing and performance) by collecting the multiple perspectives of informants. To support this aim, this study used open-ended interview questions. The questions were designed broad and general. Furthermore, based on this world view, the author collected the data in the premise of informants, interacted with them, listened to what they say, and only focused on the context in which informants work. In addition, at the end, by using an interpretive approach, the author inductively generated a pattern of meaning (model) regarding the subject matter.

Table 4.2
Features of Constructivist Ontology

Features of constructivist	Features of qualitative phase of this study
Understanding	Seeked to understand the effect of lean manufacturing on organizational performance subjectively.
Multiple informant meanings 1. Looks for complexity of views 2. Relies on informant views of situation being studied	Attempted to collect multiple perspectives of informants by using open-ended questions.
Social and historical construction	Meaning was constructed based on informants' perspective.
Theory generation	Attempted to develop a pattern of meaning inductively.

Subsequently, to underpin the way of the author in acquiring the nature of reality (knowledge), the next section discusses about epistemological justification.

4.2.2 Epistemological Justification

Besides ontology, the second world view element is epistemology. It refers to the best way of inquiring into the nature of reality (Easterby-Smith et al., 2008). In the similar point of view, epistemological justification answers the question of *"what is the relationship between the researcher and that being researched?"* (Creswell & Plano Clark, 2011). As discussed in Chapter One, this study was a sequential explanatory mixed methods, which was started with quantitative study and followed by qualitative study. The quantitative study was driven by post-positivist epistemology, whereas the qualitative study was driven by constructivist epistemology. Table 4.3 exhibits the features of the two epistemology stances adopted in this study.

As investigating the relationship between the variables was substantial, in line with the ontological justification, post-positivist epistemology was adopted. From the post-positivist perspective, confirmation to the relationship among the variables can be achieved through designing measurements in order to test the predetermined hypotheses. It was done through empirical observation (Creswell & Plano Clark, 2011; Merriam, 2009) such as surveying experiences of large samples. Hence, post-positivist attempts to verify and confirm causality among the factors involved in a research.

Table 4.3
Features of Post-positivist and Constructivist Epistemology

	Epistemology	
	Post-positivist	Constructivist
Reality	Objective, external, out there	Multiple realities, context-bound
Aims	Discovery/to test, generalize, conform	Invention/to create, describe, understand, interpret
Starting points	Hypotheses	Meanings
Designs	Testing/conforming	Reflexivity
Techniques	Measurement	Conversation
Analysis/interpretation	Verification/confirmation	Sense-making
Outcomes	Causality	Understanding

Note. Adapted from "Management Research" by M. Easterby-Smith, R. Thorpe, and P. R. Jackson, 2008, p. 63. Copyright 2008 by SAGE Publications, Inc.; and "Qualitative Research: A Guide to Design and Implementation" by S. B. Merriam, 2009, p. 11, Copyright 2009 by John Wiley & Sons, Inc.

In a different perspective, based on Table 4.3, a constructivist assumes the pre-determined/pre-existing reality as viewed by post-positivist. Adopting this view point, the author aimed to invent and create structures to help him to make sense (to understand, interpret, and describe) what was going on around the phenomena (Easterby-Smith et al., 2008) (i.e., lean manufacturing and performance). The author, consequently, gave attention to conversation (i.e., interview) and interaction with informants focusing on understanding their own meanings. Thus, the entire research process can never be separated with sense making of informants' opinions, because interpretation of data was through sense making of the phenomenon.

4.2.3 Axiological and Rhetorical Justifications

Axiological justification discusses about values brought by a researcher in the study. This justification drives a research to be value-laden (Creswell, 2007). As discussed earlier, this study adopted two different ontological justifications (i.e., post-positivist and constructivist). Adopting post-positivism in the study encouraged the author to eliminate all types of bias that may affect the research (Creswell & Plano Clark, 2011). Consequently, in preparing the research, the author referred to several relevant studies to support the measurement items. Furthermore, content validity was assessed during the pre-test through interviews with academicians and practitioners. During quantitative analyses, the author conducted several statistical tests to avoid interpretation biasness, such as outlier test, normality, construct validity, reliability, common method variance, non-response bias, goodness-of-fit, and others.

The second ontology (i.e., constructivist), which subjectively concerns with the meaning based on informants' experiences, drove the author to report values and biases actively as well as value-laden nature of information gathered from the field (Creswell, 2007; Creswell & Plano Clark, 2011). Othman (2011) suggested to use reflexivity as a technique to eliminate biases. It recommends to use a diary to note information related to informants, such as expression, body language, and mimic. More importantly, protocol was developed to guide the case study.

Rhetorical justification drove the author regarding the style of language used in the study. Language marker should be visible even in describing problem statement, research questions and objectives. In this study, the ontological justifications tended to suggest of using both formal and informal styles of language (Creswell, 2007; Creswell & Plano Clark, 2011). Quantitative terms, such as *"relationship", "content validity", "normality", "statistics",* etc., were used in the quantitative study. Furthermore, several qualitative rhetorical markers were used in the qualitative phase, such as *"how"* questions, *"transferability", "trustworthiness", "to explain",* and others.

4.2.4 Methodological Justification

Methodological justification deals with how to gain the knowledge (Denzin & Lincoln, 2005). Driven by the research questions and the nature of reality, this study combined both deductive and inductive thinking to gain the purposes of study. Deductively, in the first phase, the author tested the research framework by using a quantitative approach. This answered the first four research questions quantitatively. Subsequently, based on the findings of the first phase, the author inductively answered the last research question qualitatively through a case study method. In the second phase, the author started with informants' views, sense-making, and finally generated a pattern of meaning regarding the phenomenon. The subsequent section will elaborate the mixed methods, and the strategy used in this study to answer the research questions.

4.3 Mixed Methods

Recently, mixed methods research has been becoming increasingly recognized as a new research approach aimed to enhance the better capture regarding the phenomena. According to Creswell and Plano Clark (2011), a mixed methods research is a research design with philosophical justifications as well as methods of inquiry. As a methodology, the mixed methods research involves philosophical justifications to guide the direction of data collection, data analysis and mixture of quantitative and qualitative approaches. As a method, it emphasizes on collecting, analyzing, and mixing both quantitative and qualitative data in either single or multi-phase research. In a similar vein, Johnson, Onwuegbuzie, and Turner (2007) stated that in a mixed methods research, a researcher combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, and inference techniques) for the broad purposes of extensiveness and depth of understanding and corroboration.

Based on the argument from Creswell and Plano Clark (2011) and Johnson et al. (2007), the mixed methods involve both quantitative and qualitative research approaches focusing not only on the procedures of data collection, data analysis and possibly interpretation, but in every stage of the research process; from the start to the end of inquiry. Creswell and Plano Clark (2011) provided core characteristics of mixed methods research as follows; (1) it collects and analyzes quantitative and qualitative data, mixed the two types of data, and gives the priority to one of both approaches, (2) it can be conducted in either single phase or multiple phases, (3) research procedures should be framed with philosophical justifications and theoretical lenses, and (4) it should combine procedures into specific research design that directs the plan of study.

It is widely known that quantitative method researches were often criticized because of lack of depth and understanding, whereas at the same time, qualitative methods researches were occasionally criticized because of being anecdotal and difficult to generalize (Hohenthal, 2006; Jick, 1979). These critics provided the rationale for conducting mixed methods research. Jick (1979) postulated, the weaknesses in each single method can be compensated by strengths in another. Using mixed methods approach led to the closer to a full representation about the phenomena intended to be investigated (Lieber & Weisner, 2010). Hence, integrating the two methods, quantitative and qualitative, are powerful to reach a deeper understanding to the interested phenomena. In line with that, as explained by Hohenthal (2006), although the call for using mixed methods had been too old (Campbell & Fiske, 1959), the studies utilized mixed methods in business research were still rare. In the area of lean manufacturing, to the author's knowledge, the previous studies were dominated by quantitative methods.

Creswell (2009) provided six major strategies to choose in designing the mixed methods research. They were sequential explanatory, sequential exploratory, sequential transformative, concurrent triangulation, concurrent embedded/nested, and concurrent transformative. This study proposed to use the first strategy, namely sequential explanatory. This strategy consists of two distinct phases. The first phase was the quantitative study, and it was followed by the qualitative phase (Creswell & Plano Clark, 2011). This strategy emphasizes the quantitative method rather than qualitative one. The study was begun with the quantitative phase. Subsequently, based on the result of the quantitative study, the second phase (i.e., qualitative study) was carried out to explain, elaborate, and triangulate the results of the first phase of the study. Hence, the qualitative study built on the quantitative study, and the qualitative phase depended on the quantitative findings. Finally, the entire analyses were interpreted. Figure 4.1 shows the mixed method strategy used in the present study.

The rationale of applying the sequential explanatory mixed methods was that the quantitative data and its analysis provide a general understanding regarding the phenomena under investigation. The qualitative data and its analysis help to explain the statistical analysis results by exploring the informant's point of views (Creswell & Plano Clark, 2011). Applying the mixed methods in this study was hoped to guide the author to enhance deeper insight regarding the linkage between lean manufacturing, operations performance, and business performance. The first phase of this study looked at the statistical relationships between the variables. Following this macro-level analysis, the second phase looked into the specific cases using a qualitative method (i.e., case study) to enhance the deeper understanding regarding the interested phenomena. In other words, the qualitative data and analysis could help the author to answer the research questions to a greater extent. The subsequent sections will discuss the research design, comprising both quantitative and qualitative research designs.

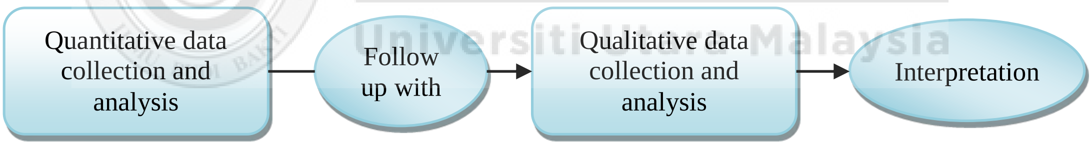

Figure 4.1
Mixed Methods Sequential Explanatory Strategy
Note. Adapted from "Designing and Conducting Mixed Methods Research" by J. W. Creswell and V. L. Plano Clark, 2011, p. 69. Copyright 2011 by SAGE Publications, Inc.

4.4 Quantitative Research Design

The present study used a cross-sectional design. It involved selecting different organizations and investigating several different factors at the same time, varies across the organizations (Easterby-Smith et al., 2008). The cross-sectional design implied that the data were collected once and represented a snapshot of one point in time (Cooper &

Schindler, 2003). In the quantitative phase, this study was begun with measurement development and pre-test of research instrument. Based on the pre-test, the instrument was revised before it was used for data collection. Subsequently, data collection and data analysis were conducted to examine the relationship among the variables.

4.4.1 Measurement Development

Connecting to the ontological and epistemological justifications of the quantitative study, the knowledge gained from the post-positivist world view is based on the objective measurement. To enhance the objectivity of measurement, data were collected by using a set of a close-ended questionnaire with ordered choice questions. Systematically, the questionnaire consists of four major sections to fulfill the following purposes, (1) section one: to obtain information related to the extent of lean manufacturing implementation, (2) section two: to obtain information about operations performance, (3) section three: to obtain information about business performance, and (4) section four: to obtain brief information about respondents and their company, including some preliminary information for conducting qualitative phase of study.

Each measurement item was addressed to measure a specific content that was adopted and adapted from several recent studies (see Appendix A.1, A.2 and A.3). Appendix A.1 provides the items used to measure the company's current implementation of all the nine lean manufacturing practices (independent variable), Appendix A.2 shows the items to measure the construct pertaining to operations performance (mediating variable), and Appendix A.3 exhibits the items to measure each of the constructs pertaining to business performance (dependent variable). Operations performance and business performance were measured based on the achievements during the past three years, in order to reduce the influence of temporary fluctuations in these variables.

The measurements were designed by using the perceptual scale. Six-point Likert scale was used to measure lean manufacturing, operations performance and business performance. In their article entitled *"designing rating scales for effective measurement in surveys"*, Krosnick and Fabrigar (1991) postulated that the five, six, and seven-point Likert scales are more valid and reliable rather than shorter and longer scales. The six-point interval Likert scale, from 1 (i.e., strongly disagree) to 6 (strongly agree), was chosen in the present study. It was rationalized by Krosnick (1991) who suggested preventing the respondents from answering a neutral point, an ambiguous response or a midpoint, because it may decrease quality of measurement, in terms of construct validity and reliability. Hence, the use of six-point scale may help to increase construct validity and reliability of instrument by reducing social desirability bias of answering in a neural point. The administered survey questionnaire is depicted in Appendix B.

4.4.2 Pre-test: Content Validity

Once a questionnaire had been developed based on the literature searches, each item and the questionnaire as a whole were validated and evaluated before the final administration (de Vaus, 2002). This validation is very critical to refine measures prior to confirmatory testing (Hair et al., 2010). If the content of a construct or questionnaire is faulty and inappropriate, the result of the study will be defective, even though statistical construct validity and reliability are sufficed.

To ensure and further enhance the content validity, readability, and brevity; the instrument was pre-tested and reviewed by a number of academicians and practitioners who were specialists in production and operations management. There is no statistical analysis can be used to ensure the content validity; it was typically determined by experts through a qualitative judgement (Flynn, Sakakibara, Schroeder, Bates, & Flynn, 1990). Five academicians and three practitioners were involved in the pre-test. The pre-test alerted the author to any potential problems that may be caused by questionnaire design. It included consultation and interviews with the respondents (i.e., academicians and practitioners) to examine the following aspects of the questions, (1) whether there are any questions that need to be included or excluded in the questionnaire, (2) whether the content of the questionnaire is sufficient, (3) whether the right questions being asked, and (4) whether the questions are easy to understand.

Subsequently, to avoid misunderstanding and data bias as suggested by the axiological justifications, the measurement items which were originally written in English were translated to Bahasa Indonesia by involving academicians from the Industrial Engineering Department of Andalas University, Indonesia. Finally, to ensure consistency between the two languages, the questionnaire was examined by Director of the International TOEFL Institute of Padang, Indonesia. In the translation, several terms were kept in English to avoid misinterpretation, such as lean manufacturing, just-in-time, setup, level indicator, signboard, rework, scrap, and lead time.

The feedbacks from the respondents (i.e., academicians, practitioners, and English teacher) were used to develop the better instrument by clarifying the wordings, and some measurement items were added, discarded, or modified. The revised instrument resulted from the pre-test was used to investigate the relationship between the variables. For this purpose, the following sections briefly discuss design of population and sample, data collection method, data analysis technique, and model validity.

4.4.3 Population and Sample

Based on the research questions, organization was considered as the unit of analysis in this study. Based on the responsibility in the organization and the person knocking the ropes of lean manufacturing, operations performance and business performance; element of the unit of analysis was determined. The element was middle or top management in production such as director, head of department, manager, and other positions, which were familiar with manufacturing activities, operations performance and business performance.

The directory published by the sub-directorate of large and medium industrial statistics of Indonesia (BPS-Statistics Indonesia, 2010) provided the data of 24,445 large and medium manufacturing companies. This number comprised 6,790 large companies and 17,655 medium companies. A company in Indonesia was considered large if it has more than 100 employees, a company with 20-99 employees is medium, and otherwise a company with less than 20 employees is considered small (BPS-Statistics Indonesia, 2010). This consideration was supported by several studies related to lean manufacturing such as Nahm et al. (2006), Furlan et al. (2011a), and Flynn et al. (1995). The data granted a number of information, including the industry sector (based on two digits of ISIC code), number of employees, formal address, phone number and contact person. Due to large manufacturing companies implement lean manufacturing more often than do small and medium companies (Fullerton & McWatters, 2001; Shah

& Ward, 2003, 2007; Susilawati et al., 2011), they were selected as population of the study.

Shah and Ward (2003) explained that lean manufacturing was commonly implemented in the discrete part industries rather than continuous process industries. According to Fogarty, Blackstone, and Hoffmann (1991), continuous production usually refers to production of goods produced in continuous quantities such as gas, fluids, powders, cement, basic metals, and other bulks items. The terms such as mix, blend, and transform are suitable to describe the production processes. On the other hand, discrete part production refers to manufacture of separate unit or countable production of items such as machinery, computer, electrical and electronic products, medical equipment and supplies, furniture, and miscellaneous manufacturing. The terms of build, assembly, and fabricate are often used to describe the discrete production. Hence, the basic fact is that in most cases, discrete products cannot be handled in the same way as continuous products. The differences between discrete and continuous manufacturing processes may affect to the extent of lean manufacturing implementation in each type of process. Following Shah and Ward (2003) and driven by axiological justification, this study focused on implementation of lean manufacturing in discrete part production to abridge generalization of results of the study.

The post-positivist ontology suggests that a quantitative research attempts to generalize the findings to the overall population. Therefore, it is necessary to obtain samples of sufficient size that are selected randomly. The sample members were drawn by using a stratified random sampling procedure. It is a modification of simple random sampling and is designed to produce the more representative and accurate samples (de Vaus, 2002). This procedure was employed to ensure that identified subgroups in the population are proportionally represented in the sample in the same proportion with the overall population (Gay & Diehl, 1992). It guarantees that in the final sample, each stratum is represented in its correct proportion.

Following the steps suggested by Gay and Diehl (1992), population of the present study was large manufacturing companies in Indonesia under the category of discrete industries. In addition, type of production process implemented in the companies should be job shop, batch, repetitive, and mass customization. The original list of large and medium manufacturing companies of 24,445 was reduced to 3,091 by eliminating medium companies and twelve manufacturing sectors, including food and beverage (ISIC 15), tobacco and tobacco products (ISIC 16); paper and paper products (ISIC 21); publishing, printing and reproduction of recorded media (ISIC 22); coal, refined petroleum products and nuclear fuel (ISIC 23); chemicals and chemical products (ISIC 24); rubber and plastics' products (ISIC 25); other non-metallic mineral products (ISIC 26); basic metal (ISIC 27); fabricated metal products, except machinery and equipment (ISIC 28); and recycling (ISIC 37). This elimination was done because the manufacturing companies categorized under these sectors are mostly non-discrete process industries. Furthermore, previous studies on lean manufacturing rarely involved these manufacturing sectors. Excluding these sectors is important to avoid bias in comparing and supporting the results of this study with previous studies. In addition, manufacturers categorized under office, accounting, and computing machinery industry (ISIC 30) were also not included in the present study because of very small population (only five large companies in this industry category).

According to Krejcie and Morgan (1970), if population is 3,500, then sample size should be 346. However, the minimum number of subjects required for a study also depends upon the type of research involved (Gay & Diehl, 1992). In order to ensure a reasonably acceptable response rate, 1,000 manufacturers were mailed a questionnaire. The stratum size of each industry was determined proportionally based on the number of population as exhibited in Table 4.4.

Table 4.4
Sampling Frame and Stratification Process

ISIC	Industry	Population*		Proportionate sample size (n=1,000)
		N	%	
17 & 18	Textiles and apparel	1,243	40.22%	402
19	Tanning and dressing of leather	196	6.34%	63
20	Wood and products of wood except furniture and plaiting materials	356	11.52%	115
29	Machinery and equipment	164	5.31%	53
31	Electrical machinery and equipment	133	4.30%	43
32	Radio, television and communication equipment and apparatus	144	4.66%	47
33	Medical, precision and optical instruments, watches and clocks	24	.78%	8
34	Motor vehicles, trailers and semi-trailers	146	4.72%	47
35	Other transport equipment	118	3.82%	38
36	Furniture	567	18.34%	184
Total		3,091	100,00%	1,000

Note. *Summarized from “Direktori Industri Pengolahan Indonesia 2010 [Directory of manufacturing industry in Indonesia 2010]” by BPS-Statistics Indonesia, 2010.

4.4.4 Data Collection Method

A post-positivist views the reality objectively (Merriam, 2009). To ensure the objectivity and prevent subjectivity of the author, data pertaining to all variables were collected using mail-based survey methodology. It was started in February 2013, and was ended in August 2013. Based on the information provided in the directory published by the sub-directorate of large and medium industrial statistics of Indonesia (BPS-Statistics Indonesia, 2010), the respondent companies were first telephoned to ensure that they are the qualified respondent companies. At the same time, the formal address was confirmed.

Together with an application letter for quantitative data collection (as depicted in Appendix C and D), the questionnaire booklets were mailed to the qualified respondent companies. It was addressed to the management position in the production or manufacturing division, such as production manager and director.

The completed survey booklets were returned by respondents in the enclosed self-address envelope with stamp, which was provided by the author. The sample companies were expected to return the completed questionnaires within 14 days of the receipt. Around 15 days later, the non-response companies were emailed or telephoned in attempting to maximize response rate.

4.4.5 Data Analysis

In the quantitative phase, the Structural Equation Modeling (SEM) approach was used to analyze the data. The SEM is recognized as a second-generation technique, which allows the simultaneous modeling of relationship among multiple variables (Gefen, Straub, & Boudreau, 2000). In the first-generation technique (i.e., regression model), according to Gefen et al. (2000), two separated steps of analysis are required. In the first step, factor analysis is conducted to examine how measures load on the constructs. Separately, in the second step, the measures with acceptable factor loading are examined to assess hypotheses. Hypotheses' testing is performed individually based on the number of hypotheses. Unlike the regression technique, SEM combines measurement and structural model in the same analysis. A measurement model provides the link between observed variables (manifest variables) and the underlying unobserved variable (latent variable) they are designed to measure. In other words, a measurement model relates a latent variable to indicators. In contrast, a structural model defines the relations among latent variables. Thus, the SEM enables the author to assess the set of factor analyses and multiple regressions simultaneously.

The use of SEM in the study was also rationalized by empirical evidence provided by Iacobucci, Saldanha, and Deng (2007), and Preacher and Hayes (2004), supporting the notion that SEM performs better than regression for assessing the mediation model. Hence, suggesting that SEM is a superior technology over the regressions. According to them, measurement errors in the SEM approach are well controlled, because of the simultaneous estimation of all parameters in an SEM model. In SEM, the measurement errors of observed variables are assessed as the integral part of the model. Gefen et al. (2000) advocated of using SEM by saying that SEM provides more complete information regarding the extent to which the model is supported by data rather than in regression. Furthermore, according to Hair et al. (2010), SEM can assess how well a theory used to develop the research model fits the reality represented by data. In addition, since multicollinearity is a problem in multiple regression analysis; in SEM, it can be modeled and further assessed (Dion, 2008).

There are two stages in the SEM process (Byrne, 2010; Hair et al., 2010). In the first stage, the author tested the fit and the construct validity of the proposed measurement model. This assessment was done by confirmatory factor analysis (CFA). Once the measurement model was satisfactory, assessment on the structural model was performed to test structural theory. Although it was possible to assess the fit and construct validity without regard to separate measurement and structural model, according to Hair et al. (2010), a valid structural test cannot be conducted with bad measures. By assessing the measurement model, the researcher would know what the constructs truly mean. If the measurement model cannot be validated, then the researcher should refine the model and/or collect new data set.

Assessment on the two models was in line with the axiological justification of the present study, as discussed earlier, suggested that all the information provided in a research must be value-laden. In order to be value-laden, post-positivism encouraged to eliminate all types of bias that may affect the research (Creswell & Plano Clark, 2011). As an attempt to eliminate biasness, assessing model validity is critical in SEM. So that, model validity should be assessed in both measurement and structural model. The next sections will discuss how to assess and further ensure the model validity.

4.4.6 Measurement Model Validity

Hair et al. (2010) provided a comprehensive guidance on how to ensure the measurement model validity. According to them, it depends on both goodness-of-fit and construct validity. Next, both will be discussed.

4.4.6.1 Goodness-of-fit

Goodness-of-fit (GOF) is intended to examine how closely the data fit the model. Hair et al. (2010) stated that model fit compares the theory to reality through assessment to similarity between estimated covariance matrix (theory) and observed covariance matrix (reality). A number of alternative measures are available to assess the GOF. Each measure is unique, but the measures are commonly classified into three general groups as below (Byrne, 2010; Hair et al., 2010):

a. Absolute fit indices. They are direct measures of how well a model reproduces its observed data. It provides information how well a theory fits the sample data.

b. Incremental fit indices. These indices assess how well an estimated model fits relative to some alternative baseline model that is referred to as a null model, where all observed variables are assumed uncorrelated.

c. Parsimony fit indices. These give evidence; which model among a set of competing models is the best, considering its fit relative to its complexity. It is conceptually similar to adjusted R^2 in the sense that they relate model fit to model complexity.

The present study relied only on absolute fit indices and incremental fit indices, not on parsimony fit indices because, according to Hair et al. (2010), parsimony fit indices are not useful to assess the fit of a single model, they are only useful in comparing the fit of two or more competing models, one more complex than the others. Hair et al. (2010) and Iacobucci et al. (2007) noted that chi-square (χ^2 or CMIN) statistic is the most fundamental absolute fit index in SEM. The objective of χ^2 test is to assess magnitude of discrepancy between observed (i.e., reality) and estimated (i.e., theory) covariance matrix (Hooper, Coughlan, & Mullen, 2008). Thus, χ^2 GOF test is used to find out how observed value of the sample is significantly different from its expected value. A large difference suggests that model does not fit. The null hypothesis of this test assumes that sample covariance matrix is not significantly different from estimated covariance matrix. In other words, it is assumed that both of reality and theory are the same. Hair et al. (2010) and Curran, West, and Finch (1996) suggested that insignificant value ($p > .05$) and low value of χ^2 indicates the model fit the data.

However, given the problems associated with using this test, Hair et al. (2010), Byrne (2010), Kline (2011), and Curran et al. (1996) noted that the χ^2 value is sensitive with sample size, multivariate normality, and number of parameters. According to Hair et al. (2010), increasing in sample size may cause difficulty in achieving a statistically insignificant GOF. It means that the χ^2 value becomes larger as increasing of sample size (Curran et al., 1996). Kline (2011) stated; if the sample size is large, then the χ^2 value may lead to the rejection to the model even though the differences between observed and predicted covariance are slight. In other words, χ^2 statistic practically always rejects the model when large samples are used (Bentler & Bonett, 1980). This test also assumes multivariate normality, and departure from normality may cause model rejections, even when the model is accurately specified (Hooper et al., 2008). In addition, increasing number of parameters in the model possibly makes it more difficult in using the χ^2 value to assess the model fit; the chi-square value will increase as the number estimated parameter increases (Hair et al., 2010). Hence, the p-value resulted from the χ^2 test is less meaningful when sample size and number of parameter become higher.

To reduce the sensitivity of χ^2 to sample size and number of parameter, Byrne (2010), Hair et al. (2010), and Kline (2011) suggested to divide its value with degree of freedom. It is well known that the χ^2 distribution is different for different degree of freedom. So that, according to Dion (2008), the interpretation should be done in its relation to the degree of freedom by computing the ratio between χ^2 and degree of freedom (χ^2/df). This value was frequently called as normed chi-square (Kline, 2011). If the ratio is less than 3.00, then the model is adequately fit (Bagozzi & Yi, 1988). However, the normed chi-square was still criticized by Kline (2011) by saying that the value does not completely correct for the influence of sample size.

Considering its sensitivity, χ^2 GOF (as well as normed chi-square) was often not used as the only GOF measure (Hair et al., 2010). Problem with χ^2 have motivated development of numerous supplements for GOF statistics. Literature noted that there are several indices available to assess GOF, which are less sensitive to sample size and number of parameter estimate. According to Hair et al. (2010), using three or four fit indices provides adequate evidence of model fit, because they are often redundant. The indices depicted in Table 4.5 were used in this study.

Table 4.5
Criterion of GOF Indices

Indices	Level of acceptance	Literature
Absolute Fit Indices		
Chi-square/df (χ^2/df)	$\leq$3.00	Bagozzi and Yi (1988)
Root mean square error approximation (RMSEA)	$\leq$.08	Browne and Cudeck (1992)
Standardized root mean square residual (SRMR)	$\leq$.08	Hu and Bentler (1998)
Incremental Fit Indices		
Non-normed fit index (NNFI)	$\geq$.90	Bagozzi and Yi (1988); Bentler and Bonett (1980)
Comparative fit index (CFI)	$\geq$.90	Bagozzi and Yi (1988)

The indices used in this study are explained as follows. Firstly, root mean square error of approximation (RMSEA) is related to the discrepancy in the sample data and what would be expected if the model were assumed correct (Dion, 2008). Secondly, standardized root mean square residual (SRMR) indicates the difference between sample covariance matrix (observed correlation) and model covariance matrix (predicted correlation) (Hooper et al., 2008). Thirdly, comparative fit index (CFI) assesses the relative improvement in the fit of the researcher's model compared to a baseline model (independence model or null model), in which covariance is assumed to be zero in the model (Dion, 2008). Fourthly, non-normed fit index (NNFI), which shows affectivity of a model compared with a null model (Dion, 2008). According to Byrne

(2010) and Hair et al. (2010), the RMSEA, SRMR, CFI, and NNFI are not sensitive with sample size. Therefore, reporting these indices together with χ^2 value associated with degree of freedom (χ^2/df) provides sufficient unique information to evaluate the model fit.

4.4.6.2 Construct Validity

Driven by the axiological justification, the quantitative phase of the study attempted to eliminate the biasness through assessing construct validity. This was because, according to Sekaran and Bougie (2009), there are possibilities of the presence of errors in attitudinal measurement. Thus, it is essential to ensure that instrument accurately measures what is intended to measure. A construct validity plays an important role to ensure that a set of measures (manifest variable) actually represent the theoretical latent variable (Hair et al., 2010). By validating the instrument, whatever which is concluded from a research can be shared confidently (Garver & Mentzer, 1999). Three of the most widely accepted forms of validity, namely convergent, discriminant, and criterion-related validity, will be discussed in the subsequent sections.

4.4.6.2.1 Convergent Validity

Convergent validity refers to the extent to which the multiple measures of the specific construct converge together and share a high proportion of variance in common (Hair et al., 2010). It reflects the high correlation between the measures designed to measure the same construct (Byrne, 2010). Following Hair et al. (2010) and Byrne (2010), convergent validity was assessed based on factor loading, average variance extracted (AVE) and composite reliability (CR).

The high factor loadings on a construct indicate a good convergent validity. High loadings on a factor indicate that they converge on a common point. Hair et al. (2010) suggested that all factor loadings should be statistically significant. Bagozzi and Yi (1988) suggested the factor loading of .50 and above as the acceptable value to demonstrate convergent validity. The AVE is a measure to determine how much variation in the multiple items is explained by the latent variable, which is comparable to the proportion of variance explained in factor analysis. AVE is calculated as the sum of the squared standardized factor loadings, divided by this sum plus the sum of indicator item error (Fornell & Larcker, 1981). The AVE ranges between 0 and 1, whereby the value exceeds .50 suggests the adequate convergent validity (Bagozzi & Yi, 1988; Fornell & Larcker, 1981).

Other than factor loading and AVE, the CR is also a common indicator of convergent validity in conjunction with SEM. It is calculated from the squared sum of factor loadings for each construct, divided by this square sum plus the sum of the indicator item error for a construct (Hair et al., 2010). The value ranges from 0 to 1. The value of greater than .60 indicates an acceptable composite reliability (Hair et al., 2010).

4.4.6.2.2 Discriminant Validity

Discriminant validity indicates uniqueness of a construct from other constructs. According to Hair et al. (2010), high discriminant validity provides evidence that a construct is unique and distinct from other constructs. In other words, a latent variable should explain better the variance of its own indicators than the variance of others. This also implies that individual manifest variable should represent only one latent variable.

Hair et al. (2010) suggested, the presence of cross-loadings indicates a discriminant validity problem.

The discriminant validity was ensured by determining whether the square root of AVE for each construct is higher than the correlations between the construct and any other constructs (Fornell & Larcker, 1981). The square root of AVE of a latent variable should be higher than the correlations between the latent variable and all other latent variables (Fornell & Larcker, 1981; Hair et al., 2010).

4.4.6.2.3 Criterion-related Validity

Criterion-related validity was defined as the extent to which all the constructs that are theoretically related are actually empirically related. Hair et al. (2010) stated that it suggested whether the relationships between the constructs make sense and agree with theory. In this study, it was investigated by using path coefficients indicating the nature of relationship among the latent variables.

4.4.7 Structural Model Validity

Once the measurement model had been specified, the last stage of the SEM procedure (i.e., testing validity of the structural model) had to be performed. Following Hair et al. (2010), assessment to structural model validity follows general guideline for measurement model validity. Hence, validity in the structural model should be established by relying on GOF (i.e., χ^2/df, SRMR, RMSEA, CFI, and NNFI) and construct validity (i.e., convergent, discriminant, and criterion-related validity).

4.5 Qualitative Research Design

As discussed earlier, this study used sequential explanatory strategy as suggested by Creswell (2009) and Creswell and Plano Clark (2011). The strategy suggested the qualitative study as the continuation of the quantitative study. The qualitative study was conducted after the quantitative data had been successfully analyzed. Furthermore, this strategy also suggested that the qualitative data were typically used to explain, interpret, understand, and triangulate the quantitative results. Based on the features of the ontological and epistemological justifications (i.e., constructivism) presented earlier, a case study method was appropriate to be carried out in the qualitative phase of the study.

4.5.1 Case Study

As discussed earlier, the objective of the qualitative phase of the present study is to investigate how lean manufacturing affects the business performance. In order to achieve the pre-determined objective, the author explored a bounded system or a case (i.e., lean manufacturer) through detailed and in-depth data collection involving several sources of evidence, such as interviews, observations, audiovisuals, documents, and so on (Creswell, 2007). The data gathered was to contribute to the better understanding of the root of problems under investigation. In line with Creswell (2007), Yin (2009) defined case study as an empirical inquiry investigating a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. Creswell (2007) provided characteristics of the case study as presented in Table 4.6.

Table 4.6
Characteristics of Case Study Method

Features	Characteristics
Focus	Developing an in-depth description and analysis of a case or multiple cases
Type of problem best suited for design	Providing an in-depth understanding of a case or cases
Unit of analysis	Studying an event, program, activity, more than one individual
Data collection forms	Using multiple sources, such as interviews, observations, documents, and audiovisuals
Data analysis strategies	Analyzing data through description of the case and themes of the case as well as cross-case themes

Note. Adapted from "Qualitative Inquiry and Research Design: Choosing Among Five Approaches" by J. W. Creswell, 2007, p. 78-79. Copyright 2007 by SAGE Publications, Inc.

Accordingly, it seems that the case study helps the author to achieve the last objective of the study (i.e., to explain how lean manufacturing affects the business performance), because the case study offers deeper insight regarding the phenomena that are not found in most quantitative research tools (Yin, 2009). More importantly, this allowed the author to explore deeper the issues that are difficult to capture quantitatively. Hence, through the case study, the findings are beneficial to explain, corroborate, triangulate, and confirm the quantitative findings (Creswell, 2009).

4.5.2 Sample for the Case Study

In line with the constructivist ontology and epistemology underpinned this case study approach; the intention is to develop an in-depth exploration regarding the interested phenomena, rather than to generalize to a population as addressed in the common quantitative inquiry. In a quantitative study, the author was required to select a number sample randomly from the particular population, aimed to generalize from the sample to the population. In contrast, the qualitative study selects the sample that can best help the author to gain the detail understanding regarding the phenomenon. So that, the term *"purposeful sampling"* was used by several scholars (Bryman & Bell, 2007; Creswell, 2007; Miles & Huberman, 1994) to represent sampling technique in a qualitative study. The purposeful sampling means that companies or individuals were selected as respondents because they can purposely inform an understanding of the central phenomenon of the study (Creswell, 2007).

Creswell (2007) stated purposeful sampling should be performed at the site level as well as at the informant level. So that, the site/company to be studied was first selected, then some sampling to select informants of the study was also done. In this study, at the site level, critical case sampling technique was used, whereas at the informant level, snowball sampling technique was applied. The critical case sampling was used to select a sample company. Considering the purpose of the qualitative phase of this study (i.e., to explain how lean manufacturing affects business performance), the critical case purposeful sampling is more appropriate to be applied of all other sampling techniques. It was selected because it allows logical generalization and maximum application of information to other cases or companies (Miles & Huberman, 1994). In this study, a case company was considered critical if it fulfilled the following criteria; (1) it had been fully implementing lean manufacturing and achieving high performance after its implementation, (2) it had been implementing lean manufacturing for more than three years, more than five years is preferable, and (3) it had standard operating procedures to guide the lean implementation.

Considering the above criteria, Toyota Indonesia was selected as a case company for the qualitative study. Toyota Indonesia had been fully implementing lean manufacturing since year 1971 and had been achieving the admire performance after its implementation. It had complete documents as guidelines for implementing lean manufacturing. More importantly, Toyota was recognized as the pioneer of lean manufacturing (Chavez et al., 2013). Even, Arif-Uz-Zaman and Ahsan (2014) stated that the foundation of lean manufacturing was Toyota Production System (TPS).

Toyota Indonesia is not only producing vehicles, but also the engines used in various types of commercial and passenger vehicles of Toyota. For supporting vehicle and engine productions, Toyota Indonesia is producing body parts, casting materials, dies and jigs. Besides production, it exports various types of Toyota vehicles' component. Hence, Toyota Indonesia produces a variety of products such as vehicles, components, jigs and dies, and service parts.

The quantitative phase of this study focused on the implementation of lean manufacturing in the discrete part production. As the qualitative study is addressed to explain, triangulate, and confirm the quantitative findings, the discrete process plants (i.e., engine production, component export and vanning, stamping, and vehicle assembly plants) were selected in this phase. Overview of Toyota Indonesia and its plants involved in this study are presented in Appendix E.

After selecting the sample company, at the informant level, the second sampling technique (i.e., snowball) was used to select informants to be interviewed. It is the most common form of purposeful sampling (Merriam, 2009). In the present study, based on the last research question (i.e., how does lean manufacturing affect the business performance?), the author interviewed key informants who have good understanding regarding the lean manufacturing implementation and/or companies' performance (i.e., operations performance and business performance).

Based on this criterion, following Merriam (2009), key informants who met the criteria were interviewed. The first key informant was a general manager (division head), with more than twenty years' experience in the company. More importantly, he has been assigned to several divisions and departments in Toyota Indonesia. Subsequently, as interviewing the early key informant, the author asked him/her regarding the next informants who are best to refer. As a guideline, there are four specific criteria to guide the informant to recommend the next interviewees as follows; (1) the next informant must at least hold supervisory level in the plant, (2) he/she should have been working in the company for at least five years, (3) he/she is knowledgeable in lean manufacturing implementation and/or operations performance and/or business performance, and (4) he/she must actively be involved in lean manufacturing activities. By applying the snowball technique, the snowball became bigger and bigger because of the accumulation of information collected from the informants. In other words, the rich and thick information could be obtained.

There is no rule of thumb regarding how many informants to be interviewed and how many sites to visit (Lincoln & Guba, 1985; Merriam, 2009). According to Merriam (2009), it depends on the questions being asked, information being gathered, and availability of resources to support the study. She suggested, *"What is needed is an adequate number of informants, sites, or activities to answer the question posed at the beginning of the study…"* In addition, Lincoln and Guba (1985) recommended that number of sample in a qualitative study is limited until the point of saturation or redundancy is achieved. In other words, data collection would be terminated when there is no new significant information are forthcoming from new sampled units or informants. Hence, the qualitative study should collect information from an adequate number of informants until the saturation point is achieved.

4.5.3 Data Collection Method

A major distinction between quantitative and qualitative methods is in terms of data used in these two methods. Quantitative method deals with numbers and numerical values, whereas qualitative method deals with words, texts, and pictures. In line with the constructivist ontology and epistemology, and features of a case study (see Table 4.6), this study typically gathered multiple types of data from multiple sources (e.g., interview, observations, documents, and audiovisual materials). Table 4.7 summarizes the types of data that can be gathered from various forms of data collection techniques.

Table 4.7
Forms of Qualitative Data Collection

Forms of Data Collection	Types of Data	Definition of Type of Data
Interviews	Transcriptions of open-ended interviews	Unstructured text data obtained from transcribing audiotapes interviews
Observations	Field notes and drawings	Unstructured text data and pictures taken during observations by the researcher
Documents	Hand-recorded notes about documents or typically scanned documents	Public (e.g., notes from meeting) and private (e.g., journals) records available to researcher
Audiovisual materials	Pictures, photographs, objects, sounds	Audiovisual material consisting of image or sounds of people or places recorded by researcher or someone else

Note. Adapted from "Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research" by J. W. Creswell, 2008, p. 222. Copyright 2008 by Pearson Education, Inc.

This study attempted to obtain as much data as possible to provide valid and comprehensive evidence by using as many data sources as possible. According to Yin (2009), various sources are complementary, since there is no single source that has a complete advantage over the others. However, this study used semi-structured interview as the main data collection method. This why, one of the most important data sources of a case study is an interview because most case studies are about human affairs or behavioral events (Yin, 2009). In addition, lean manufacturing implementation and performance achieved after its deployment are all about experience of informants. To grab a comprehensive conclusion of the study, multiple views from a number of informants are required.

The next section presents ethical consideration that must be complied during the data collection phase, as well as the interview protocol as a guidance for the researcher during the interview sessions.

4.5.3.1 Ethical Considerations

It is essential to avoid potential harms to those participated in this study. Thus, the researcher should consider ethical issues in performing the research (Bloomberg & Volpe, 2012). In the qualitative study, this consideration has been a concern since the first contact with the participating company. The author requested a letter for data collection from Othman Yeop Abdullah Graduate School of Business (OYA-GSB) of Universiti Utara Malaysia (as attached in Appendix F), and sent the letter to the company. Together with this letter, the author attached his own application letter (as attached in Appendix G) to obtain approval for conducting the data collection.

A preliminary visit was done. In this visit, the author collected an approval letter (as attached in Appendix H), performed a preliminary observation as well as a briefing with mentor (field coordinator) and his staff. In this briefing, the author highlighted the purpose behind the study, its benefits, data collection process, confidentiality protection, how the results used, and informant's rights. More importantly, this preliminary visit assisted the author to refine the data collection plans, which is not only in terms of data collection procedure to be followed but also in terms of data content. This visit helped the author to develop relevant lines of questions and even may provide some conceptual clarification for research procedure. It was also important to clarify some specific terms or wordings typically used in the company, in order to avoid terms' misunderstanding in the data collection process. Hence, the preliminary visit provided introductory insight into the procedure of data collection, as well as minimizing errors in the actual data collection process.

In the interview, the time and location were set by the informants based on their convenience. The author has been at the venue fifteen minutes earlier than the appointment time. This is to avoid the informant from waiting for the author. Before the interview session, the informant was informed about the interview consent, and he/she was encouraged to ask questions to prevent misinformation and misunderstanding. Finally, both informant and author signed the consent form (as attached in Appendix I). This is important to show the informant's willingness to involve in the present study. In addition, informant's permission to audiotape the interview process was requested before the interview took place. The author was attached in Toyota Indonesia from 4th to 29th August 2014 for the purpose of data collection. Certification of complete data collection is attached in Appendix J.

4.5.3.2 Interview Protocol

Data collection in a case study should be guided by a protocol (Creswell, 2008). Due to this study is sequential explanatory mixed methods; the detail protocol was prepared after the quantitative data analyses, because the scenario of the qualitative phase is driven by the quantitative results (Creswell & Plano Clark, 2011). This section explains the detail of interview protocol to guide entire data collection processes.

The interview protocol used in this study comprised three main sections. The first section contains questions related to general information about the informant in terms of her/his position, work experience, and duties. This section is very important to justify whether the informant is the right person to take part in the interview. Subsequently, section two contains general questions regarding the implementation of lean manufacturing in the company, such as duration of its implementation, its main objective, terms used to represent lean manufacturing and its practices, etc. Section three contains questions related to each specific practice of lean manufacturing and its implementation. In this section, the possible effects of the practices on company's performance (i.e., operations performance and business performance) are also questioned. The detail of interview protocol is depicted in Appendix K. There are three sets of the interview protocol. The first set is the protocol for the key persons of lean manufacturing implementation containing general questions. These questions were addressed to all the informants. The second set contains more specific questions related to the implementation of lean manufacturing and its effect on performance within the context of particular informants' division. The second interview protocol guided the interview with managerial level's informants. The last set contains job-related questions, which were addressed to supervisory level's interviewees.

Practically, during the interview session, the probing technique was used to make the informants share as much as possible information regarding lean manufacturing implementation and its effect on company's performance. In each session, the author recorded answers from informants. In order to obtain the accurate records of conversation, the author recorded the questions and responses by using a voice recorder. Otherwise, although it is sound to record the interview, the author took notes in case of the voice recorder malfunctions. Once an interview finished, the author immediately transcribed, re-checked, and summarized the answers to ensure the correctness, accuracy, and adequacy of information.

Equally important, the author also observed the manufacturing activities of the company, browsed through the company's website to obtain related information and useful documents (such as annual report and other published documents). These were done for triangulating and corroborating the interview results.

4.5.3.3 Role of the Author

Guided by ontological and epistemological justifications, as in common qualitative research, the researcher collaborated, mixed, and immersed himself with the social realities to enhance a deeper understanding regarding the interested phenomena. This suggested the direct interaction between the author and the informants. In attempting to make sense the multiple perspectives of informants, the author placed himself in an interpretive position. This position required the author to interpret and make sense all the information obtained from every single stage of the case study. In addition, adopting constructivist world view in the qualitative study suggested the author to report all the biasness occurred in the entire research process.

4.5.4 Mode of Analysis

As presented earlier, the main data collection method used in the case study is semi-structured interviews. The result of the interview was transcribed and written into the text format. Thus, the main data of the qualitative study were in a text form. According to Guba and Lincoln (1994) and considering the constructivist epistemology, hermeneutics is an appropriate mode of analysis. Although it was originally used to interpret the Bible by Protestant groups, it is relevant to management research (Easterby-Smith et al., 2008). Hermeneutics concern about the meaning behind the text and text analogue (Bryman & Bell, 2007; Myers, 1994). Selection of this approach was based on the reality in an organization where people can have confusing, incomplete, cloudy, contradictory, and unclear views on a case, since the hermeneutic analysis attempts to make sense the whole views regarding the object of the study (Myers, 1994).

There was no single rule of thumb regarding the analysis procedures of qualitative data. Creswell (2007) said, *"..., qualitative researchers preserve the unusual and serendipitous, and writers craft each study differently..."* However, in making sense the data, the four steps suggested by Creswell (2007) were conducted in analyzing the qualitative data. They are data managing; reading and memoing; describing, classifying, and interpreting; and finally representing and visualizing the data. Creswell (2007) then named this process as *"analysis spiral"*, as exhibited in Figure 4.2.

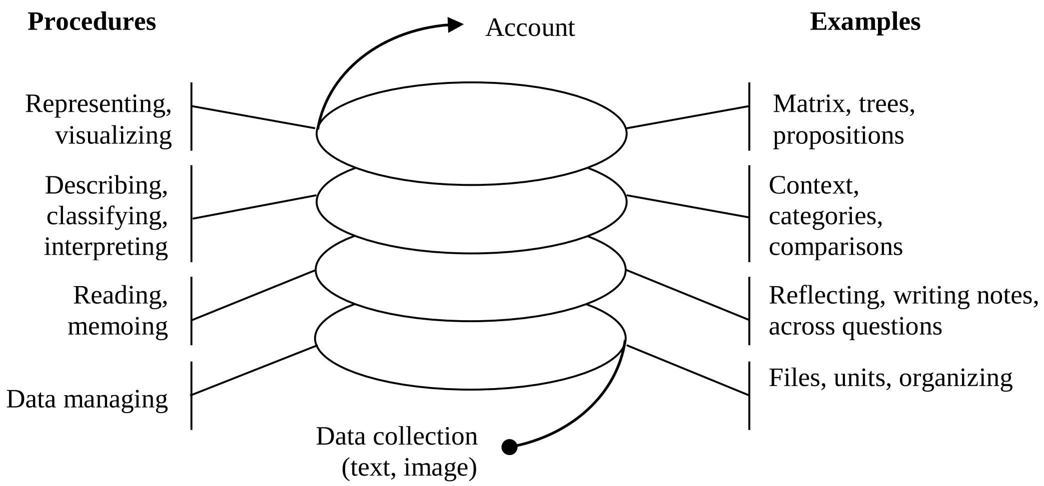

Figure 4.2
Qualitative Data Analysis Spiral
Note. Adopted from "Qualitative Inquiry and Research Design: Choosing Among Five Approaches" by J. W. Creswell, 2007, p. 151. Copyright 2007 by SAGE Publications, Inc.

4.5.5 Validity and Reliability

In line with the axiological justification, Yin (2009) suggested; quality of the research design must be ensured at every single step of the case study. Assessment on validity and reliability is important to ensure trustworthiness of the research findings. In other words, this step establishes the legitimation of the case study. Yin (2009) recommended four common techniques to assess the quality of the case study, namely construct validity, internal validity, external validity, and reliability. Subsequently, validity and reliability assessment done by the author in the entire qualitative research process are presented.

4.5.5.1 Construct Validity

The main objective of assessing construct validity is to identify and establish the correct operational measures for the concept being studied. To ensure this type of validity, this case study used multiple different sources of evidence (i.e., interview, observation, documents, and audiovisual materials). According to Yin (2009) and Creswell (2008), collecting multiple sources of evidence is preferable because various sources are complementary, since there is no single source that has a complete advantage over the others. In addition, multiple sources of evidence allow the author to converge the evidence through triangulation and corroboration processes during the data collection. Thus, findings are likely to be more convincing and accurate. Another tactic used by the author to ensure the construct validity was maintaining a chain of evidence as suggested by Creswell (2008). For this purpose, the author attempted to move from one step to another with clear and traceable procedures by recording all the process of collecting data in a field note from the beginning until the end.

More importantly, at the composition stage, the author presented this result in front of a key informant from Toyota Indonesia and got his thorough review. This key informant review was done on 28th to 29th May 2015. This is important to ensure that all the evidence presented throughout this report is valid and accurate. In addition, this review is important to avoid from reporting confidential information. A number of constructive comments were successfully gathered and had been used to enrich content of the report. In addition, confidential information was discarded from the report. Certification letter from the key informant is attached in Appendix L.

4.5.5.2 Internal Validity

Due to this case study is explanatory, internal validity is a must to explain why and how independent variable leads to the dependent variable. Internal validity is important to establish a causal relationship between certain conditions and other conditions (Yin, 2009). It ensures credibility of the research findings inferring whether the findings are congruent with the reality or not (Denzin & Lincoln, 2005).

In an explanatory strategy, pattern matching logic is related to direction of the relationship between independent variable and dependent variable. In this study, the patterns of the relationship between all the variables (i.e., lean manufacturing, operations performance, and business performance) coincided. In addition, as another form of pattern matching, logic model has become increasingly useful to evaluate case studies, which can be used not only in qualitative data but also in collaboration with quantitative data, even can be tested with structural equation models (Yin, 2009). A logic model illustrates a sequence of cause and effect relationships by integrating inputs, activities, outputs, and outcomes and effects into an account (Hoffman, 2005).

According to Hoffman (2005), inputs are resources used; activities are what are done with inputs to fulfill the goals; outputs are direct products of activities, and outcomes and effects are the change that occurs as a result of activities. In this study, logic model was done in the quantitative phase of the study. Interestingly, the result of quantitative study is strongly supported by the qualitative phase.

Besides pattern matching, explanation building was also frequently used to ensure internal validity. Explanation building is aimed to analyze the case study data by building explanation related to *"why"* and *"how"* something happened (Yin, 2009). He also stated that one of the goals of explanation building is to build a general explanation that fits each individual case (or informant), even though each case varies in detail. In the present study, explanation building was done in the data analysis stage. The outputs of the explanation building are as indicated in Chapter Six. Yin (2009) suggested that this may lead to major contributions to theory building.

Based on the above explanations, internal validity of the case study was considered sufficient.

4.5.5.3 External Validity

External validity is addressed to establish generalizability or transferability of the findings (Lincoln & Guba, 1985; Yin, 2009). This validity ensures whether the findings are applicable to any other situations and contexts. Following Yin (2009), this study used replication logic to confirm this validity. According to him, replication logic is analogous to multiple experiments in which the results are considered robust if a number of replications showed the same outcomes.

As reported earlier (see Section 4.5.2), the present case study was conducted in four plants at Toyota Indonesia. They are stamping plant, component export and vanning plant, engine production plant, and vehicle assembly plant. Each of the plants has different nature of business, types of products, types of production processes, and technology used. Even though the cases were different in terms of context, to some extent, there was a consensus regarding the conclusion of the study as stated in Section 7.1. At least, conclusions of the study are applicable within the context of the present study (i.e., discrete manufacturing process industries). Further investigation into the implementation of lean manufacturing and its effect on organizational performance within the context of continuous process industries is suggested for future research.

4.5.5.4 Reliability

Reliability refers to the stability and consistency of data collection procedure in order to minimize biases and errors in the study. Lincoln and Guba (1985) used the terms *"dependability"* to express the same purpose. Yin (2009) stated that if the procedure is repeated, the same findings and conclusion would be obtained. Following Yin (2009), the present case study used a protocol and database to ensure the reliability. The protocol, as elaborated in Section 4.5.3.2, and as depicted in Appendix K, helped the author to ensure stability and consistency of data collection procedure. In addition, the author also developed a database, which is essential to organize the data. Database helped the author to track all the related information. All the data collected in the entire data collection process were well documented. Interview transcriptions were analyzed by using Atlas.ti 7 software. So that all the data were traceable and well documented.

4.6 Chapter Summary

This chapter presented methodology used in this study comprising philosophy of research design, and the research design itself. The study applied sequential explanatory mixed methods to answer the research questions. It is hoped that the design can convey author to the more comprehensive and deeper understanding regarding the phenomena under investigation.

CHAPTER FIVE
QUANTITATIVE RESEARCH FINDING

5.1 Introduction

As elaborated in Chapter Four, the present study is sequential explanatory mixed methods in which the quantitative phase is, firstly, conducted. Subsequently, it is followed by the qualitative phase to obtain deeper understanding regarding the quantitative findings. This chapter exhibits the results of quantitative data analysis, which is the main part of the study. SPSS-AMOS 22 was used as an analysis tool.

5.2 Response Rate

As discussed in Chapter Four, a total of 3,091 manufacturing companies in Indonesia was listed as population of the study. In the data collection stage, 1,000 questionnaires were distributed by mail to the targeted respondents (i.e., manager, head of department, and director in operations/production) since the end of February 2013. The sample companies were expected to return completed questionnaires within 14 to 30 days after the receipt. Starting from 20 days after the distribution date, the non-response companies were reminded through telephone and e-mail in attempting to maximize response rate. After six months, 206 survey booklets were completed and returned, leading to 20.60% response rate. However, 24 responses were not included into the subsequent data analyses because of several reasons; such as an inappropriate person to answer the questionnaire, incomplete response, a lot of missing values, irrelevant business nature, and unsuitable type of production process employed in the companies. Finally, 182 data sets were usable for the further data analyses, leading to 18.20% effective response rate.

5.3 Measurement Model of Indicators

There are two models involved in an SEM analysis, which are measurement model and structural model (Hair et al., 2010). Measurement model exhibits the relationship between manifest variables and their underlying construct (i.e., latent variable). Whereas, structural model shows causal relationship among the measurement models, which is commonly driven by research hypotheses. Before assessing structural model, measurement model must be first assessed.

Assessing the measurement model is important to ensure how well manifest variables represent a latent variable. It was done by applying confirmatory factor analysis (CFA) separately (i.e., per construct or indicator) because of limitation of sample size (Hair et al., 2010). Measurement model of each indicator was assessed in terms of convergent validity and goodness of fit (GOF). Convergent validity, as detailed in Section 4.4.6.2.1, ensures that measurement items of a specific construct converge together and share a high proportion of variance in common (Hair et al., 2010). In other words, convergent validity reflects unidimensionality of the measurement items. For this purpose, factor loadings, average variance extracted (AVE), and composite reliability (CR) were assessed. Besides convergent validity, GOF indicating how closely the data fit the model was also assessed. Hair et al. (2010) stated that model fit compared the theory to reality through assessment of similarity between estimated covariance matrix (theory) and observed covariance matrix (reality). In this study, the χ^2 statistics, χ^2/df, RMSEA, SRMR, CFI, and NNFI were used as the indicators of GOF.

The results of CFA of the measurement model of each indicator are reported in Table 5.1. Based on the table, nine measurement items must be discarded from the subsequent data analysis. The reasons of deleting the items are either as follows:

1. Low factor loading. High factor loading is required to achieve unidimensionality among the measurement items. Low factor loading may lead to poor GOF.

2. Redundancy among the items. Redundancy among the items was examined through the modification indices (MIs) table produced by AMOS. The MIs statistically indicate the covariance between each pair of items, which is shown through the correlated error of the respective measurement items.

Table 5.1 shows that all factor loadings are acceptable, which are greater than .700. Based on the factor loadings, AVE and CR were computed. The AVEs of lean manufacturing practices ranges between .610 and .745, and are considered high in magnitude. Similarly, AVEs of operations performance and business performance measures are also high, range between .678 and .740 for operations performance measures, and between .699 and .819 for business performance measures. Similarly, CR of all the constructs indicating internal consistency of measurement items are also in high level. CR values of lean manufacturing practices are greater than .851. Likewise, operations performance measures also fulfilled the criteria of internal consistency, with CRs are greater than .895. Business performance measures are also internally consistent, with the lowest CR value is .890. Based on the factor loadings, AVEs, and CRs, the criteria of convergent validity are successfully fulfilled for all the indicators of each variable. In conclusion; for each construct, all the items are unidimensional and converge or share a high proportion of variance in common.

Table 5.1

Summary of CFA of Measurement Item (n = 182)

Construct	No. of item*	Deleted Items	Factor Loading**	AVE	CR	Goodness of Fit Indices					Normality***	
						χ^2/df	RMSEA	SRMR	NNFI	CFI	Skewness	Kurtosis
Lean Manufacturing												
Flexible resources	7	FR5	.748 - .901	.688	.901	1.170	.057	.019	.989	.993	.297 - .851	.071 - .857
Cellular layouts	8	None	.769 - .916	.682	.921	2.697	.085	.025	.969	.978	.564 - 1.108	.015 - 1.244
Pull system	6	PS6	.831 - .894	.745	.916	1.275	.034	.011	.997	.999	.660 - .957	.028 - .459
Small lot production	7	SLP7	.827 - .889	.743	.928	2.923	.090	.019	.977	.986	.182 - .473	.411 - .879
Quick setup	7	QS5	.754 - .820	.610	.851	1.811	.059	.022	.984	.991	.261 - 1.020	.034 - .927
Uniform production level	7	UPL2	.713 - .879	.677	.895	2.902	.090	.024	.972	.983	.217 - .947	.136 - .653
Quality control	8	None	.778 - .866	.665	.913	2.470	.079	.026	.971	.979	.614 - 1.295	.194 - 2.290
Total productive maintenance	7	None	.778 - .889	.712	.925	2.156	.070	.020	.983	.988	.426 - 1.147	.206 - 1.503
Supplier networks	7	None	.755 - .895	.708	.923	1.916	.062	.019	.986	.991	.507 - 1.464	.111 - 2.968
Operations Performance												
Quality	8	None	.797 - .905	.740	.944	1.721	.055	.018	.989	.992	.674 - .985	.315 - 1.208
Manufacturing flexibility	6	None	.760 - .870	.678	.895	3.279	.098	.027	.966	.980	.628 - .812	.010 - .961
Lead time reduction	7	None	.761 - .880	.718	.927	2.419	.078	.019	.979	.986	.462 - .884	.092 - 1.082
Inventory minimization	7	IM1E	.741 - .923	.730	.922	2.593	.082	.018	.981	.988	.231 - .673	.051 - .692
Productivity	8	None	.786 - .925	.686	.923	2.315	.075	.023	.976	.983	.267 - .796	.010 - .661
Cost reduction	6	None	.754 - .900	.713	.914	2.641	.084	.021	.979	.987	.254 - .626	.036 - .675
Business Performance												
Profitability	5	None	.833 - .949	.819	.949	1.017	.008	.008	1.000	1.000	.513 - .671	.080 - .301
Sales	8	SL3; SL4	.853 - .925	.777	.942	1.629	.052	.013	.993	.996	.768 - 1.085	.549 - 1.413
Customer satisfaction	6	CS1E	.803 - .874	.699	.890	1.534	.048	.014	.993	.997	.702 - 1.160	.682 - 2.226

Note. *Number of item before deletion. **Range of factor loading for all the retained items. ***Range of skewness and kurtosis for all the retained items (all values are in absolute value).

The results of assessment on GOF are presented in Table 5.1. The *p*-values indicating the significance level of χ^2 are significant at .05 for the majority of the measurement models, except for six constructs (i.e., flexible resources, pull system, quick setups, profitability, sales, and customer satisfaction). However, according to Hair et al. (2010), the χ^2 is sensitive to sample size. Due to this sensitivity, Hair et al. (2010) and Byrne (2010) suggested not to use χ^2 as a sole criterion of GOF. As indicated in Table 5.1, the other criteria of GOF (i.e., χ^2/df, RMSEA, SRMR, CFI, and NNFI) are satisfactory. Thus, all the measurement models are considered fit the data. In other words, no difference between theory and reality.

Although in a factor analysis, normality assumption is not critical and rarely used (Hair et al., 2010), this study attempted to ensure that the data used in the CFA are normally distributed because normality is a critical assumption for SEM, especially for maximum likelihood estimation. According to Hair et al. (2010), it is more efficient and unbiased when this assumption is met. As shown in Table 5.1, all the skewness and kurtosis values fall within the acceptable level of ±2 for skewness and ±7 for kurtosis (Curran et al., 1996; West, Finch, & Curran, 1995).

Albeit estimations on each measurement model indicated adequate convergent validity, GOF, and fulfilled the criteria of normality assumption; in a structural model assessment, SEM demands a high ratio of the number of sample (N) to the number of estimated parameters (q) (Hair et al., 2010; Kline, 2011), which was commonly abbreviated by N:q ratio (Jackson, 2003). According to Jackson (2003), the N:q ratio is important to ensure trustworthy estimates. Even though there is no specific guideline for the required sample size in SEM, using rule of thumb considering model complexity to justify the number of sample is preferable. Following Bentler (2005) and Hair et al.

(2010), the required sample size should be five times the number of parameter estimate. In other words, the N:q ratio should be equal to 5:1.

In this study, based on the theoretical framework, the author was required to estimate more than 250 parameters by using limited sample size (i.e., 182). In other words, the sample size did not adequate to support fitting a model that includes individual items in a second-order model. The use of individual items for the latent variables often necessitates estimating a large number of parameters, and thus requires large sample size. Hence, the threshold value of the N:q ratio cannot be achieved. Even if all the original 206 samples are included into the analysis, the ratio would have been less than one sample per parameter estimate. This is far below the ideal ratio of 5:1. Hence, the ratio was too low to obtain a stable factor solution (Bandalos & Finney, 2009). Hair et al. (2010) commented that if the ratio is too far from the threshold, researchers may face the risk of over-fitting the variate to the sample. It makes the results may lack of generalizability.

To overcome this limitation, a parceling technique was recommended (Coffman & MacCallum, 2005; Hair et al., 2010). By applying this technique, a ratio of 182:41, which equals to 4.44:1 is obtained. This ratio is considered marginally accepted. However, Jackson (2003) stated that different researchers may offer different recommendations concerning the actual ratio needed. Jackson (2003) further explained that the assertion regarding the ratio does not appear to have empirical support. In addition, to overcome the marginally accepted of the N:q ratio, in assessing structural model, this study applied bootstrapping technique (Hair, Ringle, & Sarstedt, 2011; Preacher & Hayes, 2008), as presented in Section 5.12.1.

Based on the CFA of measurement items, it seems that parceling technique for the data analysis can be performed, as its requirements are well fulfilled. The detail of parceling in SEM is then discussed in the subsequent section.

5.4 Parceling Technique in SEM

The issue of creating item parcels in SEM is not new. The parceling technique was originally coined from the work of Cattell (1956) and Cattell and Burdsal (1975), and the use of this application has continued through several works in contemporary SEM technique, such as Bandalos (2002) and Sass and Smith (2006). Item parceling was initially introduced to obtain manageable factor matrices when dealing with a large number of items (Cattell, 1956). This application generally involves summing or averaging of responses from several items, which are measuring the same construct (Kim & Hagtvet, 2003). In short, a parcel is a mathematical combination summarizing multiple items into one construct. Parcels are sometimes called mini scale (Martınez-Lopez, Gazquez-Abad, & Sousa, 2013). Nowadays, application of parcels in SEM is quite common (Bandalos & Finney, 2009; Kline, 2005; Martınez-Lopez et al., 2013; Sass & Smith, 2006); there has been a growing interest of application of this technique.

5.4.1 Justification of Applying Parceling Technique

Recently, this technique has received much attention from several scholars and has been advocated because of its advantageous properties compared to individual items. Increased reliability was cited most frequently as a reason for parceling (Bandalos & Finney, 2009). Parcels were claimed to be more reliable than individual items (Bandalos, 2002; Bandalos & Finney, 2009; Coffman & MacCallum, 2005; Hall, Snell, & Foust, 1999), whereby the reliability increases as the number of items included in the test increases. Besides a good reliability of items in a parcel, a parcel tends to be more continuous and normally distributed than those of individual items (Bandalos, 2002; Coffman & MacCallum, 2005). Thus, the use of the parcel may conform more closely to the assumption of common normal theory-based estimation methods such as maximum likelihood. The use of normal data is pre-requisite of applying the maximum likelihood; which according to Hu and Bentler (1998), if the data is not multivariately normal, the estimates of fit measures and standard error may not be accurate.

Coffman and MacCallum (2005) and Bandalos (2002) pointed out that parceling may improve the overall fit of a model. This is rationalized because a parcel reduces complexity of a model, which according to Bandalos and Finney (2009), models with fewer variables are more likely to have a good fit. This is because of cancellation of all random and systematic errors, due to the aggregation of measurement items into a parcel (Little, Cunningham, Shahar, & Widaman, 2002). In short, a model with parcels as the indicator is likely to fit better than a model with items as the indicator, because a parcel's correlation matrix is simpler than an item's correlation matrix. Hence, combining items into a parcel in a CFA can improve model estimation and fit. Meade and Kroustalis (2005) stated, because an adequate model fit is imperative for a CFA test, parcels have repeatedly been applied in SEM.

According to Bandalos and Finney (2009) and Chapman and Tunmer (1995), parceling can reduce the influence of idiosyncratic features of the items (such as caused by random errors) and simplifies the interpretation of model parameters. Hence, results of analysis are not likely to be distorted by the idiosyncratic characteristics of individual items. This implies that each variable should have a smaller unique component, and idiosyncratic wording of individual items should have less effect on factor loadings.

More importantly, the result of parceling technique is more parsimonious or simpler (Bou-Llusar, Escrig-Tena, Roca-Puig, & Beltran-Martin, 2009; Little et al., 2002) because parcels reduce the number of estimations. This means that a model based on parceled data has fewer parameters to be estimated both locally (i.e., in defining a construct) and globally (i.e., in representing the whole model). The fewer the parameter, the fewer the chances for residual to correlate or dual loadings to emerge. Thus, it increases the stability of estimated parameters and reduces the effect of sampling error during the estimation process.

Additionally, besides because of reliability, normality, goodness of fit, idiosyncratic characteristics of individual items, and the parsimonious results; several scholars have strong justifications of performing parceling technique. According to them, a model using parcel has higher communality (i.e., larger ratio of common-to-unique variance) (Little et al., 2002), more optimal indicator to sample size ratio (Bagozzi & Edwards, 1998), tends to result in a greater likelihood of achieving a proper model solution (Marsh, Hau, Balla, & Grayson, 1998), and less bias (Bandalos, 2002). Subsequently, construction of parcels will be presented.

5.4.2 Construction of Parcels

How should measurement items be combined into a parcel? A parcel can be formed through a couple of different ways (Kline, 2005; Little et al., 2002), including random assignment of items to parcels, grouping the items based upon rational grounds, and also based on statistical grounds (i.e., based on inter-correlation or factor analysis results). However, it has been always unclear, which method is the best among them. According to Coffman and MacCallum (2005), parcels may be constructed in diverse ways depending upon the nature of the model.

In order to avoid misleading analysis results and interpretations, constructing parcels should be guided by theoretical stance (Bandalos & Finney, 2009; Hall et al., 1999; Sass & Smith, 2006). This is important because all the decision taken by the author in SEM should be based on a theoretical basis. It specifies the conceptual definition of variables as well as parcels, which operationally define the nature and characteristic of the variables and parcels (Creswell, 2008; Sekaran & Bougie, 2009). Operational definitions of the variables were detailed in Section 3.2. Based on the operational definitions, the variables were detailed into several constructs (dimensions). Subsequently, the constructs were broken down into a number of measurement items. As parcels should be generated in the present study, the measurement items were then formed into several parcels by considering the similar contents and characteristics of the items (Bandalos & Finney, 2009). The measurement items with similar contents and characteristics were equally grouped to comprise item parcels. A thorough content validity assessment was performed during development of measurement items. This stage ensured that content and characteristic of the items, which are constructed into a parcel, are closely similar. In other words, the parcels contain groups of items that measuring the same latent construct.

As explained in Section 3.4, this study was underpinned by RBV, ABV, and complementarity theories. Parcels' constructions of lean manufacturing practices are supported by ABV and complementarity theories. ABV theory was used to break down each lean manufacturing practice into several activities. Activities constituting under a practice are represented by measurement items. Due to the measurement items were developed to indicate a practice; all the items should be mutually supportive and complement each other. This is supported by complementarity theory. In line with the results of CFA of measurement items, all the activities constituting under a particular practice are highly interrelated among them, which is indicated by high factor loading (see Table 5.1). This is in line with complemetarity theory suggesting that the highly correlated measurement items in a construct are mutually supportive to each other.

In addition, parcel's constructions of the operations performance and business performance measures are also supported by complementarity theory. Due to all the measurement items are constituted under a performance indicator; all the items tend to be complement and mutually supportive each other. In other words, the increase in one performance measurement item may positively affect the others. The high interrelationship among the measurement items of each measure of operations performance and business performance (see Table 5.1) are in line with the complementarity theory. In this study, lean manufacturing was constructed by nine practices/parcels, operations performance and business performance measures were formulated into six and three parcels, respectively. The structure of parcels should strictly be guided by theoretical basis (Bandalos & Finney, 2009; Hall et al., 1999).

Besides the theoretical basis, Bandalos and Finney (2009) also provided a guideline that items to be parceled must be valid individual measures of the construct of interest. This can be ensured through assessment on content validity of measurement items in the construct. Secondly, items must be at the same level of specificity both within and across parcels; items and scales or sub scales from different level should not be parceled together. Lastly, Bandalos and Finney (2009) suggested that measurement items within a parcel should be statistically unidimensional. Parceling is not recommended if the assumption of unidimensionality is not tenable.

There was a strong agreement among the previous studies (Bandalos & Finney, 2009; Coffman & MacCallum, 2005; Meade & Kroustalis, 2005; Sass & Smith, 2006) regarding the importance of unidimensionality of the items being parceled. Most of the studies recommended that parceling can only be conducted on scales for which unidimensionality has been clearly tested to ensure that all the information is not lost when applying this technique. The best parcels are formed by items that display approximately the same covariance, which should lead them to have approximately the same factor loading estimates. As unidimensionality among the measurement items in each construct is essential, testing on it was conducted as reported in Section 5.3. The testing indicated that all the remaining items in a particular construct are unidimensional and share a high proportion of variance in common (see Table 5.1). In short, all the items within each parcel load on the same factor. Hence, unidimensionality among the items in each particular construct was satisfactory.

Taking the above guidelines and considerations into account, the present study employed a hierarchical model, in which the items load on various first-order factors, which in turn, load on a single second-order factor. Typically, the items load only on one of the first-order factors. With regards to this nature of the model, according to Coffman and MacCallum (2005), homogeneous parcel could be constructed, in which each parcel is constructed based on the items loading on the same first-order factors. Each parcel represents a particular first-order factor, although different parcels may represent different first-order factors.

At the reviewing of SEM literature, summated scale score and parcel based-factor score are the two most frequently applied procedures of constructing parcels. Summated scale is formed by combining several individual variables into a single composite measure (Hair et al., 2010), by taking the simple mean or sum of a number of unidimensional items assumed to reflect their theoretical construct (Anand & Ward, 2004; Bou-Llusar et al., 2009; Hair et al., 2010). Meanwhile, factor score is a composite variable that reflects the relative contributions of all variables to the factor (Tabachnick & Fidell, 2007). The present study constructs the parcels by using the summated scale technique. Besides it is easily replicated across studies, according to Hair et al. (2010), it provides more complete control over the calculation and can portray complex and multiple concepts in a single measure while reducing measurement errors.

In the area of operations management, a number of scholars empirically applied parceling technique in their studies, such as Anand and Ward (2004), Escrig-Tena (2004), and Furlan et al. (2011a). Most of the studies proposed the parceling technique to reduce complexity in the model by formulating composite construct. Thus, number of parameters to be estimated was reduced and hence, the required sample size was also reduced.

As the parcels have been successfully developed from individual measurement items, the next step is to screen the data to be used in the subsequent analysis.

5.5 Data Screening

Based on the above discussion, construction of parcels in this study was acceptable from both theoretical and empirical perspectives. The unidimensional measurement items are averaged to be the particular parcels. Nine parcels of lean manufacturing, six parcels of operations performance, and three parcels of business performance have been successfully constructed. The subsequent data analyses will be performed based on the constructed parcels. As multivariate data analysis, especially analysis using SEM requires good quality of data, data screening is compulsory to conduct prior the analysis. It is reported in the current section.

5.5.1 Test of Outliers

Identification of outliers is one of the important tasks in a multivariate data analysis to ensure that the data is outliers free. The outliers describe abnormal behavior of data showing deviation of data from its natural data variability (Pallant, 2011). The presence of outliers in the data affects its normality, since normality assumption is a must in an SEM analysis using maximum likelihood estimation (Allison, 1999). In addition, outlier cases may have a large effect on statistical analysis results. According to Tabachnick and Fidell (2007), outlier cases can change the value of score that the researcher would predict for all other cases in the study. In this study, identification of outliers was performed in both univariate and multivariate perspectives.

5.5.1.1 Univariate Outliers

This stage identified distribution of each variable, and selected as outliers those cases falling at the outer range (above or below) of the distribution. Univariate outliers for each construct were independently identified by using box plot in SPSS. SPSS defines points of outliers if the items extend greater than 1.5 box-lengths from the edge of the box (Pallant, 2011). Furthermore, Pallant (2011) explained that extreme cases were those that extend greater than three box-lengths from the edge of the box. Table 5.2 exhibits the cases with more common outlier. Based on the table, case number 156, 8, and 58 are most frequently appeared as outliers. In addition, the three cases contain extreme values of univariate outlier. These excessive values (i.e., univariate outliers) may affect the overall measures of the constructs.

Due to the present study involved multivariate data analysis; identification of multivariate outliers was required to decide whether the outlier cases should be maintained or discarded for the subsequent data analysis.

5.5.1.2 Multivariate Outliers

To test for multivariate outliers, Hair et al. (2010) and Byrne (2010) suggested to identify the extreme score on two or more constructs by using Mahalanobis distance (Mahalanobis D^2). It evaluates the position of a particular case from the centroid of the remaining cases. Centroid is defined as the point created by the means of all the variables (Tabachnick & Fidell, 2007).

Based on a rule of thumb, the maximum Mahalanobis distance should not exceed the critical chi-square value, given the number of predictors as degree of freedom. Otherwise, the data may contain multivariate outliers (Hair, Tatham, Anderson, & Black, 1998). Based on the assessment result, the Mahalanobis distance values range between 1.495 and 37.360. Chi-square table suggested that at the 18 degree of freedom and alpha .01, the chi-square value is 34.805. By comparing the two values (Mahalanobis distance and chi-square), eight cases were considered as multivariate outliers as depicted than Table 5.2.

Table 5.2
Summary of Outliers Identification

Case*	Frequency		Mahalanobis Distance
	Univariate outliers	Extreme cases	
156	10	1	37.360
8	8	2	37.096
58	8	1	37.048
104	4		37.038
182	6		36.950
177	4		36.946
175	3		35.294
160	2		35.079

Note. *Sorted based on the mahalanobis distance value.

Table 5.2 indicates that cases number 156, 8, and 58 were identified as outliers in both univariate and multivariate tests. Due to this study involves multivariate data analysis and should achieve multivariate normality; the data set should be free from multivariate outliers. It suggested that eight cases identified as multivariate outliers (i.e., cases number 156, 8, 58, 104, 182, 177, 175, and 160) were deleted from the data set. Finally, 174 cases were remained for the subsequent data analyses. Mahalanobis distance values of the remaining cases range between 1.503 and 34.251. Next, normality assessment is reported.

5.5.2 Normality Assessment

After deleting the outlier cases, normality was then assessed based on the remaining 174 samples. Assessment on normality is essential because the most widely used method for estimating a model in SEM is maximum likelihood under the assumption of normality (Byrne, 2010; Hair et al., 2010). This estimation is more efficient and unbiased when the assumption of normality is met (Gotz, Liehr-Gobbers, & Krafft, 2010). Normality is a degree to which the distribution for the sample data corresponds with the normal distribution. The term *"normal distribution"* is used to describe a symmetrical and bell-shaped curve (Pallant, 2011) indicating the majority frequency of scores fall in the middle and the lesser frequencies towards the extreme (left and right). According to Hair et al. (2010), if variation from the normal distribution is high, then all resulting statistical analyses are invalid, because the assumption of normality is required to use the F and t-statistics.

The most commonly used method of assessing univariate and multivariate normality is Mardia's test of skewness and kurtosis statistics (Byrne, 2010; Hair et al., 2010; Mecklin & Mundfrom, 2004), which are included in the SPSS-AMOS software package. Selection of this test was rationalized by Mecklin and Mundfrom (2004) stating that this test is more effective than other methods because it provides direct measures of departures from normality. In this method, positive skewness indicates that most of the scores are below the mean, whereas negative skewness indicates just the opposite (i.e., most of the scores are above the mean). Positive kurtosis indicates heavier tails and higher peak, whereas negative kurtosis indicates flatter distribution.

There is no single agreement regarding the threshold value of skewness and kurtosis to judge whether the data is normally distributed or not. Ghiselli, Campbell, and Zedeck (1981) stated that it was desirable that the skewness value be no more than 2.0 and the kurtosis value be no more than 5.0, in absolute values. Besides Ghiselli et al. (1981), for sample of 200 or less, West et al. (1995), and Curran et al. (1996), provided a rule of thumb regarding the normality of data, namely normal distribution with both univariate skewness and kurtoses equal to 0, moderately non-normal distribution with univariate skewness of 2.0 and kurtoses of 7.0, and severely non-normal distribution with univariate skewness of 3.0 and kurtoses of 21.0. All the threshold values are in the absolute value.

As shown in Table 5.3, the absolute values of skewness and kurtosis for lean manufacturing practices are not greater than 1.030 and 1.348, correspondingly. In addition, the absolute values of skewness and kurtosis of operations performance measures are no more than .771 and .711, respectively. Moreover, for business performance measures, skewness and kurtosis values are respectively not greater than .823 and 1.426 in absolute value. Hence, the skewness and kurtosis values for each variable in the present study tend to suggest that the data approach the normal distribution, because the values are far from the moderately non-normal cutoff values as suggested by Curran et al. (1996), and West et al. (1995). In other words, all the measures in the research variables have skewness values less than 2.0 and kurtosis values less than 7.0. All the values are in the absolute value.

Table 5.3
Normality Assessment

Variable	Skewness		Kurtosis	
	Statistic	Critical Ratio (z-value)	Statistic	Critical Ratio (z-value)
Lean manufacturing				
Flexible resources	-.691	-3.721	.272	.733
Cellular layouts	-.746	-4.015	.186	.500
Pull system	-.763	-4.109	.253	.681
Small lot production	-1.024	-5.517	1.211	3.261
Quick setup	-1.030	-5.545	1.348	3.629
Uniform production level	-.911	-4.907	.939	2.529
Quality control	-.953	-5.133	.822	2.212
Total productive maintenance	-.847	-4.559	.592	1.593
Supplier networks	-.959	-5.164	1.243	3.346
Operations performance				
Quality	-.600	-3.230	.254	.685
Manufacturing flexibility	-.771	-4.152	.114	.307
Lead time reduction	-.753	-4.057	.711	1.914
Inventory minimization	-.568	-3.061	-.194	-.523
Productivity	-.589	-3.173	.430	1.158
Cost reduction	-.650	-3.498	.280	.753
Business performance				
Profitability	-.436	-2.346	.206	.554
Sales	-.647	-3.485	.593	1.595
Customer satisfaction	-.823	-4.431	1.426	3.840
Multivariate			20.237	4.974

However, although the univariate normality can be approached as indicated by skewness and kurtosis statistics, Byrne (2010) and Tabachnick and Fidell (2007) stated; the distribution may still be multivariate non-normal. Thus, assessment on multivariate normality should be performed. Multivariate normality is the assumption that each variable, and all linear combinations of the variables are normally distributed (Tabachnick & Fidell, 2007). Hair et al. (2010) stated that a set of data is considered multivariate normal if the joint effect of the variables is normally distributed. Hence, this assumption implies that the relationships among pairs of variable are linear.

A common measure of multivariate normality is Mardia's multivariate kurtosis coefficient together with its critical ratio (i.e., multivariate $Z_{kurtosis}$ or normalized estimate). Mardia's multivariate kurtosis (Mardia, 1970) is the most stable and reliable test for judging multivariate normality. The coefficient measures the extent to which the multivariate distribution of all the cases has tails that differ from the ones characteristic of the normal distribution (Raykov & Marcoulides, 2006). A higher value of multivariate kurtosis and its critical value designate that some cases have a large Mahalanobis distance and are placed far from the centroid of the data set.

Assessment on multivariate normality is shown in Table 5.3. According to Bentler (2005) and advocated by Byrne (2010), the critical ratio value of multivariate kurtosis should be less than 5.0 to indicate a multivariate normal distribution. In this study, after deleting the outliers, the assumption of multivariate normality is tenable (Mardia's multivariate kurtosis coefficient = 20.237, critical ratio = 4.974).

Multivariate normality of the data used in the present study was also supported by the works of Curran et al. (1996) and Nevitt and Hancock (2001). According to them, if all the absolute values of univariate skewness are less than 2.0, and at the same time, the absolute values of kurtosis are less than 7.0, then the data approach multivariately normal distribution. In conclusion, based on the univariate and multivariate normality assessment, the data used in this study are considered approaching normality distribution. Thus, the normality assumption for performing SEM analysis using maximum likelihood estimation method can be fulfilled. Hence, the total of 174 samples were used for the subsequent data analyses.

5.6 Respondent Profile

As mentioned earlier, the respondents for the present study were 174 manufacturing companies in Indonesia. There is no consensus regarding the minimum sample size in SEM. Anderson and Gerbing (1988) found that 150 samples were adequate to obtain a proper solution for models with three or more indicators per variable. In addition, Byrne (2010) suggested the use of minimum of 100 to 150 samples. Another school of thought tended to suggest a sample size as big as five times the number of parameter's estimates (Bentler, 2005; Hair et al., 2010). Considering the suggested sample size, related to this study, 174 samples seemed to be sufficient for an SEM method of analysis as this number is higher than the minimum sample size suggested by the scholars. Table 5.4 shows the distribution of population and sample involving in this study, in which the highest portion of population and sample is for textile and wearing apparel (ISIC 17 and 18), and the lowest portion is medical, precision and optical instruments, watches and clocks (ISIC 33). Based on the table, the sample was fairly representative of industry coverage in Indonesia.

Table 5.4
Distribution of Population and Sample

ISIC	Industry	Population		Sample	
		N	%	n	%
17 & 18	Textiles and wearing apparel	1,243	40.22%	61	35.06%
19	Tanning and dressing of leather	196	6.34%	9	5.17%
20	Wood and products of wood except furniture and plaiting materials	356	11.52%	12	6.90%
29	Machinery and equipment	164	5.31%	15	8.62%
31	Electrical machinery and equipment	133	4.30%	16	9.20%
32	Radio, television and communication equipment and apparatus	144	4.66%	11	6.32%
33	Medical, precision and optical instruments, watches and clocks	24	.78%	4	2.30%
34	Motor vehicles, trailers and semi-trailers	146	4.72%	13	7.47%
35	Other transport equipment	118	3.82%	11	6.32%
36	Furniture	567	18.34%	22	12.64%
Total		3,091	100%	174	100.00%

The profile of sampled companies is described in Table 5.5. In terms of company ownership, the sampled companies are composed of 78 (44.83%) foreign invested enterprises, 70 (40.23%) private enterprises, 22 (12.64%) joint venture, and 4 (2.30%) state-owned companies. Out of the 174 companies involved in the present study, the majority of them (i.e., 93.68%) have been established for more than five years, which are 163 companies. Only few of the companies, which are in the age of 3 – 5 years. They are only 11 companies or 6.32% of the total sampled companies.

In terms of the number of employees, as indicated in Table 5.5, the sampled companies fall within two categories of the number of employees; 139 companies (79.89%) with more than 300 employees, and 35 companies (20.11%) with between 100 and 300 employees. Based on the number of employees, all samples involved in the study were considered as large manufacturing companies (BPS-Statistics Indonesia, 2010). Selection to large companies was because they tended to implement lean manufacturing more often than do small and medium companies (Fullerton & McWatters, 2001; Shah & Ward, 2003, 2007; Susilawati et al., 2011). In addition, the sampled companies of the study included repetitive 58 companies (33.33%), batch 47 companies (27.01%), mass customization 49 companies (28.16%), and job shop 20 companies (11.49%). More importantly, as stated in Table 5.5, 143 companies (82.18%) involved in this study are the lean manufacturers. Even though 31 companies (17.82%) did not declare themselves as a lean manufacturer, they were implementing lean manufacturing practices in a greater extent. The extent of the implementation of lean manufacturing in the sample companies is depicted in Table 5.9.

Table 5.5
Sampled Companies Profile

Demographics	Count	%
Company ownership		
State owned enterprise	4	2.30%
Private enterprise	70	40.23%
Foreign invested enterprise	78	44.83%
Joint venture	22	12.64%
Age of company		
3 – 5 years	11	6.32%
More than 5 years	163	93.68%
Number of employees		
100 – 300	35	20.11%
More than 300	139	79.89%
Type of production process		
Job shop	20	11.49%
Batch	47	27.01%
Repetitive	58	33.33%
Mass customization	49	28.16%
Type of manufacturing system		
Lean company	143	82.18%
Non-lean company	31	17.82%
Total	174	100.00%

Besides the sampled companies' profile as exhibited in Table 5.5, respondent profile is shown in Table 5.6. Based on the table, the respondent fall within four positions in the companies, which are categorized as middle and top management position. A total of 111 (63.79%) respondents are production manager, 39 (22.41%) are head of production departments, and 16 (9.20%) are production directors. Else, 8 (4.60%) respondents were appointed in other middle management positions under production department, such as lean manufacturing implementer (four respondents), production internal auditor (two respondents), and master black-belt of six sigma (two respondents). As the email address was provided by the respondents in the completed questionnaire, further inquiries through email correspondences were conducted to ensure whether or not the last eight respondents are knowledgeable in answering the questionnaire. Based on the investigation, the eight respondents served in middle and top management positions, and were regularly involved in management meetings. So that, without a doubt, they were considered adequately knowledgeable to answer all the questions. Selection of middle and top management positions as respondent was due to the assumption that they had sufficient knowledge to answer the questionnaire.

Table 5.6
Respondent Profile

Demographics	Count	%
Position in the company		
Production director	16	9.20%
Production department head	39	22.41%
Production manager	111	63.79%
Others	8	4.60%
Number of years working in the company (working life)		
3 – 5 years	35	20.11%
More than 5 years	139	79.89%
Number of years serving in the current position (tenure)		
Less than 1 year	16	9.20%
1 – 3 years	72	41.38%
More than 3 years	86	49.43%
Total	174	100.00%

Based on the duration of working in the companies, the majority of respondents (i.e., 139 respondents or 79.89%) have been working in their companies for more than five years. Others (35 respondents or 20.11%) served their company for three to five years. Moreover, 86 respondents (49.43%) have been serving in their present positions for more than three years, 72 respondents (41.38%) for one to three years, and 16 respondents (9.20%) have been appointed in their current positions for a period of less than one year. Although some of the respondents were just working in their current position for less than one year, they have been in the company for more than five years. Therefore, they were considered knowledgeable to participate in this study.

5.7 Non-Response Bias

To scrutinize the probability of the non-response bias, comparison between early responses (i.e., 84 respondents) and late responses (i.e., 90 respondents) was performed by applying the extrapolation technique suggested by Armstrong and Overton (1977). They labeled those responding to the initial request as early responses, which were grouped as responding companies. Whereas, those responding after the follow-up telephone calls or e-mails were categorized as late responses, which were considered as non-responding companies.

The comparisons using a *t*-test were performed for all the lean manufacturing practices, operations performance measures and business performance measures. The results directed that there was no significant difference (at $\alpha = .05$) between the early and late responses. Thus, there was no significant difference between responding and non-responding companies. Therefore, it can be concluded that non-response bias was unlikely to be an issue in the study.

5.8 Overall Measurement Model

As presented earlier, the subsequent data analyses were conducted by employing 174 samples after treating the outliers. Overall measurement model was assessed by using CFA procedure simultaneously for all the latent constructs (i.e., lean manufacturing, operations performance, and business performance). This stage was aimed to assess GOF and construct validity before proceeding to the structural model. The CFA results showing all factor loadings of each measure together with its R^2, correlation among the latent variables, and GOF measures are presented in Figure 5.1. The subsequent sub-sections present details of the assessments.

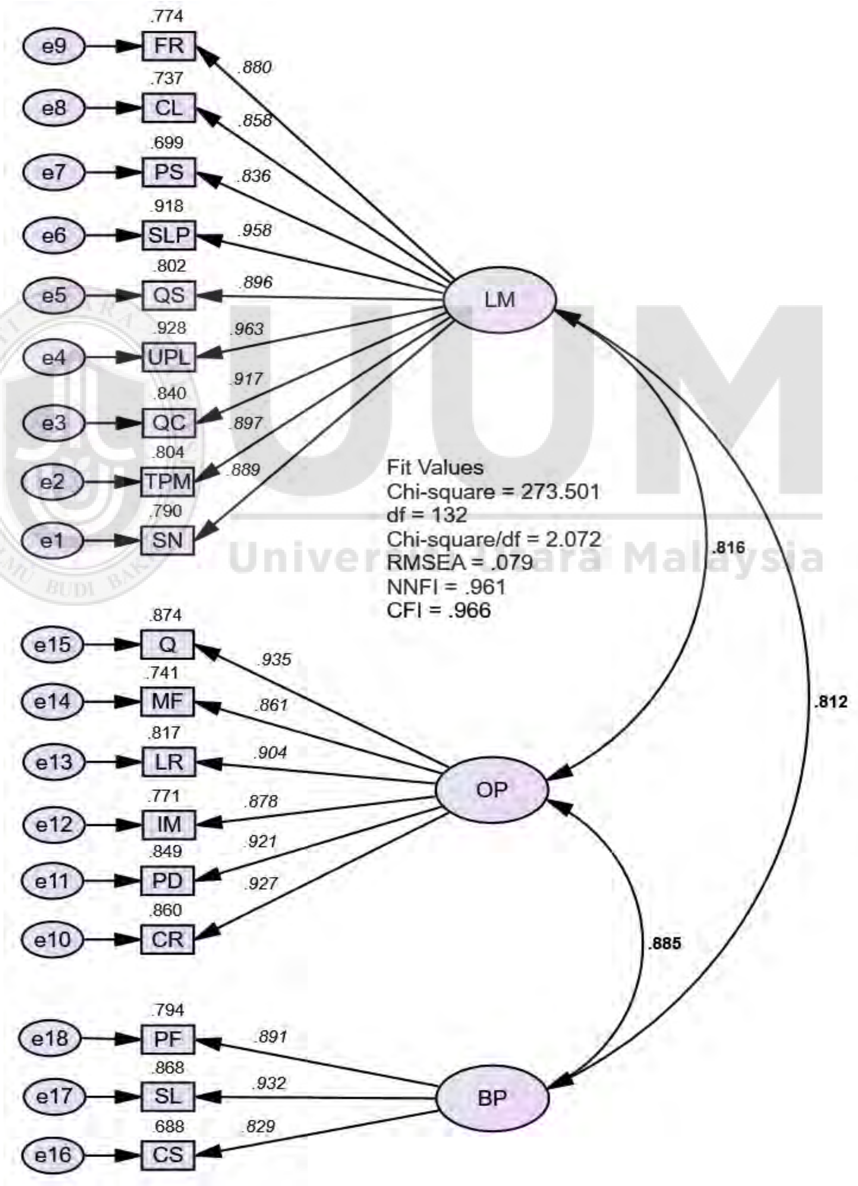

Figure 5.1
Standardized Estimate of Overall Measurement Model
Note. Italic: factor loading between latent variable and its indicators. Regular: loading squared. Bold: correlation between two latent variables.

5.8.1 Goodness of Fit

Figure 5.1 indicates that all the indices are in the acceptable level, whereby χ^2/df is 2.072, which is less than 3.00. RMSEA is .079, which is less than .080; and CFI and NNFI are .966 and .961 respectively, which are greater than .900. In addition, as calculated by AMOS, SRMR is .036. The SRMR value is much smaller than its threshold (i.e., .08). Hence, overall measurement model fits the data well. In other words, the GOF is satisfactory.

5.8.2 Construct Validity

As suggested by axiological justification, the quantitative phase attempted to eliminate the biasness through assessing construct validity. It ensures that a set of measures (manifest variable) actually represent the theoretical latent variable (Hair et al., 2010). As subsequently presented, this type of validity was assessed by using convergent, discriminant, and criterion-related validity.

5.8.2.1 Convergent Validity

After achieving the acceptable GOF, the author should address convergent validity. It refers to the extent to which multiple measures of specific construct converge together and share a high proportion of variance in common (Hair et al., 2010). Convergent validity reflects high correlation between measures designed to measure the same construct (Byrne, 2010). Following Hair et al. (2010) and Byrne (2010), convergent validity was assessed based on factor loading, average variance extracted (AVE), and composite reliability (CR). The results are as exhibited in Table 5.7. Based on the table, all the factor loadings are greater than .500. Factor loadings for lean manufacturing practices ranges between .836 and .963, with the lowest loading is for pull system, and the highest is for uniform production level. For operations performance measures, the lowest factor loading is .861 (manufacturing flexibility) and the highest is .935 (quality). Furthermore, for business performance, customer satisfaction has the lowest factor loading (i.e., .829) and sales have the highest factor loading (i.e., .932). According to Bagozzi and Yi (1988), a weak evidence of convergent validity exists when factor loadings are less than .700. Since factor loadings exceed the threshold value of .700, and all the loadings are statistically significant at .05, the criteria of convergent validity is successfully fulfilled.

Table 5.7
Convergent Validity of Overall Measurement Model

Dimension	Std. Loading	R^2	Error Variance	AVE	CR
Lean Manufacturing				.810	.969
Flexible resources	.880	.774	.226		
Cellular layouts	.858	.736	.264		
Pull system	.836	.699	.301		
Small lot production	.958	.918	.082		
Quick setups	.896	.803	.197		
Uniform production level	.963	.927	.073		
Quality control	.917	.841	.159		
Total productive maintenance	.897	.805	.195		
Supplier networks	.889	.790	.210		
Operations Performance				.819	.957
Quality	.935	.874	.126		
Manufacturing flexibility	.861	.741	.259		
Lead time reduction	.904	.817	.183		
Inventory minimization	.878	.771	.229		
Productivity	.921	.848	.152		
Cost reduction	.927	.859	.141		
Business Performance				.783	.895
Profitability	.891	.794	.206		
Sales	.932	.869	.131		
Customer satisfaction	.829	.687	.313		

Note. R^2 = Standardized loading squared; AVE = Average variance extracted; CR = Composite reliability

AVE reflecting the overall amount of variance in the manifest variables accounted for by the latent variable should exceed the recommended value of .500

(Fornell & Larcker, 1981; Hair et al., 2010). Table 5.7 indicates that all the AVE values are higher than the cutoff value. AVE for lean manufacturing is .810, indicating that 81.00% of total variance is explained by the construct. Similarly, 81.90% and 78.30% variance of operations performance and business performance, respectively, are explained by the constructs.

The present study calculated CR to assess the internal consistency within the measurement model indicating homogeneity of the manifest variables in the latent variable. The interpretation of CR is similar to Cronbach's alpha, except that it also takes into account the factor loadings rather than assuming that each item is equally weighted in the composite load determination. Table 5.7 shows that CRs of all the latent variables exceed the benchmark of .600 as recommended by Bagozzi and Yi (1988), whereby the CRs of lean manufacturing, operations performance, and business performance are .969, .957, and .895, respectively. Based on the values of CR, reliability of all the latent constructs is acceptable and satisfactory.

5.8.2.2 Discriminant Validity

Fornell and Larcker (1981)'s test of discriminant validity suggested to compare the square root of AVE and the structural link (correlation estimates) among the latent variables. Following Fornell and Larcker (1981), if the square root of AVE is higher than the correlation of the two latent variables, the discriminant validity is achieved. The complete result of discriminant validity assessment is given in Table 5.8. Based on the table, square root of AVE of lean manufacturing (i.e., .900) is higher than the correlation between lean manufacturing and operations performance (i.e., .885), and also higher than the correlation between lean manufacturing and business performance (i.e., .812). Somewhat similar, the square root of AVEs of both operations performance and business performance are higher than correlation estimates between that variables and other latent variables. Hence, these indicate the adequate discriminant validity.

Table 5.8
Discriminant Validity of Overall Measurement Model

	Lean manufacturing	Operations performance	Business performance
Lean manufacturing	**.900**		
Operations performance	.885	**.905**	
Business performance	.812	.816	**.885**

*Note***.** Diagonal values (bolded) are square root of the AVE, whereas the off-diagonals are correlations.

5.8.2.3 Criterion-related Validity

Criterion-related validity indicates the degree of correspondence between a measure and criterion variable. It concerns the relationship between a measure and some measurable criterion (Pallant, 2011). In the same vein, Kimberlin and Winterstein (2008) stated criterion-related validity as evidence about how well the score of a measure correlates with the score of other measures that theoretically should be related. According to Sekaran and Bougie (2009), this validity is typically measured by the correlation between the score and its measureable criterion. As indicated in Table 5.8, all the bivariate correlations (i.e., between lean manufacturing and operations performance, between lean manufacturing and business performance, and between operations performance and business performance) were found significant at the .05 level. Hence, the criterion-related validity has been successfully achieved.

5.9 Common Methods Variance

Common methods variance (CMV) might be introduced in a research due to a single informant data source (Malhotra, Kim, & Patil, 2006; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). In SEM, common latent factor method was frequently used to capture common variance among all the manifest variables in the model. This was done by adding a latent factor to the measurement model and connecting it to all the manifest variables. In other words, all the manifest variables were modeled as indicators of a single latent variable. The test results indicated that there is no common factor that accounted for a majority of variance.

In addition, according to Malhotra et al. (2006) and Kline (2011), the CMV is substantial if the model fits the data. Furthermore, the fit indices clearly show that a single-factor model poorly explains the data, whereby χ^2/df = 6.510, RMSEA = .178, SRMR = .410, NNFI = .798, CFI = .821, and *p*-value < .01. Based on the fit values, there is no index fitting the acceptable value. Equally important, according to Kline (2011), the presence of CMV in a model is also indicated by the inability of the model to achieve discriminant validity. The poor discriminant validity indicates that all the manifest variables measure only one domain. Based on these assessments, it is concluded that a substantial amount of CMV did not present in this study.

In sum, the overall measurement model assessments delivered a strong evidence that all the validity and reliability criteria are acceptable and satisfactory. Thus, the structural model could be assessed confidently.

5.10 Descriptive Statistics of Variables

This section explains the descriptive statistics of variable involved in the present study. These statistics are important to judge general state of manufacturing companies in Indonesia concerning lean manufacturing, operations performance, and business performance. This part provides the information in terms of minimum value, maximum value, mean, and standard deviation of the key constructs. Summary of the descriptive statistics is given in Table 5.9.

Table 5.9
Descriptive Statistics of Variables

Construct	Minimum	Maximum	Mean	Std. Deviation
Lean Manufacturing				
Flexible resources	2.630	6.000	4.914	.744
Cellular layouts	2.380	6.000	4.846	.777
Pull system	2.330	6.000	4.810	.873
Small lot production	2.440	6.000	4.869	.700
Quick setups	2.000	6.000	4.936	.783
Uniform production level	2.140	6.000	4.853	.743
Quality control	2.750	6.000	5.061	.742
Total productive maintenance	2.710	6.000	5.120	.720
Supplier networks	2.290	6.000	4.892	.803
Operations Performance				
Quality	2.250	6.000	4.622	.774
Manufacturing flexibility	2.500	6.000	4.817	.825
Lead time reduction	2.710	6.000	4.810	.753
Inventory minimization	2.430	6.000	4.632	.848
Productivity	2.130	6.000	4.763	.765
Cost reduction	2.170	6.000	4.667	.810
Business Performance				
Profitability	2.000	6.000	4.747	.785
Sales	2.130	6.000	4.804	.777
Customer satisfaction	2.500	6.000	4.973	.660

As stated earlier, all the measurement items used perceptual scale with six-point likert scale. Based on the scale used, the minimum and maximum statistics should range between 1.000 and 6.000 as indicated in Table 5.9. The minimum values of lean manufacturing practices range between 2.000 and 2.750, with maximum values are 6.000 for all the lean manufacturing practices. For operations performance, the minimum values range from 2.130 to 2.710, with maximum values are 6.000 for all the measures of operations performance. Furthermore, for business performance, the minimum values range between 2.000 and 2.500, and maximum values are 6.000 for all the business performance measures. As shown in Table 5.9, the maximum values of all the manifest variable are 6.000. At the earliest stage of the data screening process, it was observed that the maximum scores of 6.000 came from different respondent companies.

Mean values are used to judge the level of lean manufacturing implementation and the level of companies' performance. Besides the mean values, standard deviations express homogeneous or uniformity of lean manufacturing implementation and performance. Based on the results presented Table 5.9, the descriptive statistics explain the mean of lean manufacturing practices ranges between 4.810 and 5.120 with standard deviation ranges between .700 and .873. The highest mean for lean manufacturing practices is for total productive maintenance, and the lowest is for pull system. These figures indicate that lean manufacturing practices have been implemented in marginally high level in manufacturing companies in Indonesia.

Table 5.9 indicates that TPM achieves the maximum level of its implementation among manufacturers in Indonesia (i.e., 5.120), followed by quality control (i.e., 5.061). This shows that the surveyed companies have put more emphasize on these two practices compared to others. In other words, the two practices were more frequently implemented in manufacturing companies in Indonesia. Interestingly, TPM is one of the practices, which has the lowest standard deviation. This indicates that TPM has been uniformly implemented in the manufacturing companies of Indonesia. Furthermore, pull system achieved the lowest mean among the practices (i.e., 4.810) with the highest standard deviation (i.e., .873). This gives an evidence that large variations within the surveyed companies with regards to this practice. It may imply that pull system was sometimes neglected by a number of manufacturers in Indonesia. In addition, supplier network also has a large standard deviation, showing that in some surveyed companies, it was applied extensively; while in others, it was not. In general, most of the companies had made a significant level of lean implementation, albeit some practices still need further improvement.

In relation to the operations performance, manufacturers in Indonesia have a relatively high overall mean score, ranging between 4.622 and 4.817 with low standard deviation, ranging between .753 and .848. However, a deeper look at the results showed a difference level among the operations performance measures. This study found that manufacturing flexibility and lead time reduction achieved the highest scores of mean (i.e., 4.817 and 4.810, respectively). Interestingly, manufacturing flexibility has a high standard deviation (i.e., .825), which is the highest value after inventory minimization (i.e., .848). This fact implied that some companies are extremely flexible, but some are not. Look at lead time reduction, this operations performance indicator has the lowest standard deviation than the others (i.e., .753), indicating that lead time reduction among the surveyed manufacturers are in a uniform level. Thus, the respondents should emphasize ensuring the more flexible manufacturing processes and shorter manufacturing lead time. Furthermore, quality performance among the respondent companies was the lowest mean score among the operations performance measures (i.e., 4.622). It shows that, compared with other measures, quality was not the main emphasis of manufacturers in Indonesia. Similar with quality, inventory minimization was found in the lower score among the others (i.e., 4.632), but with the highest standard deviation (.848). This may imply that some of the companies have a good inventory performance, but some may neglect this performance measure.

In terms of business performance, as indicated in Table 5.9, the mean scores are also considered marginally high, ranging between 4.747 and 4.973 with low standard deviation (i.e., from .660 to .785). The highest score of mean was for customer satisfaction (i.e., 4.973) with the lowest standard deviation (i.e., .660). This implied that customer satisfaction among the manufacturers is relatively in a uniform level. At the same time, profitability scored the lowest mean (i.e., 4.747) with the highest standard deviation (i.e., .787), which provides evidence that largest variations within the surveyed companies with regards to these business performance measures. Generally, the surveyed companies perceived somewhat uniform level of business performance measures.

5.11 Linear Correlation between Indicator Variables

Linear correlation between the variables has been assessed by applying Pearson's correlation analysis. Magnitude of association between two variables is indicated by the correlation coefficient (r). The r-values vary from −1 to 1. The r-value of −1 indicates a perfect negative correlation, whereas the r-value of 1 indicates a perfect positive correlation, and r-value of 0 indicates no linear correlation between two variables. Cohen (1988) provided a rule of thumb for social science context to interpret the meaning behind the value of correlation coefficients. He postulated, the r-values from .100 to .290 represent a weak or small correlation; the r-value between .300 and .490 is thought to a moderate association; and the r-value of .500 or larger is considered to represent a strong or large association. This rule of thumb was commonly used set of descriptors in interpreting the correlation coefficient values in social science. Summary of Pearson's correlation analysis among all the variables involved in the study is exhibited in Table 5.10.

Table 5.10

Correlation Matrix of Variables

No	Variable	Lean Manufacturing									Operations Performance						Business Performance		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Lean Manufacturing																			
1	Flexible resources	1																	
2	Cellular layouts	.782	1																
3	Pull system	.720	.703	1															
4	Small lot production	.888	.814	.795	1														
5	Quick setups	.783	.796	.727	.859	1													
6	Uniform production level	.826	.844	.841	.917	.879	1												
7	Quality control	.780	.749	.756	.881	.811	.881	1											
8	Total productive maintenance	.797	.746	.728	.870	.793	.844	.854	1										
9	Supplier networks	.758	.741	.752	.840	.762	.862	.845	.810	1									
Operations Performance																			
10	Quality	.649	.697	.556	.680	.653	.704	.661	.659	.655	1								
11	Manufacturing flexibility	.679	.732	.608	.736	.701	.743	.696	.721	.672	.799	1							
12	Lead time reduction	.668	.695	.612	.717	.721	.750	.716	.728	.707	.844	.778	1						
13	Inventory minimization	.658	.660	.622	.685	.638	.702	.684	.685	.699	.819	.778	.808	1					
14	Productivity	.655	.694	.575	.717	.694	.728	.714	.707	.715	.857	.779	.823	.808	1				
15	Cost reduction	.613	.667	.535	.650	.631	.681	.661	.646	.664	.888	.792	.821	.803	.864	1			
Business Performance																			
16	Profitability	.570	.590	.576	.630	.612	.686	.665	.666	.643	.727	.661	.717	.632	.725	.752	1		
17	Sales	.618	.669	.653	.691	.677	.728	.697	.676	.743	.749	.688	.757	.708	.778	.759	.844	1	
18	Customer satisfaction	.637	.649	.586	.676	.656	.687	.676	.682	.714	.700	.637	.743	.616	.713	.693	.727	.758	1

Note. All the correlations are significant at the .01 level (one-tailed).

5.11.1 Linear Correlation among Lean Manufacturing Practices

Table 5.10 provides evidence regarding the relationship among lean manufacturing practices. The table indicates that all the practices are highly correlated among them; all the *r* values are significant at $\alpha = .01$ (one-tailed). The *r*- values range between .703 and .917. Based on the rule of thumb provided by Cohen (1988), all the correlation coefficients are high. The highest correlation (i.e., .917) is between small lot production and uniform production level, whereas the lowest (i.e., .703) is between pull system and cellular layouts.

The high correlations among the lean manufacturing practices tend to support the presumption stated that lean manufacturing is not advisable to be implemented in limited subset or in a piecemeal approach. In other words, the practices must be implemented in a holistic and comprehensive manner in order to achieve maximum advantages of the implementation. In addition, the high inter-relationship among the practices implies that they tend to be mutually supportive; the higher implementation of one practice may contribute to the better implementation of others. The studies conducted by Furlan et al. (2011b) and Shah and Ward (2003) tended to support this finding.

In addition, it is interesting that strong correlation among lean manufacturing practices provided an ideal condition to parcel these indicators into a single latent variable in the SEM application (Agus & Hajinoor, 2012). Agus and Hajinoor (2012) rightly argued that as the strong correlations among the lean manufacturing practices are existed, it may yield multicollinearity among the practices. It may be likely to mix up effects of each practice on the outcome variable.

5.11.2 Linear Correlation between Lean Manufacturing Practices and Operations Performance Measures

Table 5.10 shows that all the lean manufacturing practices are significantly related with all the measures of operations performance. All the *r*-values are significant at .01 (one-tailed) ranging between .535 and .750. Based on the Cohen (1988)'s rule of thumb, all the correlations are considered high. The weakest magnitude of correlation is for the association between pull system and cost reduction, whereas the strongest association is for correlation between uniform production level and lead time reduction. In general, it can be clinched that the better the employment of lean manufacturing practices within a company, the higher the operations performance.

The high correlations between lean manufacturing practices and operations performance are rationalized because the practices are commonly implemented in a shop floor in attempting to eliminate all types of non-value added activities. In a similar vein, operations performance reflects internal properties of a production system, which is possibly influenced by production strategies implemented. So that, utilization of lean manufacturing strategy tends to be associated with operations performance.

5.11.3 Linear Correlation between Lean Manufacturing Practices and Business Performance Measures

Lean manufacturing practices are also positively correlated with business performance measures. Based on Cohen (1988)'s guidelines, all the *r*-values are considered high, ranging between .570 and .743 and significant at .01 (one-tailed). The lowest *r*-value is between flexible resources and profitability, and the highest is between supplier networks and sales performance. From these results, it can be stated that implementation of lean manufacturing practices tends to enhance business performance in terms of profitability, sales and profitability.

5.11.4 Linear Correlation among Operations Performance Measures

Linear correlation between the operations performance measures is shown in Table 5.10. The table indicates that all measures are positively correlated and significant at α = .01 (one-tailed). The lowest correlation coefficient is for association between manufacturing flexibility and lead time reduction, and between manufacturing flexibility and inventory minimization (r = .778), whereas the highest is between quality and cost reduction (r = .888). All the r-values are high as suggested by Cohen (1988). This implies that one measure may influence others. In other words, all the operations performance measures are related each other; enhancement in one measure may improve others.

5.11.5 Linear Correlation among Business Performance Measures

With regards to business performance, this study observed that all the measures of business performance are positively and highly correlated. Association between sales and profitability scores the highest r-value (i.e., .844), whereas the correlation between customer satisfaction and profitability scores the lowest (i.e., .727). However, as suggested by Cohen (1988), all the correlation coefficients are high and significant at .01 (one-tailed). This inferred that improvement in one measure may influence achievement in other measures.

5.11.6 Linear Correlation between Operations Performance Measures and Business Performance Measures

Linear correlation between operations performance measures and business performance measures is exhibited in Table 5.10. Based on the table, positive correlations between the measures are found. All the coefficients are significant at α = .01 (one-tailed) with high coefficient values ranging between .616 and .778. The association between inventory minimization and customer satisfaction is the lowest coefficient, whereas the correlation coefficient between productivity and sales is highest. This finding indicates that operations performance may positively influence the level of business performance of a company; the higher the operations performance, the better the business performance.

Comparing the *r*-values of the correlation between lean manufacturing practices and operations performance measures, and the correlation between the lean manufacturing practices and business performance measures as indicated in Table 5.10; the results tend to suggest that lean manufacturing practices are correlated higher with operations performance than with business performance. It may be an indication that operations performance may take the role of mediating variable on the relationship between lean manufacturing practices and business performance, because operations performance measures represent the lower level than the business performance measures in an organizational performance measurement system.

Based on the results of Pearson's correlation analyses, lean manufacturing practices are interrelated among themselves and are positively related with both operations performance and business performance measures. Furthermore, the positive and significant associations are also found among operations performance measures, and operations performance measures are found to be highly correlated with all the business performance measures. These indicate that the data fulfill the assumption of linearity in performing SEM analysis.

5.12 Structural Model

After assessing the measurement model and addressing the issue of unidimensionality, validity, and reliability of the measurement model, the next step is to convert the measurement model to a structural model. In specifying the structural model, a distinction must be made between exogenous and endogenous constructs (Hair et al., 2010). Exogenous construct is the predictor, whereas endogenous construct is the outcome (the structural relationships predict it). The next section provides a detail discussion regarding the empirical testing of the hypothesized model. It is started with an explanation on bootstrapping and is continued by assessment on relationships among the variables of the study. Subsequently, structural model validity is presented.

5.12.1 Bootstrapping

This study proposed to apply a more sophisticated approach to confirm the hypotheses of study, namely bootstrapping. It is a computer-based statistical resampling technique, firstly developed by Efron (1979). Practically, the bootstrapping takes the repeated samples (i.e., sub samples or bootstrap samples) with replacement (in a specified number of times) from an original data (i.e., sample), taken as the representative of population, to generate the sample bootstrap estimates and standard error for hypothesis testing (Hair et al., 2011; Preacher & Hayes, 2008).

5.12.1.1 Justification of Applying Bootstrapping

Various justifications are associated to bootstrapping in evaluating mediation model. Zhao, Lynch Jr., and Chen (2010) clearly postulated that mediating effect is not pre-conditioned by the significant relationship between *X* (independent variable) and *Y* (dependent variable) (path *c*), instead the significant effect between *X* and *M* (mediating variable) (path *a*) and the significant effect between *M* and *Y* (path *b*). Hence, testing for mediation hypotheses should focus on the product term *a* x *b*. If *a* x *b* is statistically significant, then the mediation effect exists in the model. Especially in small and moderate sample size, there is a strong reason to be suspicious of this assumption whereby, according to Preacher and Hayes (2008), Hayes (2013), and Zhao et al. (2010), the sampling distribution of indirect effect (*a* x *b*) is rarely to be normal with non-zero skewness and kurtosis.

According to Bollen and Stine (1990), a given standard error value of an indirect effect tends to be incorrect for a small and moderate sample size. Byrne (2010) clearly stated that in combination with the maximum likelihood estimation, bootstrapping gave the better results; it allows the researcher to obtain more stable parameter estimates. This application may circumvent large-sample and multivariate normality assumptions for maximum likelihood estimation (Byrne, 2010). Hence, bootstrapping can be applied in a smaller sample with more confidence (Preacher & Hayes, 2008). Furthermore, a simulation study conducted by MacKinnon, Lockwood, and Williams (2004) justified that bootstrapping can avoid the statistical power problems of non-normal data of an indirect effect, while maintaining control over the type I error (i.e., probability of incorrectly rejecting the null hypothesis). Moreover, Bollen and Stine (1990) noted that the use of bootstrapping may provide more accurate confidence limits for mediating effects. Additionally, Hayes (2009) explained that bootstrapping does not require estimation on standard error in making inference of indirect or mediation effects. Hence, argument regarding the best estimate for standard error of indirect effects is rendered. Moreover, Hayes (2009) also postulated that bootstrapping is a very general approach, which can be used for making inferences about the indirect effect in any mediation models, regardless of how complex and how many the paths between the independent and dependent variables.

Another justification came from Preacher and Hayes (2008). They confirmed that the result of bootstrapping is more trustworthy and powerful than other methods, such as Baron and Kenny approach (Baron & Kenny, 1986) and Sobel test (Sobel, 1982, 1987), because it requires fewer assumptions. Numerous simulation studies (such as MacKinnon et al. (2004), and Cheung and Lau (2008)), have carried many convictions regarding its superiority. Lately, bootstrapping has been considered as one of the more valid and powerful methods for testing mediation effects (Hayes, 2009). Many scholars (such as Preacher and Hayes (2004), Preacher and Hayes (2008), Hayes (2009), MacKinnon and Fairchild (2009), and Zhao et al. (2010)) recommended bootstrapping for the assessment of direct and indirect effects in a mediation model in SEM.

In conclusion, bootstrapping method may convey the benefits as follows; (1) it can be applied to small (not extremely small) and moderate sample size with high confidence, (2) it strictly controls over the type I error, (3) it allows the researcher to obtain more stable parameter estimates. So that, the results can be reported with a greater degree of accuracy, and (4) it avoids the issue of statistical power introduced by multivariate non-normality in sampling distribution of *a, b,* and their product (*a* x *b*). Especially, the sampling distribution of indirect effect (*a* x *b*) is rarely to be normal.

Considering its superiority over other approaches on evaluating the mediation effect, statisticians are advocating a move away from statistical methods that are required assumptions (such as multivariate normality) to more accurate computational methods such as bootstrapping (Preacher & Hayes, 2008). This approach requires fewer unwarranted assumptions, but can produce more trustworthy results.

5.12.1.2 Bootstrapping Methods

The present study employed bias-corrected bootstrap (BC bootstrap). The simulation study conducted by MacKinnon et al. (2004) provided evidence that BC bootstrap afforded the most accurate confidence limits and greatest statistical power compared with other bootstrap methods, such as percentile bootstrap, bootstrap-Q, and Monte Carlo bootstrap. In addition, they observed that BC bootstrap strictly controlled for type I error. Hence, the study by MacKinnon et al. (2004) revealed that this method was the best among the others. Furthermore, in their study, Fritz and MacKinnon (2007) compared Baron and Kenny's approach, Sobel test, percentile bootstrap, and BC bootstrap in terms of their statistical power for assessing mediation and indirect effects. Their study led to a consensus that statistical power of BC bootstrap is consistently superior over other techniques. The used of BC bootstrap was also rationalized by Cheung and Lau (2008) who stated that BC bootstrap confidence intervals performed best in testing for mediation model. Considering the above advantages of the BC bootstrap, this study employed this method to evaluate the mediation model.

In this study, bootstrap procedure was employed based on 10,000 bootstrap samples to derive a 95% bias-corrected bootstrap confidence interval for the hypotheses' testing (Preacher & Kelley, 2011). There is no consensus regarding the number of resample (bootstrap samples) should be generated, except that more is better (Preacher & Hayes, 2008). According to Hair, Hult, Ringle, and Sarstedt (2013), bootstrap samples should be larger than the number of original samples. Hayes (2013), justified that 5,000 to 10,000 bootstrap samples are sufficient in most applications; increasing the bootstrap sample above 10,000 is typically not necessary because it does not give significant difference to the estimation.

Bootstrap confidence interval provides additional information regarding the stability of coefficient estimate (Hair et al., 2013). It provides the information; to what extent the true population parameter will fall assuming a certain level of confidence. Next, the results of hypotheses testing are reported.

5.12.2 Hypotheses Testing

After converting the measurement model to structural model, and setting up for bootstrapping in SPSS-AMOS, the hypotheses' testing was subsequently conducted. There are four hypotheses developed in the present study indicating direct and indirect relationships among the latent variables as follows:

H_1: Lean manufacturing has a positive relationship with operations performance.
H_2: Lean manufacturing has a positive relationship with business performance.
H_3: Operations performance has a positive relationship with business performance.
H_4: Lean manufacturing affects business performance directly and indirectly through operations performance as a mediating variable.

The model with 10,000 bootstrap samples at the 95% confidence level was estimated by using the BC bootstrap. Standardized estimate of direct and indirect effects of lean manufacturing on business performance is presented in Figure 5.2 and Table 5.11. The results indicate that β-value of the relationship between lean manufacturing and operations performance is .816 with significant critical ratio (i.e., 13.388). As exhibited in Table 5.11, the β-value has a confidence interval ranging between .735 and .877. Due to the range does not contain zero, then the hypothesis stating that β-value equals to zero can be rejected. The standardized β-value shows that if lean manufacturing goes up by one standard deviation, subsequently operations performance will increase by .816. The relationship leads to the supporting of H_1 (i.e., lean manufacturing has a positive relationship with operations performance).

As shown in Table 5.11, standardized β-value of the relationship between lean manufacturing and business performance is .271 with significant critical ratio (i.e., 3.489). This value has a confidence interval ranging from .129 to .413. Because the range does not include zero, the hypothesis that the β-value equals to zero should be rejected. This specifies that lean manufacturing has a positive relationship with business performance, and therefore H_2 is strongly supported.

Similarly, there is a positive relationship between operations performance and business performance with the standardized β equals to .663 and significant critical ratio (i.e., 7.846). Table 5.11 indicates that the relationship has a confidence interval between .526 and .789, which does not include zero. This implies the hypothesis stating that the β-value equals to zero should be rejected. The β-value of .663 indicates that if operations performance goes up by one standard deviation, then business performance will go up by .663. Hence, H_3 (i.e., operations performance has a positive relationship with business performance) is also statistically supported.

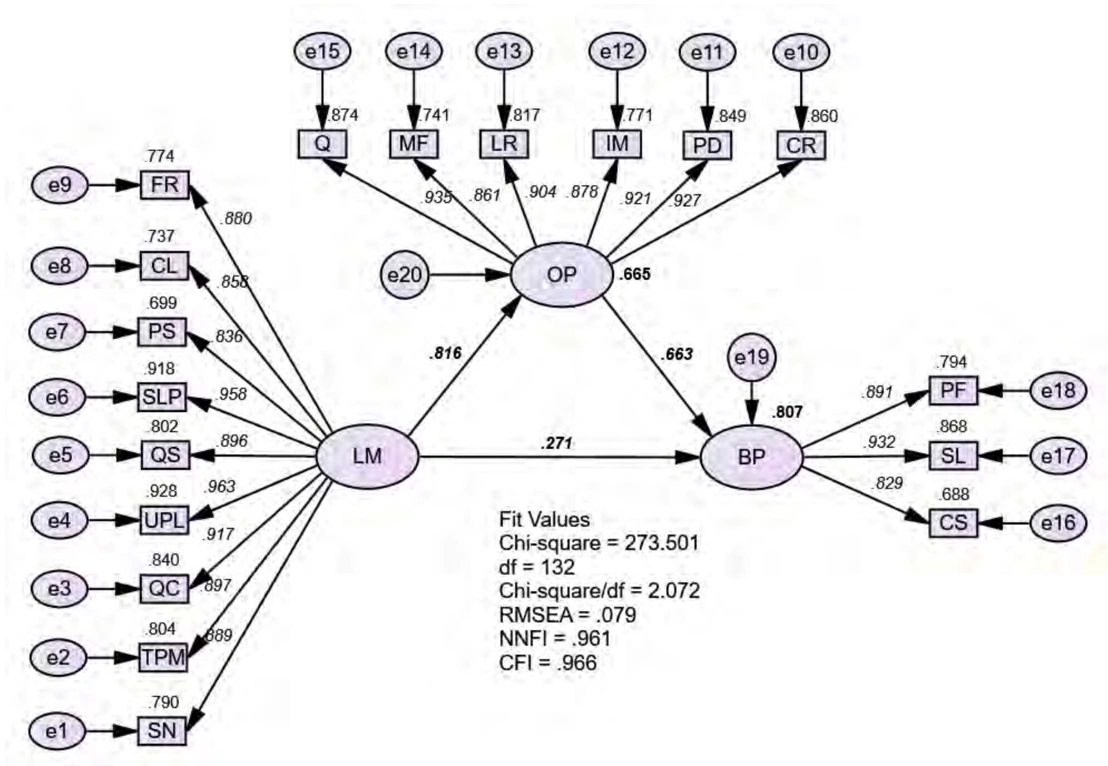

Figure 5.2
Standardized Estimate of Structural Model
Note. Italic: factor loading between latent variable and its indicators. Regular: loading squared. Bold regular: R^2 from exogenous variable(s) to endogenous variable. Bold italic: standardized beta between two latent variables.

Table 5.11
Relationships among Latent Variables

Hypothesis: Path	Std. β	Std. Error	Confidence Intervals*	CR**
H_1: Lean manufacturing → Operations performance	.816	.064	.735-.877	13.388
H_2: Lean manufacturing → Business performance	.271	.060	.129-.413	3.489
H_3: Operations performance → Business performance	.663	.062	.526-.789	7.846
H_4: Lean manufacturing → Operations performance → Business performance	.541	.059	.434-.666	9.169

Note. *Confidence intervals (95 percent) were supplied by bootstrap sample. ** All are significant at $p < .05$.

Recently, several studies, such as Hayes (2013), MacKinnon and Fairchild (2009), Preacher and Hayes (2008), and Zhao et al. (2010), suggested that the existence of mediation or indirect effects should be determined based on the significance of the product of path *a* (i.e., relationship between lean manufacturing and operations performance) and path *b* (i.e., relationship between operations performance and business performance). If the product is significantly different from zero, then mediation or indirect effects do exist within the model. Table 5.11 indicates that direct effect of lean manufacturing on operations performance is considered high (i.e., path *a* = .816), which is similarly to direct effect of operations performance on business performance (i.e., path *b* = .663). Both values are statistically significant at .05 level (one-tailed). Thus, the indirect effect of lean manufacturing on business performance is .541 (i.e., .816 *x* .663) with significant critical ratio (i.e., 9.169). The indirect effect has a confidence interval between .434 and .666. Due to the range does not contain zero, then the hypothesis indicating no indirect relationship between lean manufacturing and business performance can be rejected. Hence, this condition implies that the indirect effect is statistically significant at .05 level (one-tailed).

Based on the assessment results, direct relationship between lean manufacturing and business performance is positively significant albeit the presence of operations performance as a mediating variable. Considering this fact and supported by the significant standardized indirect effect, the model fulfils criteria of complementary mediation (Zhao et al., 2010), in which both indirect effect (*a x b*) and direct effect (*c*) exist and point at the same direction (i.e., positive). This means that lean manufacturing positively affects business performance in both direct and indirect manners. Hence, the last hypothesis (H_4) is empirically supported.

Additionally, as the data approach the multivariate normal distribution (as discussed in Section 5.5.2), for the purpose of triangulation of mediation effect of operations performance in the model, a two-tailed Sobel test (Sobel, 1982, 1987) was performed. Sobel test Statistics of 6.748 were found significant at $p < .05$. This result strongly supports the result of bootstrapping that operations performance mediates the relationship between lean manufacturing and business performance.

In addition, the total effect of lean manufacturing on the business performance is reported in Table 5.12. The table shows that the total effect is .812, which is sum of direct effect (β = .271) and indirect effect (β = .541) of lean manufacturing to business performance. The standardized β of the total effect has confidence interval ranging from .727 to .876. This range does not contain zero suggesting that the hypothesis indicating that there is no significant total effect should be rejected. This leads to a conclusion that the total effect of lean manufacturing on the business performance in the presence of operations performance as mediating variable is significant. Furthermore, this condition implies that when lean manufacturing goes up by 1 standard deviation, business performance goes up by .812.

Table 5.12
Standardized Effects of Latent Variables

Path	Direct	Indirect	Total
Lean manufacturing → Operations performance	.816	-	.816
Operations performance → Business performance	.663	-	.663
Lean manufacturing → Business performance	.271	.541	.812

Note. All the effects are significant at $p < .05$ (one-tailed).

The R^2 indicating the contribution of independent variable to the dependent variable is exhibited in Figure 5.2. The standardized estimate of the structural model illustrated that around 66.50% of the variance of operations performance is explained by lean manufacturing. Furthermore, both lean manufacturing and operations performance explain 80.70% of the variance of business performance.

5.12.3 Structural Model Validity

The last stage of SEM is to test validity of the structural model. For this purpose, comparison between overall fit of a structural model and the measurement model was performed. Hair et al. (2010) stated that the closer the structural model GOF comes to measurement model, the better the structural model fit. In this study, the comparison indicates that the models are saturated. According to Hair et al. (2010), the saturated model is obtained if the number of structural model relationships equal to number of possible constructs' correlations in CFA. The fit statistics of the saturated structural are the same as those obtained from measurement model (Hair et al., 2010).

Besides GOF and construct validity, criterion-related validity for structural model was also assessed. As elaborated in Section 4.4.6.2.3 and 5.8.2.3, this validity indicates the extent to which all constructs that are theoretically related are empirically related. In other words, it suggests whether the relationships between constructs make sense and agree with theory. In this study, it was investigated by using path coefficients indicating nature of relationship between latent variables. Ensuring criterion-related validity was done simultaneously with assessment on direct and indirect relationships between the variables. The results indicated that all the variables are theoretically and empirically related. Hence, criterion-related validity was achieved.

5.13 Chapter Summary

In the present chapter, the four hypotheses have been successfully tested as summarized in Table 5.13. The results indicated that lean manufacturing positively affects business performance (H_1) and operations performance (H_2). At the same time, operations performance also positively contributes to business performance (H_3). Moreover, lean manufacturing affects business performance directly and indirectly through operations performance as a mediating variable (H_4).

Table 5.13
Summary of Hypotheses Testing Results

Hypothesis	Decision
H_1: Lean manufacturing has a positive relationship with operations performance.	Supported
H_2: Lean manufacturing has a positive relationship with business performance.	Supported
H_3: Operations performance has a positive relationship with business performance.	Supported
H_4: Lean manufacturing affects business performance directly and indirectly through operations performance as a mediating variable.	Supported

The key findings are concluded into the following inferences:

1. All lean manufacturing practices are positively associated with one another. In other words, all practices are interdependent. It implies that all the practices should be implemented simultaneously, holistically, and comprehensively as a total system to enhance maximum benefits from its implementation. This suggests that all the practices are mutually supportive; implementation of one practice supports the others. In a few words, all the practices are complementary with one another.

2. Lean manufacturing explains a significant percentage of the total variance of operations performance. This bears evidence of positive and significant contribution of lean manufacturing to operations performance. In short, the higher the implementation of lean manufacturing, the higher the operations performance.

3. Lean manufacturing contributes positively to business performance. This was supported by the analysis results showing that lean manufacturing explains a significant percentage of total variance of business performance. However, even though the direct relationship is still significant, it is much lower compared to the relationship between lean manufacturing and operations performance. In addition, the direct relationship is also considerably weaker than the indirect relationship (i.e., through operations performance as a mediator variable).

4. Operations performance positively related to business performance. The increase of operations performance contributes to the increase of business performance.

5. The SEM analysis highlighted the role of operations performance in the model. Operations performance complementary mediates the relationship between lean manufacturing and business performance, in which both indirect and direct effects exist in the model and point at the same direction (i.e., positive).

Although this study has been able to grasp a set of key findings, the findings are too general. The above findings only provided a general understanding regarding the relationships among the variables. To reach a deeper understanding regarding the outcome of the statistical analysis, a micro-level analysis is required. A qualitative study helps the author to enhance a deeper insight regarding the linkage between lean manufacturing and companies' performance. In short, the qualitative study further explains and confirms mechanisms or reasons behind the quantitative results.

The next chapter will follow up the key findings through a case study approach to confirm, explain, and triangulate the findings of the quantitative research.

CHAPTER SIX
QUALITATIVE RESEARCH FINDING

6.1 Introduction

This chapter presents the qualitative phase of the study as a confirmation, explanation, and triangulation of the quantitative results. The key findings of the quantitative phase (as presented in Section 5.13) directed specific research questions of the qualitative study as well as its propositions. Based on the research questions and propositions, a set of interview protocol as presented in Section 4.5.3.2 and depicted in Appendix K was developed to guide the entire processes of data collection. Finally, this chapter will highlight data analysis and findings of the case study.

6.2 Qualitative Research Question

Due to the limitation of quantitative research, which only provided a general understanding regarding the phenomena under investigation, the qualitative study is required to further explain, confirm, and triangulate the general findings. Based on the quantitative key findings as summarized in Section 5.13, the following qualitative research questions were developed:

1. How are lean manufacturing practices implemented?
2. How does lean manufacturing improve operations performance?
3. How does lean manufacturing improve business performance?

6.3 Research Proposition

Propositions were developed in order to guide, limit and narrow the qualitative phase of the study. Propositions are similar to hypotheses in the quantitative analysis addressing something that should be examined within the qualitative study. Besides reflect an important theoretical issue, propositions direct attention to what being researched and help to look for significant evidence (Yin, 2009). The following propositions were arranged accordingly based on the quantitative key findings and specific qualitative research questions.

Proposition 1: *All the lean manufacturing practices should be implemented holistically because they are mutually supportive with one another.*

Proposition 2: *Holistic implementation of lean manufacturing improves operations performance.*

Proposition 3: *Holistic implementation of lean manufacturing improves business performance directly, and indirectly through improvement of operations performance.*

The holistic implementation of lean manufacturing implies that all the practices are applied comprehensively and simultaneously, because of the complementary nature of the relationships among them.

6.4 Profile of Informants

Driven by the social constructivist ontology and epistemology, and features of a case study as presented in Chapter Four, this study typically gathered data from multiple sources. Due to the essence of constructivism is that the reality is determined by people rather than by objective and external factors; as suggested by its epistemology, the best data collection technique is the interview (or conversation). A series of the semi-structured interviews was successfully conducted in Toyota Motor Manufacturing Indonesia. For this purpose, the author was attached to the company from 4th to 29th August 2014. The snowball purposeful sampling method was applied to select the informants being interviewed. A key informant was first interviewed. At the end of the interview, the author asked him the next informants who are best to refer. The interviews were limited until the point of saturation is achieved. In other words, interview was terminated when there is no new information forthcoming from new informants.

This study involved 19 selected informants, consisting of nine informants from component export and vanning plant (CEV), four from engine production plant (EP), three from stamping plant (ST), and three from vehicle assembly plant (VA). Details about informants are presented in Table 6.1. Pseudonyms were used to replace the informants' names to protect their identity and maintain confidentiality.

Table 6.1
Profile of Informants

No	Pseudonyms	Working life (years)	Position/level	Education
1	CEV1	21	Managerial	Bachelor
2	CEV2	23	Managerial	Bachelor
3	CEV3	20	Managerial	Bachelor
4	CEV4	21	Managerial	Diploma
5	CEV5	24	Supervisory	Bachelor
6	CEV6	21	Supervisory	Diploma
7	CEV7	24	Supervisory	Bachelor
8	CEV8	10	Supervisory	Diploma
9	CEV9	23	Supervisory	Bachelor
10	EP1	23	Managerial	Bachelor
11	EP2	23	Managerial	Diploma
12	EP3	11	Supervisory	Bachelor
13	EP4	14	Supervisory	Senior high school
14	VA1	21	Managerial	Bachelor
15	VA2	17	Supervisory	Diploma
16	VA3	8	Supervisory	Diploma
17	ST1	20	Managerial	Bachelor
18	ST2	14	Supervisory	Diploma
19	ST3	8	Supervisory	Diploma

As shown in Table 6.1, all the informants held senior posts; eight were managerial level (i.e., manager and general manager) and eleven were supervisory level (i.e., supervisor and section head). Majority of them (i.e., 63%) have been working within the company for more than 20 years. They also were educated in diploma and bachelor. Hence, all the informants have sufficient experience in the implementation of lean manufacturing. Additionally, they are considered knowledgeable to provide information regarding the effect of lean manufacturing on organizational performance.

6.5 Data Analysis

As stated in Section 4.5.4, the analysis was conducted by following the qualitative data analysis spiral recommended by Creswell (2007). As exhibited in Figure 4.2, there are four loops of performing data analysis for a qualitative study, namely (1) data managing, (2) reading and memoing, (3) describing, classifying, and interpreting, and (4) representing and visualizing the data analysis results.

At the early stage of data analysis, the author managed the data obtained from the fields. The data were organized and systematized into file folders and computer files. As the main data collection method applied in this study is the interview, at the first loop in the spiral, each interview was professionally transcribed by converting the data files into text forms. It is an act of representation, and it influences how the data are conceptualized. Once the transcription process was finalized, the interview transcripts were imported into the software of ATLAS.ti 7 for the subsequent analysis. Secondly, following the data managing, the author attempts to get a sense from the whole data by reading and scanning the transcripts several times to identify the important ideas.

Thirdly, the author moved to the next loop. In this loop, the author described what he saw, developed themes through a classification process, and provided interpretation. In this stage, based on the qualitative research question, the author developed codes to classify texts into relevant themes. Using the software, the codes were tagged to the interview transcripts. At the same time, the author wrote memos in the margin of transcripts to help in exploring and making sense of data in this initial analysis process. An advantage of Atlas.ti is that it enables the same sentence, phrase, and paragraph to be coded to a number of codes. In addition, it also eases the author to excerpt any parts of the interview to be put into the finding's write-up as evidence for analysis. Unlike quantitative research that uses numerical data as evidence, a qualitative research shows its findings by using excerpts from interviews.

Generally, considering the qualitative research questions and its propositions, this study ended up with seven general codes as presented in Table 6.2. Some of the codes were divided into a number of sub-codes. In the table, the author provides a summary of passages associated with each code as an indicator of informant interest. Following Creswell (2007), the codes are classified into two categories as follows:

1. Pre-figured category, which provides information that was already expected to find before the study. Six codes were classified under this category, namely lean manufacturing practices, holistic implementation of lean manufacturing, the effect of lean manufacturing on operations performance, relationship among the operations performance measures, the effect of operations performance to business performance, and effect of lean manufacturing on business performance.

2. Emergent category, which contains surprising information that was not expected to find in a qualitative study, and contains information that is conceptually interesting to the author. Contextual factor affecting lean implementation is classified under this category.

Table 6.2
Summary of Codes Indicating Informants' Interest

Code	Informants																		
	CEV									EP				VA			ST		
	1	2	3	4	5	6	7	8	9	1	2	3	4	1	2	3	1	2	3
Lean practices	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
FR	x	x	x	x	x		x		x	x	x	x	x	x	x	x		x	x
CL							x		x			x			x			x	x
PS	x	x	x		x	x	x	x	x		x			x	x		x	x	x
SLP	x		x		x		x	x			x			x	x		x	x	x
QS	x		x	x	x				x					x	x	x	x	x	x
UPL	x	x	x	x	x	x	x	x		x		x		x	x		x	x	x
QC	x	x	x	x	x	x	x		x		x	x	x	x	x	x		x	x
TPM	x									x	x	x	x	x		x		x	x
SN	x	x	x	x	x		x	x	x		x		x	x	x	x	x		
Lean holistic implementation	x		x	x	x		x		x			x		x			x	x	x
Contextual factors	x	x	x	x	x		x	x	x		x			x			x	x	x
Effect of LM to OP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
LM-Q	x	x	x	x	x		x		x		x	x	x	x	x		x	x	x
LM-MF	x	x	x	x	x		x		x		x	x	x	x	x		x	x	x
LM-IM	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x
LM-LR	x	x	x	x	x		x		x		x	x	x	x	x		x		
LM-PD	x	x	x	x	x		x		x		x		x	x			x		
LM-CR	x	x	x		x	x	x	x	x		x			x	x		x	x	x
Relationship among OP measures	x	x	x	x	x		x	x	x			x		x	x		x	x	x
Effect of OP to BP	x		x	x	x		x		x		x	x		x		x	x		
OP-PF	x		x		x		x		x		x	x		x			x		
OP-SL	x			x					x					x					
OP-CS	x		x	x	x				x			x		x			x		
Effect of LM to BP	x		x	x					x		x		x	x			x		

Note. x indicates code expressed by the informants

As expected, Table 6.2 indicates that most of the informants explained regarding the lean manufacturing implementation and its effect on operations performance. They are also interested in the effect of operations performance on business performance. There are only few informants explaining the effect of lean manufacturing on business performance.

As explained in Section 4.5.3.3, the author placed himself in an interpretive position in order to make sense the multiple perspectives of informants. In performing interpretation, the author combined and compared the personal views of each informant. At the final loop of the spiral, the author represents and visualizes the analysis results into text and figure form as presented in the subsequent sections. In order to systemize the presentation, the following analysis results were arranged based upon the order of the qualitative research questions and propositions.

6.6 Findings Related to Holistic Implementation of Lean Manufacturing

The quantitative phase pointed out that lean manufacturing must be implemented in a holistic manner, because of the mutually supportive nature of the relationship among the practices. The qualitative phase attempted to confirm this quantitative finding. This is associated with the first proposition of the case study stated that all lean manufacturing practices are mutually supportive with one another. So that, the practices tend to be adopted holistically. This section is divided into three subsections. Firstly, the implementation of each lean manufacturing practice in Toyota Indonesia is presented. Secondly, interdependency among the lean manufacturing practices are addressed. Lastly, emergent factors affecting holistic implementation of lean manufacturing are elaborated.

6.6.1 Implementation of Individual Practices of Lean Manufacturing

There are nine lean manufacturing practices investigated in this case study. They are flexible resources, cellular layouts, pull system, small lot production, quick setups, uniform production level, quality control, TPM, and supplier networks. The implementations of each practice in Toyota Indonesia are subsequently presented.

6.6.1.1 Flexible Resources

With regards to the lean manufacturing system, flexible resources are viewed not only in terms of multi-functional machines and equipment, but also in terms of multi-skilled workers. Below, the entities of flexible resources are discussed.

(a) Flexible production lines, and multi-functional machines, tools, and equipment

At Toyota, production is performed by employing flexible production lines, machines, and tools, in which they can be used to perform multiple processes and to produce the variety of products. The flexible lines can be used to produce many variances of products, as observed in vehicle assembly plant and engine production plant of Toyota Indonesia. VA1 explained that in Karawang Plant I, all variants of Toyota Fortuner and Innova can be manufactured in a common production line with the same route. Similarly, in Karawang Plant II, all variants of Toyota Vios, Yaris, and Etios Valco are produced in one line. The same was done in engine production plant; a common production line is used to produce all types of engines. At the time of observation in Karawang Plant II, VA3 also said, *"We use a flexible production line, in which it can accommodate all variants of products being produced. It is the result of our improvement; any variant of vehicles can get through the production line."*

Utilization of flexible production lines is intended to support small lot production systems. Ideally, lot size should be one. It was reviewed by VA1 as follows, *"Around the 1990s; we applied batch production (but in minimum lot size). We made Corolla, Corona, and Starlet. Each type used different jig. So that, for example, once five units of Corolla are completed, then the jig must be replaced for the next product (i.e., Starlet). Once five units of Starlet are completed, then the jig was again replaced. Finally, we improved. Now, one jig can be used for all variants, and production can be accomplished in the ideal lot size, one."* In other words, small lot size production cannot be performed successfully when production lines are not flexible. Hence, the existence of flexible production lines is a pre-requisite for small lot production.

Associated with machines and equipment flexibility, some of the machines and equipment can be used to perform a number of operations. Although there are differences in terms of product, the flexible machines and equipment can be used to perform operations for different products. VA1 said, *"Our production line is flexible; all the variants of Fortuner and Innova are produced here. To get into the line, machines must be able to process all variants of Innova and Fortuner."* Similarly, tools should also be usable to perform several different jobs. VA1 explained, *"... tools are certain. Wheels for Innova and Fortuner are different, tools being used must be designed in such a way. So that, it can assemble wheels for all variance of the car."*

One of the flexibility indicators is the minimum setup process that needs to be performed for each product being manufactured. CEV9 expressed as follows, *"In vehicle assembly plant, virtually no setup required. We utilize flexible machines, tools, and equipment, in which a single production line is extensively used to produce all types of the car. Replacement between units being produced in a workstation does not require* *any setup, because the production line can be used to process all types of the car. Whatever the models and whatever the variants, as long as they are still our variant, no setup is required."* It was also expressed by ST3. According to him, production line in the stamping plant can perform multiple operations, but certainly not as flexible as in vehicle assembly and engine production plants, because the stamping plant produces in batch that requires dies change whenever the product being manufactured is changed. ST3 stated, *"One line can produce a variety of items. Here, we can produce around thirty types of items. It is certainly different from vehicle assembly line, which implements one-piece flow production. Here, it is such a thing that cannot be done."*

(b) Multi-skilled workers

Having multi-skilled workers is an important requirement for a lean manufacturing to be successfully implemented. At Toyota, it is a must in all plants; all the workers must be able to perform multiple jobs and operations.

Toyota adopted *shojinka* principle, in which number of operators in a shop floor can be altered (increased or decreased) when production demand has changed (increased or decreased). In other words, by applying *shojinka*, number of workers in a shop floor can adapt to demand changes. On the production lines, workers should be able to perform multiple operations, and handle a number of different machines. It was highlighted by CEV7 as follows, *"…, one worker handles multiple operations."* To ensure workers flexibility, the following activities are done by Toyota Indonesia:

1. Toyota implements "*tanoko"* system. *Tanoko*, which is recognized as capability or skill mapping, is a system that provides complete information regarding the skills of workers. *Tanoko* is made based upon the number of jobs in one production line.

The more mastery the worker, the more the number of full *tanoko*. Number of full *tanoko* reflects the skill level of workers and their flexibility, as mentioned by VA2. By applying *tanoko*, Toyota monitors the skill level of its production workers. Example of *tanoko* is given in Figure 6.1. For each job, all workers are leveled based on their skills, from level 1 to level 4, based on the pre-determined criteria as mentioned by CEV2 as follows, *"We have workers' fundamental skill levels from level 1 to level 4. Level 1 (25% tanoko filled) reflects the worker who has recently been trained of doing a particular job. Level 2 (50% tanoko filled), indicates that the worker has been able to work under supervision, he/she has been already familiar with his/her work. If there is a problem, he/she can do stop-call-wait. An operator is allowed to work on the production line when he/she has been at level 2. Level 3 (75% tanoko filled) indicates the worker who has been able to work independently, there is no defect produced by him/her during the last six months. And level 4 (100% tanoko filled) reflects a worker who has been skillful to work alone without any supervision, and has undergone training for Toyota Job Instruction (TJI). So, he/she is able to teach particular jobs to others."*

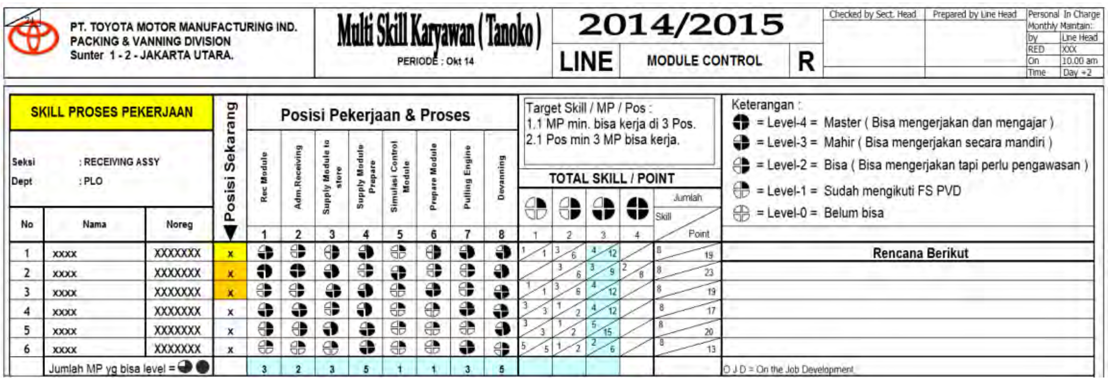

Figure 6.1
Sample of Multi-skill Mapping

In simpler terms, *tanoko* system helps Toyota to ensure how mastery an operator in performing their jobs within a production line. Job rotation and promotion are also done based on the information provided in *tanoko*.

2. Regularly, Toyota performs job rotation. EP3, VA1, and VA3 expressed somewhat similar information regarding the importance of job rotation. As an example, EP3 stated, "In order to be multi-skilled, our production workers must be rotated regularly...." Job rotation was done periodically based on the tanoko. If a worker has mastered a job, then he/she will be transferred to another workstation to perform other jobs. In addition, besides ensuring worker flexibility, rotation is also very useful for promotional and advancement purposes. A worker is promoted, if he/she has been multi-skilled. It was explained by CEV1 as follows, *"If the worker has been multi-skilled; after some time, he/she will be promoted as a group leader... A group leader, at least, has mastered all the jobs in his/her line... So, job rotation is advantageous not only for multi-skilling workers, but also for carrier-up."*

3. Cross-training. Training is essential for Toyota to strengthen the implementation of lean manufacturing. It is also important to ensure that skills of all workers are at the targeted level. EP2 conveyed, *"This is the importance of trainings. An operator in a particular production line, at least, should be able to do jobs in three or four different workstations. For example, one operator is now able to operate ten machines. In his/her group, he/she is still being planned to master more different machines... These all are through training. That's why we have "dojo" or training area. New or transferred operators must be first trained in the dojo."* Besides *dojo,* Toyota Indonesia has Toyota Institute (TIN), which is responsible to plan and

organize various trainings. This was confirmed by CEV4, *"TIN is concerning on organizing trainings for process development and to level-up skills of workers."*

As having flexible resources is compulsory in a lean manufacturing system, a company should use multi-functional lines, machines, tools, and equipment, besides ensuring multi-skill of workers. The skills are developed through *tanoko* system, job rotation, and training.

6.6.1.2 Cellular Layouts

Implementation of cellular layouts is important for those who are implementing lean manufacturing. This practice ensures that workstations, machines, and equipment are arranged into a sequence in order to support smooth flow of materials in a production process with minimum transportation, movement and delay. However, based on the interviews and observations conducted by the author, even though the practice is highly recommended in all plants of Toyota Indonesia, its implementation depends upon a number of contextual factors, such as type of production process, technology used at the plant, and type of product. These factors are presented in Section 6.6.3.

Based on the observations, in a number workstations, the concept of cellular layouts is applied, such as at engine production, vehicle assembly and CEV. In the plants, dissimilar activities and together with machines, equipment, and tools are grouped into a workstation. Plants applying cellular layout arrange its workstations, machines, equipment, and tools in relation to each other. Thus, material movement could be minimized. In addition, in line with cellular layouts; production lines are usually laid out in a U-shape to improve workers' efficiency as well as to support the implementation of *shojinka*. CEV7 conveyed, *"We adopt shojinka. It is defined as producing with a flexible number of workers without reducing productivity."* By implementing *shojinka*, number of workers in a production line is adjustable depending on production volume, as described by CEV7 as follows, *"With shojinka, if production volume is 400, then four workers are needed; each worker controls multiple machines… If 100, only one worker is required. Thus, we can operate with any number of workers depending on production volume."*

The cellular layout minimizes material movement, material handling, and transit time. Because distance between workstations is closer, workers' responsibility can be broad; one worker may handle several different machines and equipment. This was highlighted by EP3 as follows, *"With the U-line, one operator can handle multiple jobs. So that, one worker can handle a number of workstations... With this layout, every second can be utilized. No one will be idle..."* This concept was detailed by CEV7. He said, *"... in the machining process of engine production plant, its production line is laid out in a U-shaped. So that, a worker in workstation A can perform jobs in workstation B. Furthermore, he can also handle workstation Y and Z... If production volume and workload increase, and additional workers are required; workstation A and B will be handled by one worker, and workstations Y and X will be handled by another worker."* Application of *shojinka* is illustrated as in Figure 6.2 and 6.3. The two figures show that each worker handles multiple machines, operations or workstations.

Figure 6.2 describes that according to the monthly demand in January, the cycle time was one minute per unit. Under this cycle time, eight workers were working. Walking routes of each worker are described by arrow line. However, in February, monthly demand was reduced, and cycle time was increased to 1.2 minutes per unit (see

Figure 6.3). So that, operations and jobs were re-allocated; only six workers were required. The remaining two workers were assigned to perform other jobs outside these production lines. Consequently, number of machines handled by each worker and their walking routes were expanded. In short, changes in volume and takt time can be easily handled by adding workers to or subtracting them from the workstation and adjusting walking routes accordingly.

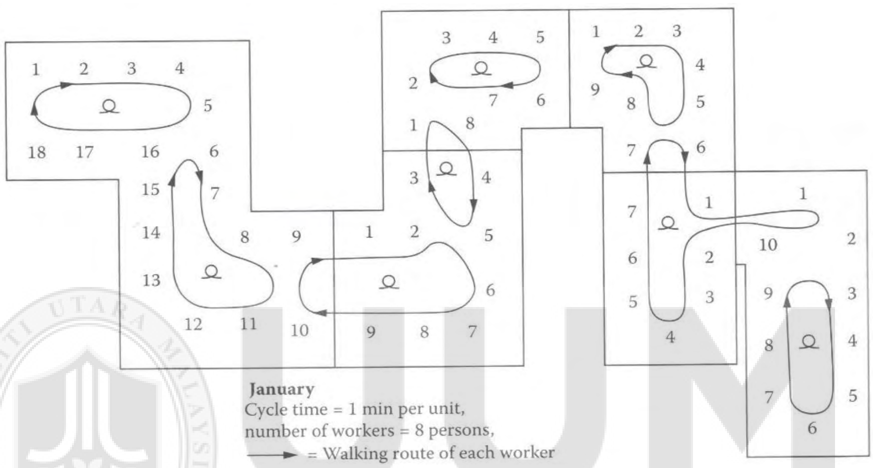

Figure 6.2
Allocation of Jobs among Workers in January
Note. Adopted from "Toyota Production System: An Integrated Approach to Just-In-Time" by Y. Monden, 2012, p. 150. Copyright 2012 by CRC Press, Taylor and Francis Group.

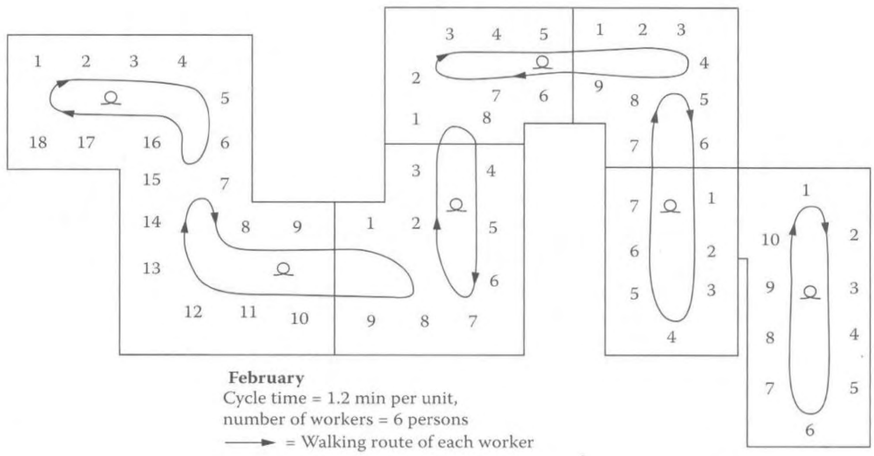

Figure 6.3
Allocation of Jobs among Workers in February
Note. Adopted from "Toyota Production System: An Integrated Approach to Just-In-Time" by Y. Monden, 2012, p. 151. Copyright 2012 by CRC Press, Taylor and Francis Group.

Additionally, equipment, machines and tools could be easily moved from one location to another. Thus, layout of shop floor facilities is easily rearranged to adapt to changes in volume, design, or product development. CEV9 stated, *"..., we can adjust our layout easily. When production volume increases or decreases, our layout is adjustable."* However, at vehicle assembly plant and at machining area of engine production plant, changing main line layout was truly rare and seems very difficult. In the vehicle assembly plant, changes in layout are often performed along its sub lines (supporting lines) only. This was highlighted by VA2, "*..., when we talk about the flexible production line, we are talking about supporting lines; such as racks, parts supply, etc., instead of conveyor (main line)."* The difficulty of changing facility layouts was also seen in the engine production and stamping plants because of the use of big size of machines and equipment. Layout adjustments are frequently caused by the changes of takt time as a result of the changes of production volume. Takt time is the intervalat which a product is moved ahead to next workstation, which is determined by dividing available production time per day with customer demand or production volume per day. Layouts' adjustments for supporting lines are easy to perform, as stated by VA2 as follows, *"..., layout adjustments in supporting line usually take a maximum of two days. Not hard, because racks, supporting machines, and equipment are movable."*

Cellular layouts also virtually eliminate material movements through distance reduction, because it reduces travel distance, inventory and space required. ST3 said, *"We avoid WIPs. Therefore, distance between workstations, as much as possible, is brought near to each other. We imagine working on a conveyor, so no waiting time for parts to get through subsequent workstation. The products smoothly flow from one workstation to the following workstation, no waiting."*

In summary, as the application of *shojinka* is important in Toyota, cellular layouts must take place in order to ensure flexibility in the production system.

6.6.1.3 Pull System

Toyota performs its production based on the pull system principle, in which production and material movement are triggered by customer demand. In other words, production in the final workstation is pulled by customer demand, and production in a workstation is triggered by the request from subsequent workstation. This was highlighted by ST3 and EP2. For instance, EP2 stated, *"Toyota is not going to produce, when there is no demand. There will be no movement of parts and materials, if there is no demand."*

Application of this system distinguishes between Toyota and other companies. By applying pull system, inventory is less required. Thus, warehouse is not mandatory. This was explained by CEV7 as follows, *"In other companies, production is sometimes carried out by applying a push system with large lot sizes. It generally may impose for holding some amount of inventory. Warehouse is therefore, indispensable. WIP is also essential; it will be stored for some times before the next process is carried out. In contrast, production in Toyota is done by applying the pull systems with small lot size. We prefer not to maintain some stocks. Our production is purely driven by customer demand. No demand, no production, and no material movement."*

In order to maintain the pull system (JIT in general) on a production floor, kanban is used as a tool to authorize production and material movement. CEV6 explicated, *"JIT is defined as producing based on customer request, in the right* *quantity, at the right time, and right quality. To achieve the aim, kanban is used as a tool."* In general, functions of kanban are as described by CEV7. He mentioned that kanban is used to instruct and authorize production, delivery, and material movement, as follows, *"Kanban is a tool of JIT. Goods are delivered by suppliers based on information provided in kanban. Likewise, production and material movement are also driven by the kanban. So, without kanban, there is no delivery from suppliers, no production and no transfer of materials."* In addition, kanban is frequently used as visual control tools, to prevent overproduction, to monitor progress, and to identify delays and processes that are too fast. CEV7 said, "*Producing too fast is not preferable, because there will be a build-up of materials in our store. Thus, some parts are possibly waiting for subsequent process… With kanban system; we know conclusively its circulation, there may be a delay of delivery from suppliers, or it could be very fast delivery form suppliers, resulting accumulation of parts and materials in storage."*

Prior to 2004, Toyota Indonesia used cyclic kanban, which is kanban that having cycles. Practically, this cyclic kanban uses cycle issue, which is symbolized by three numbers representing the number of delivery days-frequency of delivery per delivery days-delay cycle (interval of delivery). ST3 described as follows, *"We recognize the existence of cycle issue. For example, the cycle issue is 1-4-2… This means that there are four times delivery of this particular item per day, and the items will be conveyed two delivery times later after the kanban is given to supplier."* However, due to the increase in production volume, cyclic kanban is no longer effective; it was replaced with e-kanban (electronic kanban) in 2004. This was explained by CEV1 as follows, *"Previously, we used cyclic kanban. If kanban was thrown, then the next few cycles will come. Number of circulated kanban was monthly adjusted. The number of circulating kanban was determined based on production volume; the more the* *kanban circulated, the more the possibility of overstock. If daily order quantity was fluctuated, then we had to adjust number of circulated kanban daily. If production volume was high, and fluctuation of order was also high, cyclic kanban was no longer effective and practical, because we had to adjust number of circulated kanban everyday. That's why, we improved by applying e-kanban."* In addition, delay in giving signals for ordering was also a major problem of applying cyclic kanban in Toyota Indonesia. CEV9 explained, *"We used to hang the kanban card late; part had finished since four days back, kanban was just hung today. Whereas, the rule is, if goods are almost exhausted, kanban has to be hung immediately as a signal to make an order. If kanban is hung late, then production will be interrupted, line stop may happen."*

In general, the concept of e-kanban is the same as cyclic kanban. The major difference is in terms of communication between manufacturer and suppliers, as stated by CEV2, *"Basically, the concept of the two types of kanban is the same, but slightly different in terms of communication. With e-kanban system, it is virtually emailed to suppliers. It will be printed by suppliers, afterwards the supplier will process the order based on the information provided in the e-kanban. Then, the products will be delivered to us."* Conventional kanban is operated by manually passing kanban cards to the handler responsible for moving parts from previous to subsequent processes. In contrast, by using e-kanban, Toyota no longer passes any kanban cards to the handler. Order information is sent to parts' manufacturers electronically by using information technology, without passing it through anyones' hand. Sample of e-kanban is displayed in Figure 6.4.

Among the advantages of e-kanban are shorter lead time, besides the loss of kanban may be avoided. It was expressed by CEV7 as follows, *"E-kanban is important* *to shorten lead time, not only production lead time but also delivery lead time from suppliers, especially for suppliers locating far apart from Toyota. Conventionally, kanban card was often lost and sometimes required long lead time to reach the suppliers. With e-kanban, it is sent to suppliers by virtual technology. Thus, lead time of sending e-kanban becomes almost zero. If e-kanban is missing, it can be re-printed by suppliers in their own plant."*

Figure 6.4
Sample of E-kanban

As in stamping plant, cyclic kanban is used for its internal production process. E-kanban is used to make orders to suppliers. E-kanban is used by certain customers who had e-kanban system for clicking orders to stamping plant. However, some customers still use cyclic kanban to make their order to stamping plant, because they have not used the e-kanban system. ST3 explained, *"Actually, there are only two types of kanban, namely withdrawal and production kanban. Withdrawal kanban is e-kanban (or cyclic kanban) from customers that is used to issue goods from stamping plant. E-kanban is also issued by stamping plant to order materials from suppliers. Meanwhile, production kanban is used for internal production processes."*

6.6.1.4 Small Lot Production

One of the basic principles of the lean manufacturing system is small lot size production. It is preferable to achieve the ideal lot size of one. Toyota Indonesia has implemented this practice successfully, especially in engine production and vehicle assembly plants. EP2 elaborated, *"In these two plants (engine production and vehicle assembly); ideal lot size of one has been successfully achieved. However, in stamping plant, the ideal lot size cannot be achieved because it is associated with type of technology and type of production processes applied."* Metal stamping is produced by batch. Even though stamping plant cannot achieve the ideal lot size, its lot size was made as small as possible by improving dies change process or setup (see Section 6.6.1.5). In other words, production done in Toyota remains committed to the principle that production should be performed in small lot size with high frequency. This was stated by CEV3 as follows, *"we have to produce in small lot size with high frequency."*

This practice is to avoid creating a large inventory. By implementing the principle of *"small lot size, high frequency"*, inventory could be eliminated significantly, and the requirement of space could be less. This was confirmed to CEV3. He stated, *"Thus, if production is done in large quantities per lot, inventory and space requirement may increase."* In other words, inventory is remained zero if small lot production is applied. In addition, no workers are idle. In contrast, producing in a large lot size causes stocks in a substantial amount, not only materials and WIPs, but also finished products. At the same time, a number of workers are idle.

The same principle (i.e., small lot size and frequent delivery) was also applied in the case of delivery from suppliers. According to CEV1, Toyota has undergone a revolution in terms of delivery from suppliers, from large lot size (with single route delivery) to small lot size (with milk run delivery). This is as described by CEV1 as follows, *"Last time, we applied single route, but delivery lot size was large. If lot size is small, then we supposed to use small trucks, but it is expensive and truck efficiency is low. The solution is to apply milk run."*

Nowadays, Toyota Indonesia adheres to the principle of milk run delivery to ensure that delivery from suppliers follows the JIT principles. Milk run delivery means that goods are collected from several suppliers and transported to one customer. CEV1 and CEV7 conveyed a similar idea about this delivery system. For instance, CEV1 explained as follows, "*Suppliers' addresses were geographically mapped. Suppliers who are located near by to each other, their goods are picked by one truck provided by logistics partner. So, one truck collects goods from a number of suppliers. Thus, frequency of delivery can be increased, and lot size can be reduced. Finally, we do not need to stock up parts and materials in large quantities."*

The same opinion was expressed by CEV3. According to him, delivery from suppliers must be in a quantity corresponding to production requirement, no more and no less. He compared old delivery system (i.e., single route delivery) and milk run as follows, *"We strive to make delivery from suppliers in high frequency and small lot size in accordance with production requirement. For example, with single route, supplier X should deliver its products twice a day with large lot size. By applying milk run, we make it six times per day with small lot size. Likewise, with single route, supplier Y delivers its products once a day with large lot size. Now, we make it six times delivery with small lot size. Similarly, supplier Z, with single route, performs three times delivery with large lot size. Now, we make it six times per day with small lot size by applying* *milk run. Thus, milk run required six trucks in order to collect and deliver all products from the three suppliers. It is similar with single route delivery. Thus, transportation costs remain the same. The difference is in terms of delivery lot size. By applying milk run, delivery is done in a small lot size. Whereas, with single route, delivery is in large lot size. Nevertheless, total volume of goods received by Toyota is the same."*

CEV3 explained, *"This is the concept of small lot delivery applied in Toyota. It implies that delivery volume from suppliers should be performed in small lot size, and its frequency is increased. Likewise, production is also carried out in small lot sizes. This is what we have been doing; producing little by little as necessary."* By implementing this technique, there is no material build-up in the receiving area, because deliveries from suppliers are carried out in accordance with production requirement, no more and no less.

Milk run delivery drives lead time to become shorter, not only delivery lead time from suppliers, but also waiting time for materials to be processed on the production line. This is in line with what was presented by CEV3 as follows, *"... With single route delivery system, goods arrived at our place within two days, because it depends on completion of the production process at the supplier's plant. With single route, there is a time spent to wait until the truck is fully loaded. So, the truck must wait until production of 23M^3 (in accordance with truck's volume) completed. In contrast, with milk run, shipment is done little by little; it is not required to wait until production of 23M^3 completed and not necessary to wait until the truck is fully loaded. Thus, lead time will be shorter."*

Different from single route, by applying milk run delivery, there are only small number of trucks delivering parts and materials to Toyota Indonesia everyday. This was stated by CEV8 as follows, *"If we do not apply milk run, for example, if we have sixty suppliers, then all suppliers will come to deliver their goods to Toyota everyday. We can certainly imagine; sixty trucks will be coming here everyday. Furthermore, if order quantity to one supplier is small (e.g., 10 pcs bolts and nuts), inevitably this supplier must deliver it to Toyota once required. We can imagine, how inefficient this is. With milk run, only twenty trucks will be coming per day to deliver parts and materials from a number of suppliers."* CEV3 pointed out, *"When you pass through in front of company X in the morning, you can observe how many trucks are coming in at the same time. How many trucks are waiting to unload? Sometimes, it reached about the extent in which there is no space available for parking. The trucks jammed the road. This is because of not applying milk run."*

Based on the above explanation, not only production that must be performed in small lot size, but also delivery from suppliers. This is beneficial not only for minimizing inventory and shortening lead time, but also for resolving suppliers' transportation problem.

6.6.1.5 Quick Setups

Shortening setup time is essential for the successful of lean manufacturing implementation. This is because production in a lean system is driven by customer demand. In addition, production in small lot size is preferable in a lean manufacturing system. If setup time is long, then lot size is likely to remain larger. This may lead to waste arising from overproduction. Toyota Indonesia is constantly attempting to shorten setup time throughout the production line. As a result, in vehicle assembly and engine assembly lines, as stated by VA1 and CEV5, there is no machine setup to perform. As an example, VA1 said, *"At vehicle and engine assembly lines, although we perform mixed model production with heijunka, machines' setups are not necessary. If it is required, it is done very fast."*

Shortening setup time is essential to achieve the ideal lot size of one. As highlighted by VA1, around 1990s, Toyota Indonesia produced three types of car (i.e., Corolla, Corona, and Starlet) in large quantity per batch because each type of car is jig type dependent. In other words, each type of car being assembled required different type of jig. According to him, "*Different types of car used different jigs. For example, once production of five units of Corolla is completed, then the jig must be replaced, because Starlet will be entering the production line. Once the five units of Starlet passed the production line, the jig must again be replaced."* This explanation indicates that the existence of setup (i.e., jig changes) does not support production with the ideal lot size of one. In short, to achieve the ideal lot size, setup must be eliminated. VA1 said, *"At that time, we produced five units per batch. Finally, we improved. Now, we have been able to produce in lot size of one, without any setups."* In fact, the absence of setups (called as *dandori* in Japanese) in the vehicle and engine assembly lines is due to flexibility of machines, equipment and production lines itself. The following review from VA2 stated, *"There is no dandori, because we use flexible machines and equipment... Flexible production line must be able to process all types of vehicle entering into the production line, without any setup."* He spoke, *"At least, when we are talking about robots, there are some parameters that must be set at the beginning of a process. However, setup is done so quickly within one or two seconds. Sending information to robots is done by scanning barcode."*

The need of setup and its setup time are depending on the type of production process and technology used at the plant, besides the improvement made along the production lines. This was explained by CEV9 as follows, *"Here (referring to CEV), there is no setup required, most of the activities are done manually (without using machines). In the vehicle assembly plant, also there is no setup because of the use of flexible production lines, in which one line can be used to process all types of vehicles. Although mixed model production is applied, the setup is still not required, because of flexibility of machines... Whatever the model, and whatever the variants, as long as it is still in our variant, then no setup is required."* The absence of the setup process in the vehicle and engine assembly plants is also because of continuous improvement, which is intensively done in the plants. This is different from stamping plant, which is producing car body parts such as doors, side member, hood, roof, apron feeder, hinge side and others. Production is carried out by using press machines, in which machine setups are necessary and unavoidable, because different products require different dies. CEV4 explained, *"Dies for roof is not the same as the dies for the door, therefore, dies must be changed whenever there are changes in the products manufactured."* Hence, setup cannot be avoided in the stamping plant as described by ST2 as follows, "*Dandori is inevitable. Different dies, different setting."*

There are two types of setups, namely internal setups (*uchi dandori* in Japanese) and external setup (*soto dandori* in Japanese). ST2 stated, *"Uchi dandori should be done when the machine is stopped from operation, because it is impossible to replace dies when the machine is still running."* Meanwhile, external setup is preparation in advance, while press machine is still processing the previous product. Technically, during an observation session at the stamping plant, ST3 showed how to perform setup, *"This is a soto dandori. Dies (upper and lower) are transported from* *dies store, then both are placed on a booster (dies table), and soto dandori is begun."* Once production processes for previous product are completed, then its dies are detached from the machine and internal setup (to fit dies to press machine) for next product is begun. ST3 went on to explain, *"..., when the previous process has stopped, uchi dandori for next dies is done. Dies for previous product are detached from the machine, and then are removed through the back door. By using a crane, it is conveyed to dies store. Then, dies for next product are placed into the machine through the front door. This machines used ADC (automatic dies change) technology. When uchi dandori is done, a button is pressed with a one-touch system to provide information to the machine that dies number X has been placed in the press machine. Then, parameters for dies number X are automatically set, and setup process is finished."* Based on observations made by the author, external setup is done while production for previous product is still running.

In the context of stamping plant, the issue is not how to eliminate setup process, but how to shorten it. For this purpose, Toyota has been applying the principle of SMED (single minutes of exchange of dies) as described in Section 2.4.5. With this principle, internal setup must be done in a very short time. So that, most of the internal setups should be converted to external setup. In other words, most of the setup processes should be done outside the machine. Therefore, improvement is a must. This is in line with the statement from ST1, *"Last time; preparations were mostly done inside the machine (i.e., internal setup), but now they are mostly done outside (i.e., external setup). So, setup processes that can be performed outside will be done outside."* ST3 explained in detail, *"It is closely related to motion study. We have the standardized work documents for each setup process. With the standardized work, we observe all setup activities, we evaluate, and we identify all muda (non-value added activities), mura* *(unevenness), and muri (overburden). Based on the evaluation, we know what activities that can be improved, simplified, removed, and so on. We strive to the concept that most of the uchi dandori activities must be converted to soto dandori. So that, most of the machine setup activities are done externally."*

In the stamping plant, production is currently done in a large lot size. Still, efforts are consistently made to reduce the lot size. ST3 said, *"... we have targeted that we can only do uchi dandori 10% of our working time. Our working time is 850 minutes per day. So, uchi dandori allowed is just 85 minutes per day. Hence, dies change process (i.e., setup) must be improved. The faster the dies change, the smaller the lot size."* Thus, it can be concluded that to reduce lot size, one of the strategies that must be done is to shorten the setup time.

6.6.1.6 Uniform Production Level

Uniform production level or as widely known in Toyota as *heijunka*, is addressed to ensure production stability by mean of reducing production variability caused by fluctuation in customer demand. The more the variability, the greater the incidence of creating waste. According to CEV6, *"TPS requires heijunka. It is not a TPS, if production is not performed by following heijunka principles."* This viewpoint was confirmed by CEV3, *"The pre-requisite of TPS implementation is heijunka. Orders, production, etc. should not fluctuate. Pull system, milk run, and so on, are unlikely to be implemented smoothly without heijunka. So, customer order, supplies from suppliers, production process, and delivery to customers, all must be heijunka."* Both of the above opinions were strengthened by CEV1 as follows, *"In the JIT system; production should be stable, and there must be a high capability. If line stops are still* *frequent, or order is still fluctuating, then JIT could not be applied properly. If supply from suppliers has no problem, can be smooth, and supply chain is good; JIT can be applied smoothly."* Hence, it seems that, *heijunka* is a truly critical factor to create a lean system because it is a key of achieving production stability.

Toyota manages its production system by leveling and smoothing production by volume and product type to guard against variability of demand. Toyota applied *heijunka* with a mixed model production system. According to VA3, *"Here, we implement heijunka. Wherein the composition of product being produced is arranged based on the composition of orders. Mixed model production is carried out; with the sequence such as Etios-Yaris-Yaris-Vios-Etios-Yaris-Yaris-Vios; and so forth... We are not going to produce all Yaris first, followed by all Vios, and all Etios at the same time. Heijunka considers all existing variants, including model, type, and so on."* Due to Toyota implement a pull system, in which production is driven by customer order; by applying *heijunka*, all the variances (such as styles, color, tires, and other options) must be taken into account.

Heijunka ensures the production runs stably with uniform workload from time to time. EP3 states, *"JIT can be executed, if production runs smoothly. This means; JIT system requires a stable production."* This is similar to what presented by VA1, *"The goal is to make processes from the beginning to the end run smooth, and to equalize workloads. It is associated to production in small lot size. Unless, if we produce only one model, we do not need to apply heijunka. However, if we produce various models and variants, heijunka is a must. In terms of process, Fortuner and Innova should be heijunka. Workload of making Fortuner is greater than Innova. If Fortuner continuously produced, of course, workers will be busy with high workloads. Hence, it* *must be heijunka."* Through *heijunka*, workload for each workstation becomes uniform. This is important to keep production runs smoothly. It was highlighted by CEV5 as follows, *"Without heijunka, there is a possibility of one process will delay. Let's say, we have five processes, if one is not heijunka, it is possible that one workstation will be delaying or waiting; that may cause muda."*

For works that are performed on a conveyor, uniformity of workload is done by considering takt time. In other words, if takt time is two minutes, means that one car should be coming out from the production line every two minutes. CEV4 explained, *"Takt time must be determined at the beginning of the process based on the customers' demand. Takt time is working time divided by quantity of customer demand."* Takt time at each workstation should be uniform to ensure production smoothing. CEV2 explained, *"It is widely used in works done on a conveyor. Thus, we need to set the same takt time for each workstation. If takt time is set for two minutes, then the jobs in all workstations in the main production line must be completed within two minutes."* CEV2 explained further, *"Takt time for each workstation should be the same. If it is different, then production will not be running smoothly. Logically, if we have ten workstations, jobs in each workstation should be finished within two minutes. If production in workstation A is faster than workstation B, then there will be a build-up of WIPs between the two workstations. If the process in workstation A is longer than B, then workstation B will be waiting/delay/idle."* To equate takt time, it is necessary to improve the production line by way of leveling workload in all workstations. EP3 and VA1 conveyed the similar opinion. As an example, VA1 stated, *"..., workstations with longer takt time; some of its activities should be moved to workstations with shorter takt time. So that, takt times in all workstations are the same."* Hence, line balancing is performed by equalizing workloads at each workstation.

According to CEV7, *heijunka* is useful in eliminating *muda* (non-value added activities), *mura* (unevenness), and *muri* (overburden). He stated, *"Ideally, production workload should be uniform. It is not preferable if the workload is high in one day, whereas in the other days is lower. If a job should be completed within three days, but it is completed within one day, then there is no job in the second and third days. Both are muda. When the job is completed within one day, a lot of stock must be maintained. Likewise, when the workload is lower than it should be, idle time will be higher."*

With regards to inventory, VA1 stated as follows, *"If heijunka is applied, inventory can be minimized, even no inventory... If production is done in large lot size without heijunka, there will be a build-up of parts and materials along the production line. However, if mixed model production with heijunka is applied, parts for Fortuner are kept only one box, parts for Innova are also one box, so its turnover will be faster and inventory is minimized..."* CEV6 conveyed the similar opinion. He stated that when *heijunka* is not applied, then it may cause accumulation of stock for one model, whereas the other models are precisely stock out. A good example was presented by CEV6, production that is not performed with *heijunka* is similar to the case of *TransJakarta* buses that operate without a definite schedule. He stated, *"As with TransJakarta buses. Its departure and arrival were not heijunka and without a definite schedule. Thus, resulting in accumulation of passengers at bus stops at one time, and at other times, there are no passengers. There are crowded buses and there are empty buses. If it is empty, costs may be higher. If it is crowded, buses may be damaged."*

Given the importance of *heijunka*, it must be implemented starting from collecting orders from customers. Uniformity of customer demand is called *heikinka*. In essence, *heikinka* is important because demand rate fluctuation may create *'peaks* *and valleys'* of production that possibly causes waste. VA1 stated, *"Period of our production is monthly and daily. From month to month, fluctuations of demand and production are avoided."* Furthermore, CEV7 explained, *"We have to maintain heikinka. So that, workloads can be maintained at the same level every day. By applying heikinka, heijunka can be applied successfully, and stock can be minimized."* So, performing *heijunka* should be preceded by equity of demand rates.

To be successful in leveling production, Toyota equalizes not only its production volume but also its product types. Demand rate for all the product variances is used as main input for production planning with *heijunka* system. VA1 explained, *"…, monthly production must be planned in accordance with heijunka. The monthly production is broken down into daily, also with heijunka. Everyday, what kind of cars being produced are also planned by considering principles of heijunka."* Accordingly, the ratio of daily production volume should equal to the ratio of monthly production. VA1 pointed out, *"For example, this month; Innova is ordered 500 units, and Fortuner 200 units. Thus, the order ratio is 5:2. Daily production ratio should also be 5:2. Then, production sequence will be arranged as three Innova, one Fortuner, two Innova, one Fortuner, and so forth."* CEV7 also provided examples as follows, *"Production is done evenly for each type of product. It is carried out in accordance with the demand ratio. For example, if the demand ratio for X, Y, and Z is 3:2:1, then production sequence may be X-Y-X-Y-X-Z and so forth."*

In summary, it seems that a lean manufacturing can be applied successfully when the load-smoothing system takes place. Without it, lean manufacturing may fail. In a nutshell, uniform production level is pre-requisite for a lean manufacturing system.

6.6.1.7 Quality Control

A lean manufacturing system ensures quality at the earliest stage of a production process. It is important to warrant that products being passed to the subsequent workstation is high in quality, no defect, no reject, and conforms with the required specification. CEV9 explained, *"In terms of quality, we strive to ensure that each process does not receive, process and dispatch any defect to subsequent process. So, there is an imperative role of quality control starting from suppliers up to vanning process. In every single process, from receiving up to vanning, quality must be strictly controlled. Each process should ensure that no defective items are processed and delivered to subsequent process."* Thus, by implementing the quality control, complaints from customers are eliminated, as stated by CEV9 as follows, *"the role of quality control in each process is to ensure that there is no complaint from customers, not only internal customers, but also external customers."*

To ensure the achievement of its quality standards, Toyota applies *jidoka*. CEV4 explained, *"There are two pillars of TPS, namely JIT and jidoka"*. CEV7 explicated the purposes of *jidoka* application as follows, *"The first goal of jidoka is to create a product with 100% good quality. Second, to prevent damage to the machines. The third is man power saving; quality control activities should not be performed by occupying man power."* Philosophy of *jidoka* was originated from the idea of weaving machines invented by Sakichi Toyoda (the founder of Toyota); every time the thread broke, then the machine was automatically stopped. This principle was taken by Toyoda into TPS. CEV6 explained, *"Jidoka, derived from Jidou (automatic) and Ka (tool). So, jidoka is an automated mechanism that in cases of abnormality happens, the machines will automatically stop."*

The results of field observations performed by the author indicated that the machine (or production process) stopping mechanism depends upon the type of job. There are two ways to stop the production lines when abnormality occurs, namely by means of automatic devices and by relying on human judgement. If the job is done by machine; once an abnormality occurs (such as defect, wrong parts supply, etc.), then the machine will automatically stop without any trigger from operators. VA2 mentioned as follows, *"When a Fortuner is produced, all entities in the production line (i.e., hanger, robots, etc.) will fit with Fortuner; each line will prepare itself to be ready to process the Fortuner. If a component/part does not fit Fortuner, then the production line will stop."* At the production processes that use machines (such as pressing process in the stamping plant, or machining process in the engine production plant), *jidoka* is very useful, especially to avoid producing defective products in large quantities. This was stated by ST2 as follows, *"When a problem occurs, such as product defect, the process must be first stopped to avoid producing defects in large quantities."* CEV7 also explained, *"For example, if a tool is broken, the machine will automatically stop. If the machine is still in operation, of course, it possibly causes producing a large number of defects. This may also cause machines damage."*

For most of the manual operations activities, when an abnormality occurs, operators will stop production line based on their own judgment by applying a switch button available at each workstation. Once the switch is applied, the process will automatically stop. Thus, in cases of abnormality happens, operators are given a full authority to stop the production process. Termination of the process by the operator was confirmed by VA3. He detailed, *"In cases of abnormality, operators perform S-C-W (stop, call, wait). First, the process will be stopped. As we know, operators have full authority to stop production in cases of abnormality."* CEV2 detailed the meaning of

S-C-W as follows, *"S-C-W refers to an operators' responsibility to "stop" a process when abnormality occurs, "call" for requesting supports from the group leader, and "wait" for the support to arrive before proceeding."* This is where the concept of autonomation with the human touch comes into play.

To support *jidoka*, Toyota uses *andon* and call light. *Andon* is an indicator board that shows that a worker has stopped the production line due to an abnormal occurrence. Call light is used to call for various parties concerned to handle major problems. CEV7 added, *"If an abnormality occurs, andon will display location of the problem. Call light is then used to call group leader, section head, or supervisor."* Observation done by the author showed that *andon* has different colored light to indicate the condition of the production line. Green light indicates normal operations. Yellow light indicates a worker in a particular workstation is calling for help because of an abnormality. The yellow light will be lit once yellow button is applied by an operator. If trouble cannot be handled, a red light will come to show that production line has stopped. The red light is on when the red button is applied.

Usually, when an abnormality occurs, operator can easily identify its source, and corrective actions can be taken immediately. ST3 explained, *"When a machine is stopped, its operator will check the source of the problem. If it can be resolved by the operator, he/she will independently resolve it. If a major problem happened, the operator will call maintenance technician."* He went on to explain as follows, *"We can check it easily. At which process an abnormality occurred can be identified immediately. For example, when workstation X received a defective item from workstation Y, then operator X will stop production and will report to group leader.*

Furthermore, if there is a hole that is unsuccessfully drilled found in workstation X, we can directly identify that the hole was resulted from workstation Y."

To support *jidoka*, Toyota also applies *pokayoke* (Japanese, means mistake proofing). *Pokayoke* is a mechanism that helps an equipment, machines or operators to avoid *(yokeru)* mistakes *(poka)*. With *pokayoke*, product defects can be eliminated by preventing, correcting, or drawing attention to human errors as they occur. CEV5 explained, *"For example, this door handle. It is for the left door, of course; it does not fit with the right door. This is the application of pokayoke."* Together with *pokayoke*, Toyota also implements *Go/NoGo* system, which is a testing mechanism using two boundary conditions; pass and fail. The test is passed only when the *Go* condition is met, and the *NoGo* condition fails. CEV9 explained, *"Go/NoGo mechanism is actually the same as the principle of pokayoke to avoid errors from occurring."*

In addition to *jidoka*, for quality control purposes, Toyota also applies the built-in quality systems, in which each production worker is responsible for all the jobs he/she does, and must ascertain the quality for each operation done. Built-in quality is essential because receiving, producing, and forwarding the defective products mean investing resources (e.g., materials, equipment, and labors) in something that cannot be sold. Therefore, those who are engaged in a manufacturing process are totally responsible for full quality assurance. Here is an explanation from CEV4 about built-in quality, *"At Toyota, all the operators perform according to the built-in quality principle. With this principle, we do not receive defects, do not produce defects, and do not pass defects to subsequent workstation... It is guaranteed by suppliers or previous workstations. In my workstation, I must perform my jobs based on the standards prescribed. So, I guarantee* *that products resulted from my workstation are in good quality. Then, I forward good quality of product to the next workstation. This is called as the built-in quality system."*

Likewise, in conjunction with customers, Toyota considers the subsequent process as customer and does not allow any products that do not meet specifications requested by the customer. CEV4 explained further, *"Delivery of products to customers must comply with specifications requested, in the right quantity, and no defects. All are guaranteed through the built-in quality system."* Thus, built-in quality requires a self-inspection from each operator before the product is delivered to subsequent workstation. If an abnormality happens, then *jidoka* will be applied, as described by EP3, *"We also perform a built-in quality system, in which operators themselves perform a quality checking... If defects are identified, we use andon, production line may be stopped."* By implementing built-in quality, defective products will never reach the subsequent process. In short, production workers must do everything right the first time.

In some plants where large lot production takes place, statistical quality control is practiced. It was observed in stamping plant. At high speed automatic punch press, where 200 units are kept in the chute, only the first and the last units are inspected. If both are good, all products within that batch are considered good. If the last unit is defective, a search should be performed to find the first defective unit. All defects are removed, and corrective action is taken. In stamping plant, no lot will escape from inspection. The punch press is set to stop automatically at the end of each lot.

Because inspection is a non-value added activity and possibly causes longer lead time, it must be simplified. Thus, total checking of the products is not necessary. ST2 explained as follows, *"Quality checking was done randomly with a sampling* *procedure, albeit some products may require total checking. The quality checking is done visually at a certain key point. And of course, it requires a special skill. Inspectors have undergone a special training to perform quality inspection."* In addition, inspection is carried out according to the standard described on standard operating procedure (SOP) containing a detailed explanation of inspection activities that must be performed for every product made. ST3 explained, *"We have SOP issued by quality engineering. Key points that must be checked, how to check, and tools used for inspection, all are described in the SOP. If we observe any new problems, the SOP will be updated if necessary. For example, there are ten key points for item A, when a new problem is observed, a new key point may be added. If there is no problem for certain key points, then the SOP will be updated by discarding that key point."*

Besides *jidoka* and built-in quality, to support quality control mechanism, Toyota also uses visual control boards to describe current condition of a particular production line. Basically, it is used to evaluate and improve production processes. This was explained by CEV2 as follows, *"Visualization is very important. In all the lines, we have visual control boards. From here, everyone may know current condition of this line looks like. It serves as a tool for management to evaluate current conditions of a production line... With the boards, we know the occurrence of abnormality within a certain period."*

6.6.1.8 Total Productive Maintenance

Maintenance system is addressed to support and sustain a lean manufacturing system, because availability and efficient use of machines and equipment are pre-requisite of lean manufacturing implementation. Thus, maintenance activities should be performed to ensure that all machines and equipment are in a state of readiness to perform all the production processes. This was conveyed by EP1, *"To support TPS; TPM is required."* EP2 expounded, *"One of the foundations of TPS is TPM. Because, if TPM is not well performed, machines' breakdown may frequently occur. Consequently, we cannot produce and are not able to supply products to customers. As a result, TPS itself will be disrupted... How to implement JIT, while machines and equipment have a lot of interference. Impossible..."*

As stated by EP1 and EP2, key activity of TPM is machine maintenance, consisting of predictive maintenance, preventive maintenance, and breakdown maintenance (repair). Through predictive maintenance, status of machines and equipment is clearly ensured before a breakdown occurs. Various tools, such as thermal imaging, vibration analysis, and so on, are used to predict when a breakdown may occur. With data and information collected from predictive maintenance; preventive maintenance can be accomplished before a breakdown. Predictive maintenance is usually performed not only by maintenance technicians but also involving production workers. EP3 explained, *"In a predictive maintenance, there are activities that should be carried out together with production workers. Regularly, we jointly review work improvements, shop floor condition and others that require production and maintenance technicians to work together."*

Predictive maintenance is a complement of preventive maintenance. Preventive maintenance, as explained by EP2, is defined as maintenance activities that regularly executed on machines or equipment to diminish the possibility of its failing. It is done while machines and equipment are still working. Besides predictive maintenance and preventive maintenance, Toyota also rarely performs breakdown maintenance, which is done when machines or equipment are broken down. However, according to EP3, most of the maintenance activities done in Toyota are preventive maintenance. To perform it effectively, Toyota Indonesia divides the activities into two categories. The first category is activities that must be performed by production workers, and the second category is activities that should be carried out by maintenance technicians. Activities in the first category are accomplished through ownership maintenance (autonomous maintenance), which is limited only for maintenance activities using human senses. While activities that require special skills and tools must be performed by maintenance technicians. This classification was elaborated by EP3 and EP4. As an example, EP3 stated, *"There are maintenance activities that cannot be done by production operators. For example, activities that require special skills and tools. These are all done by maintenance technicians. However, activities that can be done with human senses without special skills and tools, must be done through ownership maintenance."*

Ownership maintenance (or autonomous maintenance) is defined as maintenance activities that are conducted by the operator of machines and equipment rather than dedicating maintenance technicians. EP4 provided a hint as follows, *"We implement an ownership maintenance (jishu hozen in Japanese). This is my area; I have five machines; I am somehow responsible for these machines."* EP3 described the principle of ownership maintenance just like a driver taking care of his/her car. He stated, *"The concept is like taking care of our own car. We must regularly check engine oil, brake fluid and others. Everyday, we clean the car after used. We use it everyday; we should know precisely how it is. If, for example, the sound is turned into a loud and noisy, we know better, instead of mechanics at the car workshop. However, when there is a remarkable thing, mechanics must be called to check and repair."* Thus, it can be stated that daily maintenance performed by production operators may avoid machines and equipment from severe damage and termination of the production process.

Toyota endeavors that maintenance activities, especially ownership maintenance, can be carried out by any production workers. So that, maintenance activities undertaken by Toyota must have a set of complete guidelines. Among the guidelines are maintenance ledger, job instruction sheet, and maintenance kanban.

Toyota Indonesia performs its maintenance activities based on a maintenance ledger that provides information about machines and equipment, maintenance period, and others. EP2 explained, *"Preventive maintenance is to make a system better. We conduct periodic maintenance based on a maintenance ledger containing detailed information about machine itself and its checking period. The period depends upon the type of machines and equipment. It also depends on type of spare part used within the machines and equipment. For example, for machine A, its bolt and nut are checked every 12 months, and so forth."* Hence, Toyota Indonesia documented all the required information for maintenance activities, as well as definite maintenance schedule for all machines and equipment. ST3 described, *"We have detail information related to all maintenance activities, as well as its schedule from daily to yearly, from daily checking activities to overhaul."*

In addition to the maintenance ledger, Toyota has a complete job instruction sheet for all maintenance activities. EP2 stated, *"There should be a job instruction sheet. For example, if we want to check a bolt, when and how to check it, there should be its job instructions. So, even new operators can do the same."* The job instruction sheet explains manual for each job in detail. Thus, the job can be done by any production worker. EP3 explained, *"We should have a manual for each job in detail. There must be guidance, how to do this job, how to change gear oil, engine oil, and so forth; all steps and procedures must be there. Hence, we created a system, if an operator is absent, others can do the same job without any risk. Consequently, the system may guarantee production sustainability."*

Equally important is maintenance kanban, which is used to instruct routine maintenance activities. In other words, it contains maintenance work instructions, as described by EP3 as follows, *"We have maintenance kanban for each machine. It provides information about items that require checking for all machines and equipment. At the beginning of every month, all kanbans are distributed to machines' operators. Based on this kanban, operators check the machine. Once completed, kanban will be placed into kanban's pigeonholes awaiting for next inspection as scheduled in kanban."* If any abnormality is detected, operator should report the problem together with possible corrective actions that have been or should be taken. EP3 went on to explain, *"If the sign of abnormality observed, it is reported by filling TPM findings' form. Problem and its corrective actions are written. Problems that can be solely resolved by the operator should be overcome by him/her; whereas problems that require maintenance technicians to fix, it will be scheduled."*

To ensure that TPM is properly performed, Toyota periodically conducts an assessment for maintenance activities that are carried out in a plant. Through this assessment, performance of maintenance activities is categorized into three levels, namely bronze, silver, and gold. EP2 explained that bronze level is awarded when the maintenance system has existed, but has not run properly. Once the bronze level is gained, the plant is subsequently prepared to obtain the silver level. Silver level is conferred when the maintenance system has been running well, all items in the maintenance ledger have been totally done, and significant improvements due to maintenance activities have been realized. Whereas, gold level is granted when real advantages from maintenance activities have been achieved. The real advantage is the absence of production disruptions caused by unavailability of machines and equipment.

6.6.1.9 Supplier Networks

Supplier support is critical to the success of lean manufacturing implementation. EP4 stated, *"If suppliers fall down, then we will surely fall down as well."* Therefore, a lean manufacturer needs suppliers who are capable on serving the needs of the company. The success of supplier networks' implementation is one of the pre-requisites to the success of a lean manufacturing system as a whole. CEV1 stated that JIT production system can be applied totally when supplies of parts and materials from suppliers are running smoothly. To ensure this, Toyota established long-term and mutually supportive nature of relationship with suppliers, performed suppliers' development programs, and synchronized its internal production schedule with the delivery schedule from suppliers.

Relationships between Toyota and suppliers are mutually beneficial cooperative. CEV1 revealed, *"Toyota will not be successful, if suppliers are not invited to work together... Toyota and suppliers are like family... We are bound in a long-term relationship. If they have a problem, we support them, and the problem is solved jointly… Toyota visits and observes their problem, and it will be resolved together."* The same idea was conveyed by EP2, stating that contracts between Toyota and suppliers are long-term; even as long as Toyota is still in operations. Cooperation will certainly go well when the two parties (i.e., Toyota and suppliers) are bound to an agreement. The main agreement is that all suppliers must comply with all rules set by Toyota. CEV1 explained, *"As long as suppliers can follow the rules of the game established by Toyota... For example, they must be able to provide products that meet Toyota standards and requirements, then cooperation will continue."* Thus, according to CEV1, each supplier should adapt the Toyota rules in doing business.

In addition to the long-term cooperation, Toyota also conducted supplier development programs. This is important because supply of parts and materials is suppliers dependent. According to CEV3, although TPS has been nicely applied at Toyota, but if it is not supported by a good supplier, then the possibility of line stop will be high. CEV4 stated, *"It must be done. To support our process, suppliers should be well developed... Suppliers must be trained. So that, they follow rules of the game set by Toyota."* With these development programs, it is expected that Toyota and suppliers move forward together as emphasized by CEV8, *"Suppliers are invited jointly to move forward, in order to be able to support Toyota."* CEV8 and CEV3 stated that supplier development in Toyota Indonesia is done under coordination of a division called Operations and Management Development Division (OMDD).

According to CEV3 and CEV9, many aspects within the suppliers that must be developed, ranging from production systems, internal production processes, logistics, and performance aspects (such as safety, quality, productivity, delivery, and so on). Even, human resource and purchasing divisions are involved in development processes. To undertake supplier development, routine assessment on suppliers' performance is indispensable. According to CEV9, this assessment is usually undertaken by OMDD, purchasing division, and other divisions that deal directly with suppliers. Development must be carried out for all suppliers. CEV4 stated, *"... development is undertaken not only for new suppliers, but also for existing suppliers."*

In terms of the production system, according to CEV1 and VA1, all suppliers should implement TPS in their company. It was similarly explained by CEV8 as follows, *"We have TPS. We also encourage suppliers to implement it. We usually send our people to supplier sites to develop them. There, their workers were recruited and trained to ensure that TPS is implemented correctly... So, TPS is not only implemented at Toyota, but suppliers must do so. However, it depends on suppliers, whether they apply it totally or not."* CEV8 explained that the most obvious is implementation of the pull system with kanban. He stated, *"Kanban is not unusual for Toyota, but some suppliers are not necessarily familiar with it. In the past, the most important thing for suppliers is that they can supply products to Toyota. They did not care about maintaining a lot of stock. Sometimes, poor quality of product is not a matter for them. By implementing TPS, stock is eliminated, but with the guarantee that they must be able, all the times, to provide parts and materials needed by Toyota. This is what we maintained; suppliers can support us without maintaining a lot of stock. Now, all suppliers are vying to reduce stock."*

For the suppliers' development purpose, some employees of Toyota Indonesia (usually manager or general manager) were deliberately placed in supplier companies. This was done to ensure a common mindset between Toyota and its suppliers. It was explained by CEV3 as follows, *"We placed our workers to supplier companies. Some of the managers or general managers are assigned to work at supplier companies as a director or other important positions. So, it is hoped that Toyota and suppliers are having the same mindset."*

One of the purposes of supplier network is to ensure that suppliers are able to deliver their products as promised, just as it is needed, in the right quantity, at the right time, and at the right place. This is consistent with the statement from EP4, *"delivery from suppliers must be in a JIT basis."* This can be realized through synchronization between Toyota production schedule and delivery schedule of parts and materials from suppliers. CEV5 described as follows, *"In CEV, we arranged schedule of shipment to customers, as well as schedule for vanning, stacking, boxing, quality check, and ordering to suppliers. All are scheduled down to the detail of time. This schedule is then communicated to suppliers. Suppliers will arrange their own schedule. So that, the schedules are synchronized."* Regularly, according to CEV5, Toyota held meetings with suppliers to notify its production schedule. Based on the schedule, suppliers arrange their own production and delivery, matching with the requirement of Toyota. Thus, as Toyota is applying milk run delivery system, in which the goods are collected by logistic partner; suppliers should prepare their products on time. This is important because Toyota needs on-time delivery. CEV9 stated, *"..., we give 10 minutes allowance for trucks of logistics partner to stand by here. Suppliers and logistics partner must follow the delivery schedule. For example, based on the schedule, they should deliver their product at 7 pm, then they should not come at 6 pm or 8 pm. They supposed to come only 10 minutes before the schedule. Currently, we have an optimal delivery system; all suppliers and logistic partner are on-time."*

JIT also requires that delivery must be made to the right place at where the parts and materials are required. EP2 explained, *"... the system is suppliers deliver their products to the point where it is required."* Related to this, besides milk run delivery, Toyota Indonesia is currently applying two other systems, namely *jumbiki* and *jundate*.

In short, *jumbiki* is defined as pick in order of use. In other words, *jumbiki* is a delivery system that uses a fax order system according to *heijunka* patterns or products sequence passing through the main production line. By applying *jumbiki*, parts are directly sent to the main line with the prior preparation of the sequence by suppliers according to the vehicle to be assembled in the Toyota's production line. With this system, suppliers deliver parts based on production sequence in which they are going to be used. This was explained by VA1 as follows, *"Once the vehicle main body enters production line; we immediately sent a fax to suppliers. The suppliers will prepare parts and materials based on sequence of production in main line. Arrivals of parts and materials are in line with sequence of the main body processed in the production line."* *Jumbiki* system adopted the principle of *"keiretsu"*, in which suppliers and Toyota are at a nearby location. CEV9 explained, *"The basic idea of supplier networks is keiretsu. At Toyota of Japan, we have a Toyota city. Suppliers and Toyota are located in the city. So, distance between suppliers and Toyota is very close. Thus, they can apply jumbiki perfectly; delivery of parts by suppliers follows the sequence of assembly-line production."* In addition, CEV9 said that *jumbiki* could work well when delivery lead time from suppliers is quicker or at least equal to the speed of production along the assembly line. Hence, close proximity with suppliers and their delivery reliability are pre-requisites for the attainment of *jumbiki*.

Through the implementation of *jumbiki*, inventory can be reduced up to the lowest level, not only in Toyota but also in supplier companies. Hence, this synchronized system eliminates waste of inventory and space requirement. CEV9 explained, *"Actually, this brings advantage not only for Toyota but also for suppliers. When jumbiki was not applied, Toyota and suppliers should maintain parts (such as seat and tire) as inventory in a large quantity. However, due to the implementation of* *jumbiki, production at suppliers' plant can be done by following sequence of the assembly process at Toyota. It really helps suppliers to eliminate inventory."* Thus, there is no cost incurred because of accumulation of inventory. According to CEV9, *jumbiki* is widely applied for large parts (such as tire, seat, etc.), unique items (uncommon parts), and parts with low delivery costs.

Besides *jumbiki*, Toyota Indonesia also applied *jundate* system. Unlike *jumbiki*, whereby suppliers directly deliver parts or materials to the main line in line with production sequence; with *jundate* system, suppliers do not deliver parts directly to main line. The parts must be prepared in sub line to combine a number of parts into a set form. It is frequently applied for large-volume parts that cannot be delivered in its original packaging to the main line, or parts containing a lot of components. VA1 explained, *"In vehicle assembly plant, we apply jundate system, whereby parts come indirectly to main line, but must be combined in advance in sub line. Because, if all parts directly delivered to main line, it requires large space for inventory. By applying jundate, delivery to main line is done in a set form. Thus, installation to the main vehicle body can be performed quickly; lead time may be reduced."*

As explained by CEV2, through *jundate* system, parts are prepared in a sub line by combining multiple components into a set form before its installation to the main vehicle body. CEV9 provided an example, *"An example is an axle that connects left and right tires. The main components of the axle and its supporting components are provided by different suppliers. If all parts are directly installed on the car, it is difficult and takes a long time. Therefore, the parts must be prepared in a sub line. In addition, in Indonesia, there is an only single supplier who provides the axle, it monopolized the market. So that, when the supplier was requested to provide axle together with its* *supporting components, the supplier refused. Inevitably, Toyota must prepare the axle in a sub line. When preparation is finished, components that have been combined are taken to main line to be assembled to its main body."* The same was done for tire and rim. As explained by VA1, the tire and rim are provided by different suppliers; both must be combined (or prepared) in sub line before they are assembled to the main body.

Besides very useful for minimizing inventory, *jundate* system is also beneficial to shorten production lead time, as described by CEV4 as follows, *"For example, before jundate system was applied, all the components of the instrument panel (or dashboard) were installed one by one to the main body at main line. Now, not anymore. All parts are prepared and installed beforehand in a sub line. Thus, production lead time becomes shorter, because manufacturing lead time is the time required for the production in the main line. Previously, there were so many jobs done in the main line. Now, many are prepared in sub line to shorten the processing time in the main line."* Thus, preparing the parts in the sub line, before the parts are assembled to the main vehicle body, may expedite the process done in the main line.

Typically, processing time in the sub lines is longer than takt time in the main line. Thus, to maintain the production runs smoothly, a number of WIP should be maintained to ensure that no disruption due to lack of part supply from the sub line. WIP must be within the pre-determined minimum and maximum quantity levels. CEV2 explained, *"For example, to assemble all components of transmission may take 10 minutes. Whereas, takt time in the main line is only 2.5 minutes. Thus, we need to consider WIPs to ensure that the process in the main line continues to run. So that, production in the main line is not an obstacle. However, the stock should be maintained at the pre-determined minimum and maximum levels. If it does not, due to takt time in* *sub line is longer, production disruptions may occur in the main line because of late part supply from sub line."*

In addition, competition among suppliers is also encouraged by Toyota. Annual assessment to suppliers' performance is performed. Annually, Toyota Indonesia provides award for outstanding performance suppliers. According to CEV9, orders given to suppliers considers their performance. The better the performance of suppliers, the more the orders allocated to them. CEV9 explained, *"Usually, a good supplier will be given a lot of orders. So that, suppliers themselves are also competing. Similarly, Toyota affiliation companies worldwide, are also competing, and our parent company (i.e., TMC) allocates orders to affiliated companies based on their performance."*

Based on the above elaboration, the main objective of the supplier networks is to ensure that deliveries from suppliers are done in the JIT basis. For this purpose, several activities and strategies have done in Toyota Indonesia, namely long-term relationship with suppliers, mutually supportive nature of the relationship between Toyota and suppliers, supplier development programs, synchronize production and delivery from suppliers, *jumbiki* and *jundate* systems, and competition among suppliers. These activities support Toyota Indonesia to perform its production smoothly without any interruptions caused by lack of part supply.

6.6.2 Interdependency among Lean Manufacturing Practices

Lean manufacturing is applied in a holistic manner in Toyota, meaning that all the practices of lean manufacturing are applied simultaneously. CEV9 confirmed, *"TPS has been implemented holistically in Toyota."* The interview with CEV1 and CEV5 indicated the obligation to implement all the practices concurrently. CEV1 said, *"..., by implementing TPS holistically and simultaneously, zero stock can be realized. Zero stocks are a must. If we are still having the stock, we will be questioned why. TMC performs audits regularly."* CEV5 supported this idea. He stated, *"When TPS had not been fully implemented, we have a lot of stock of materials, WIPs and finished goods. We required large space. Once the stock was sold, we requested the plant to fill new stocks."* This was happened at the earlier stage of establishment of Toyota in Indonesia. VA1 judged that having a large number of stocks at the early stage of establishment of a plant is reasonable. VA1 explained, *"..., because the scenario of establishment of a factory at the initial stage is, build the plant, and start to operate. However, after production volume increased, improvement was done consistently, now TPS has been implemented holistically at all the Toyota plants."* CEV1 explained, *"Actually, TPS had been implemented from the early stage of establishment of Toyota Indonesia, but it was not fully as it is today. At that time, our production volume is still low."* These imply that TPS was implemented gradually through various improvements, as stated by CEV9, *"We implemented TPS in Toyota gradually."*

CEV1 explained the reason behind holistic implementation of lean manufacturing practices as follows, *"... because all the practices are supporting each other, with one ultimate goal, profit."* In line with CEV1, CEV7 conveyed that all plants are expected to adopt it holistically. According to CEV7, application of lean manufacturing cannot be done by halves, because all the practices are mutually supportive with one another. He stated, *"In its application, adoption of TPS depends on characteristics of each plant. However, we expect that all plants totally adopt the practices, because of the mutual supportive nature among the practices. We cannot apply pull system without kanban. Likewise, impossible to apply pull system in the* *absence of close relationship with suppliers. It is also difficult to produce in ideal lot size if setup takes long time."* Hence, although adoption of lean manufacturing depends on characteristics of each plant, all the practices are expected to be applied in a holistic manner in such a plant. Of course, intensity or level of the application is driven by a number of contextual factors (see Section 6.6.3). CEV1 further explained, "*It was not only implemented in production lines, but also in logistics. However, the way we implement is different*."

Based on the interviews and observations done in Toyota Indonesia, the relationships among the lean manufacturing practices are exhibited in Figure 6.5 and described as follows:

No. 1: Relationship between pull system and quick setup. Applying the pull system implies that composition and sequence of products being manufactured in a shop floor are driven by customer demand. Therefore, to apply pull system, machines' setup must be done quickly, even if possible, up to the level of zero setup. VA1 stated as follows, *"At assembly lines (i.e., vehicle and engine assembly lines), although we perform mixed model production with heijunka, no machines' setup is needed. If it is needed, it is done quickly."* In the stamping plant, setups (i.e., dies change) cannot be avoided. To support pull system, improvement was always done to expedite the setup process. ST3 told, *"The faster the dies change, the smaller the lot size."* This statement implicitly implies that the smaller the lot size, the more the variety of products that can be manufactured. In short, pull system can be applied effectively when setup is done quickly.

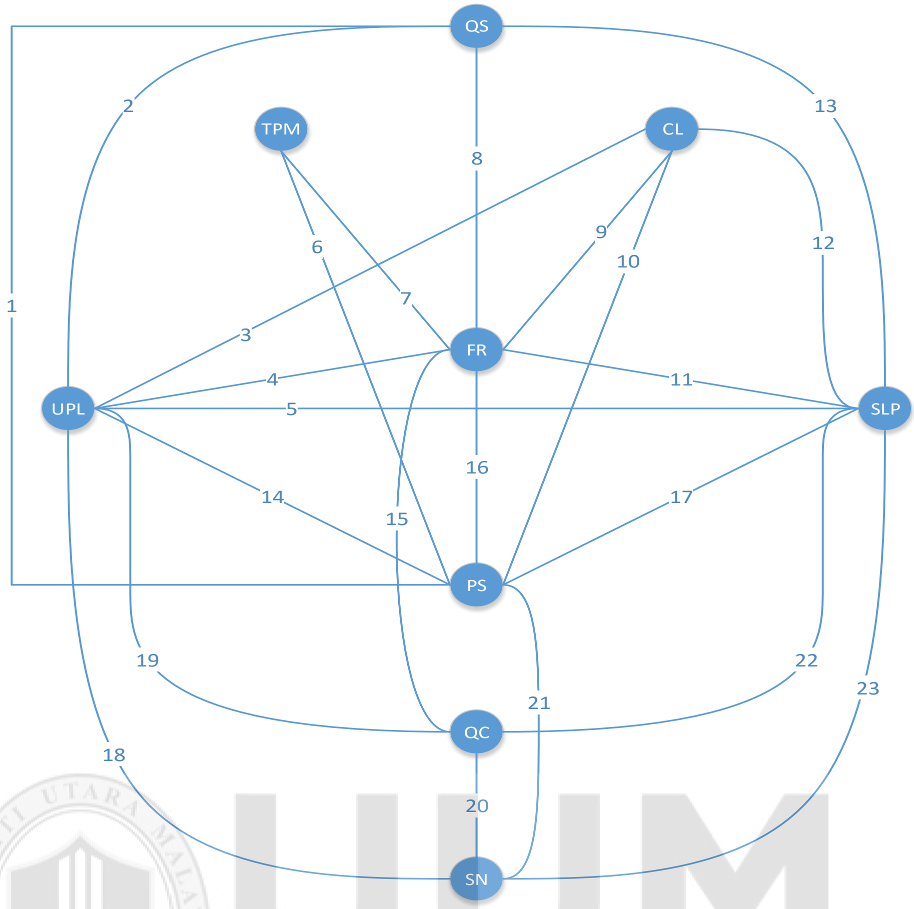

Figure 6.5
Relationships among Lean Manufacturing Practices

No. 2: Relationship between uniform production and quick setup. Toyota applies mixed model production. The sequence of product being manufactured is determined based on the composition of customer orders. VA3 said, "*Production is carried out in mixed; with the sequence such as Etios-Yaris-Yaris-Vios-Etios-Yaris-Yaris-Vios and so forth.*" Therefore, machines' setup (for each type of product being manufactured) should be done quickly, and is expected to be zero. This is important to support the smoothness of production flow without any interruption due to the long setup process. In addition, the relationship between these two practices was also highlighted by CEV4 when he was talking about the setup done in the stamping plant. He said, "*Dies for* *roof is not the same as the dies for the door, therefore, dies must be quickly changed whenever the products being manufactured are changed."* Hence, to perform mixed model production, setups must be carried out quickly.

No. 3: Relationship between uniform production and cellular layouts. Uniform production or *heijunka* suggests to determine the composition of product being manufactured based on customer demand. In addition, *heijunka* also suggests to equalize the workload between workstations. The number of machines or workstations handled by each worker should adapt the demand changes. This is called as *shojinka*, which is addressed to ensure that production is performed only by the required number of workers by considering demand volume and workload. As explained in Section 6.6.1.2, a *shojinka* is only possible when the cellular layout is applied. CEV7 stated, "…, *by shojinka, we can operate with any number of workers in accordance with production volume demanded."* In a nutshell, applying uniform production requires flexibility, and cellular layout helps to make the production line to become more flexible.

No. 4: Relationship between uniform production and flexible resources. At Toyota, there are various models of cars differentiated in various combinations of types, tires, colors, etc. Thousands variants are produced. To promote the smooth production in such a variety of products, it is necessary to have general-purpose machines and equipment as well as multi-skilled workers. These are important to support mixed model production, in which sequence of products being manufactured must follow the composition of order. This was highlighted by VA1 and CEV7. VA1 said, *"All the variants of Innova and Fortuner are produced in the same line. To get into the line; machines,* *equipment, and workers must be able to process all variants of Innova and Fortuner."* In addition, CEV7 explained, *"..., one worker handles multiple operations. Workers who work along the production line must have a great skill..."* Hence, to support mixed model production, flexible resources must be in place.

No. 5: Relationship between uniform production and small lot production. Production in a lean manufacturing system should be done in small lot size. *Heijunka* and mixed models production can be applied successfully if small lot size production is applied. Without the two practices, WIPs may be accumulated in the production line. VA1 highlighted, "*If production is done in a large lot size and without heijunka, there will be a build-up of WIPs in the production line."* In addition, uniform workloads and line balancing could be achieved when production lot size is small. VA1 explained, *"The goal is to make processes run smoothly and to equalize the workload. It is associated to production in small lot size. Unless, if we produce only one model, we do not need heijunka."*

No. 6: Relationship between pull system and TPM. Toyota produces based on customers' request (pull system). Production volume and product variants being manufactured are driven by customers' demand. As such, the machines used for production must be in a high state of readiness to produce multiple types of product. It should be supported by TPM activities. TPM ensures that production process can be performed smoothly without any interruption due to machines' failure and long breakdown maintenance. EP2 elaborated, "*..., if the TPM is not performed well, there are possibilities of machines' breakdown. Consequently, we cannot produce and are not able to supply products to* *customers."* In addition, it is important to maintain the e-kanban system to run well without any disturbance caused by malfunctions of computer networks, barcode reader, printer, and others. This malfunction can be avoided through thorough TPM activities.

No. 7: Relationship between flexible resources and TPM. Maintenance activities at Toyota are mostly done by production operators, as explained in Section 6.6.1.8. It is called as ownership maintenance. EP3 stated, *"…, machines and equipment checking that can be done with human senses, must be performed through ownership maintenance by production operators."* It was also highlighted by EP4 as follows, *"... there is also an ownership maintenance (jishu hozen in Japanese). This is my area; I have five machines; I am somehow responsible for these machines."* Therefore, to support TPM (especially ownership maintenance), the availability of multi-skilled workers is crucial. Activities of flexible resources ensure that all workers are multi-skilled and should be able to perform multiple operations, not only production processes, but also maintenance activities. In addition, TPM may also support flexibility of machines and equipment. Production line is not flexible if there are frequent interruptions caused by malfunction of machines and equipment.

No. 8: Relationship between flexible resources and quick setup. Performing machines' setup requires special skills. Qualified workers are generated through flexible resources' activities (such as training, capability mapping, job rotation, etc.). In addition, the shorter setup time is easily achieved with supports from flexible resources (workers, machines, and equipment). Hence the more flexible the manufacturing system, the shorter the setup time. VA2 and CEV9 highlighted this relationship. VA2 stated, *"There is no dandori. Because the machines and equipment used are flexible... Flexible production line must be able to cover all types of vehicle entering into the production line, without performing any setup."*

No. 9: Relationship between flexible resources and cellular layouts. Toyota prefers to arrange its production facilities into a U-shaped line. Even, at certain places, Toyota combines several U-shaped line into one integrated line as shown in Figure 6.2 and 6.3. In the integrated line, increasing or decreasing number of workers due to production volume changes *(shojinka)* becomes easy. Therefore, workers may handle multiple machines and operations. To support it, having multi-skilled workers is essential. The multi-skill is generated through flexible resources' activities. Thus, the workers are not only able to do a single production activity, but they are also able to perform some other activities. This was highlighted by CEV7, "*Typically, we shape our production line like "U". So that, on the production line, one worker handles multiple operations. Workers who work along the production line have a great skill that can handle multiple processes, can operate different types of machine…"*

No. 10: Relationship between pull system and cellular layouts. As presented in Section 6.6.1.3, pull system is a demand-driven production system. To adapt the demand changes, Toyota applies *shojinka* as previously detailed in Section 6.6.1.1 and 6.6.1.2. By applying *shojinka*, Toyota can alter (increase or decrease) the number of workers at the shop floor when customer demand has changed. This was explained by CEV7 as follows, "*…, by shojinka, we can operate with any number of workers based on production volume demanded."*

Therefore, it is necessary to have the facility layouts that are adaptable to the changes of customer demand. This adaptable layout is possible if a company implements the concept of cellular layouts.

No. 11: Relationship between small lot production and flexible resources. The concept of small lot production in Toyota is like water, production flows smoothly through factory one by one without any holdups. Applying this system means that the work is passed down to the production line one unit at a time, following the product's processing sequence. To achieve such a system, the workers must be multi-skilled, each of whom can operate several different processes. As presented in Section 6.6.1.1, the existence of multi-skilled workers is supported by flexible resources' activities. In addition, the use of flexible machines or flexible production lines is one of the key success factors of the small lot production system. The more flexible the production lines, the lot size can be reduced to a very minimum level. Furthermore, one of the indicators of flexibility is short setup time. As highlighted by ST3 as follows, *"The faster the dies change (setup), the smaller the lot size."* Thus, to reduce the lot size, one of the strategies is to increase flexibility by performing setups quickly.

No. 12: The relationship between small lot production and cellular layouts. Producing in small lot size is preferable in a lean manufacturing system, in which the products are conveyed from one workstation to another in a very small quantity. This requires the workers to be able to handle multiple processes. To make the multi-process handling possible, the concept of cellular layouts must be applied. This concept suggests that production lines should be laid out in a U-shape form. Eventually, a number of U-shape layouts should be combined.

This helps the multi-process handling to be realized. EP3 said, "*With the U-line, one operator can handle multiple jobs. So that, one worker can handle a number of workstations... With this layout, every second can be utilized. No one will be idle...*" Hence, this layout makes workers are able to handle multiple tasks to support the small lot production system.

No. 13: Relationship between small lot production and quick setup. Toyota adheres to the principle of producing in a small lot size with high frequency. This causes Toyota struggled to develop such an incredibly short setup time. By shortening setup time, Toyota could minimize its production lot size. This was observed in the stamping plant of Toyota Indonesia; when setup time is long, lot sizes tend to be larger. In contrast, the lot sizes are smaller. So, in order to realize small lot production, the setup time must be shortened, as described by ST2 as follows, *"The faster the uchi dandori, the smaller the lot size, the higher the variety of items that can be produced per day."*

No. 14: Relationship between uniform production and pull system. As earlier expounded, TPS is a demand driven production system. Customer demand drives both volume and type of products being manufactured. To maintain the production stability, principles of *heijunka* (as stated in Section 6.6.1.6) are applied. By implementing *heijunka*, Toyota manages its production system by leveling and smoothing production by volume and product type to guard against variability of demand. This was indicated by VA3 as follows, *"Here, we implement heijunka. Wherein composition of products being manufactured is arranged based on composition of orders. Production is carried out in mixed; with the sequence such as Etios-Yaris-Yaris-Vios-Etios-Yaris-Yaris-*

Vios; and so forth... Heijunka considers all existing variants, including model, type, and so on." Thus, the pull system can work well, if *heijunka* is applied.

No. 15: Relationship between flexible resources and quality control. In Toyota, machines should be able to do several functions, including quality control. Quality control at Toyota is done through *Jidoka*, in which in case of abnormality, the machines will automatically detect the problem, and the operations will stop. One of the mechanisms of stopping production lines is by means of automatic devices. This mechanism can be performed only by multi-functional machines. CEV7 said, "*For example, if a tool is broken, then the machine will automatically stop."* In addition, production workers should be able to perform production processes and to conduct quality control through built-in quality activities at the same time. This was indicated by EP3, "*We also perform a built-in quality system, in which the operators themselves also perform a quality checking..."* Thus, quality control is supported by flexible resources (in terms of machines, equipment, and production workers) that can be occupied not only for production but also for quality control.

No. 16: Relationship between flexible resources and pull system. Due to Toyota's production (both volume and type of product) is driven by customer orders, the use of flexible resources is a must. Thus, any customers' order can be absorbed. This is in line with what VA1 delivered, *"Innova and Fortuner have many variants. The machines in the line must be able to process all the variants of Innova and Fortuner."* In addition, CEV7 described, *"..., on the production line, one worker handles multiple operations. Workers who work along the line must have great skills…"* In simpler term, the more the variety of products being manufactured, the more flexible the resources required. Flexible resources' activities guarantee the availability of flexible workers, machines, and equipment.

No. 17: Relationship between small lot production and pull system. The basic idea of the pull system is to produce only when requested, move to where it is needed just as it is needed. One of the objectives of the pull system is to minimize inventory. Inventory minimization can be realized when the production is done in a small lot size. CEV3 believed, "*..., if the production is done in large quantities per lot, then inventory and space requirement may increase. If lot sizes are turned down, space requirement can be minimized. Thus, the smaller the lot size, the inventory can be reduced to a very minimum level*." In addition, under large lot production, pull system will not make any sense because it will neither shorten the production lead time nor reduce the inventory level. This is why the pull system should only be applied for small lot production.

No. 18: Relationship between uniform production and supplier networks. By applying uniform production, all types of product are mixed throughout the day in very small quantities. Thus, to support the mixed model production, parts and materials should be provided by suppliers on a JIT basis. This is consistent with the statement from EP4, *"delivery from suppliers should be done in a JIT basis."* This is possible when synchronization between Toyota production schedule and delivery from suppliers is realized. VA1 said, "*Once a vehicle main body enters the production line; we immediately sent a fax to suppliers. The suppliers will prepare the parts and materials based on sequence of production in our main line. Arrivals of parts and materials are also in line* *with sequence of the main body processed in our production line."* Hence, uniform production can be carried out perfectly when deliveries from suppliers are done in a JIT basis.

No. 19: Relationship between uniform production and quality control. As mixed model sequencing production is applied as part of implementation of uniform production, sound quality control activities must take place. The sound quality control activities through *jidoka* and built-in quality guarantee the quality from the earliest stage of the production process. Thus, only high quality of product can be received from previous workstation, produced, and conveyed to the subsequent workstation. This is in line with what explained by CEV9, *"In terms of quality; we strive to ensure that each process does not receive defect, process defect, and dispatch defect to the subsequent process."* Therefore, quality control supports the smooth production flow addressed by uniform production. Without a sound quality control, there may be a high possibility of frequent process interruption in the production lines.

No. 20: Relationship between supplier networks and quality control. One of the basic principles of Toyota's quality control is not receiving any defects, either from suppliers or from previous workstation. Implementation of supplier networks through the supplier development program ensures that suppliers only supply good quality of products. CEV3 elaborated, *"Our quality department also develops our suppliers in terms of quality. If quality of parts and materials provided by supplier is high, then we do not need to perform any inspection here."*

No. 21: Relationship between pull system and supplier networks. In Toyota, production is pulled by customer demand, not only in terms of production volume but also in terms of product types being manufactured. To support pull system, suppliers should deliver parts and materials according to production requirement, just as it is needed, at the right quality, quantity, and time. EP4 explained, *"Delivery from suppliers should be done on a JIT basis."* Thus, synchronization between Toyota production and delivery from suppliers is a must. CEV5 told, "*..., we have arranged schedule of delivery to the customers, as well as schedule for vanning, stacking, boxing, quality checking, and ordering to suppliers. All are scheduled into the detail of time. The schedule is then shared to the suppliers. Suppliers will arrange their own schedule."*

No. 22: Relationship between small lot production and quality control. In a lean manufacturing system, quality control could be successfully implemented when production is performed in small lot size. In short, quality control can be applied effectively, if production is done in a minimum lot size. VA2 said, *"The smaller the lot size, the easier the quality control and the problem tracking."* Therefore, the chances of receiving, processing, and forwarding defects could be minimized. In addition, by applying small lot production, source of the quality problem can be easily detected. It avoids a production system from reworking defective products.

No. 23: Relationship between small lot production and supplier networks. Toyota produces in small lot size. This aims to minimize inventory. To achieve this objective, delivery from suppliers should be done in small quantity according to production requirement. This was stated by CEV3, *"We strive to receive* *parts and materials from suppliers in high frequency and small lot size, in accordance with production requirement."* Consequently, all parts and materials received from suppliers can be absorbed by production line as a whole, without remaining any inventory. Hence, supplier support is essential to small lot production.

Based on the relationships among the lean manufacturing practices, it is indicated that the practices are mutually supportive and complement each other.

6.6.3 Emergent Factors Affecting Holistic Implementation of Lean Manufacturing

Although this study revealed that lean manufacturing practices should be implemented holistically, it may be dependent upon several contextual factors (i.e., type of production process, technology, and type of product). These three factors were highlighted by several informants as presented below.

Type of production process

Characteristics of a production process also influence the application of lean manufacturing in a plant. Some practices are appropriate in some processes, but it is not relevant in some other processes. CEV4 stated, *"TPS is applied holistically at Toyota. However, there are differences in terms of intensity of implementation of each practice, depending on characteristics of a production process. At the vehicle assembly plant, we can apply one-piece production system. However, in stamping plant, it is not relevant; production must be performed in large batch size; it can be 500 pieces produced together."* Thus, even though the ideal lot size (i.e., one) can be achieved at the vehicle and engine assembly plants, it is impossible at stamping plant, because of the difference in type of production process. This was stated by EP2, *"In these two plants (engine production and vehicle assembly plants); the ideal lot size of one has been successfully achieved. However, in stamping plant, it cannot be applied perfectly because this application is associated with type of technology and production processes applied."*

Similarly, ST3 delivered that mixed model production cannot be applied at stamping plant as in vehicle assembly plant, because each type of product being produced has different dies. Consequently, production in the stamping plant should be performed in large lot size. He expounded as follows, *"This is certainly different from vehicle assembly line, which implements one-piece production with heijunka. Here, such a thing could not be applied. If we want to produce different products, dies must be replaced in advance through setup activities. So, when dies for part A are installed in a machine, only part A can be produced. At the same time, part B cannot. So, mixed models production cannot be applied in stamping plant. Production must be performed alternately. Once a batch is completed, dies must be replaced for subsequent batch."*

Based on these explanations, it can be concluded that implementation of lean manufacturing is contingent upon the type of production process applied to a plant.

Technology

The technology used in a production process also influences the application of lean manufacturing. CEV4 said, "*TPS activity also depends on the technology used at the plant."* Lean manufacturing implementation on manual works would be different from the works done by machines. CEV5 stated, *"In CEV, most of the jobs are done manually. So, we do not use multi-purpose machines. However, in other plants, we can observe; one machine can perform a number of different operations."*

Likewise, TPM and its activities are mostly applicable to a plant that uses machines for its production process. In the context of plants that do not operate by using machines, activities such as predictive maintenance are not fully required. CEV4 reviewed, *"TPM, for example, is more widely implemented in a production system that depends on its production to machines, such as engine production and stamping plants. TPM is not much applicable in CEV, in which most of the production processes are done manually. However, we still conduct some TPM activities to maintain forklifts, towing trucks, and other tools and equipment."*

In addition, the stamping plant of Toyota Indonesia is currently using two types of kanban (i.e., cyclic and e-kanban). Some orders from customers are using cyclic kanban, and some are using e-kanban. This is due to the technology used by customers. ST2 explained, *"Not all the orders received by stamping plant used e-kanban. The constraint is the technology used by customers. As with Hino, this is a "new rising" company. Its internal development is still carried out. Thus, it has not been using e-kanban yet. However, orders from CEV and vehicle assembly are performed by using e-kanban. To implement e-kanban, customers must provide an online system for suppliers, as done by Toyota. We provide e-kanban online system to all the suppliers."*

In short, application of some lean manufacturing practices depends on the technology used in the plant.

Type of product

Product type influences the application of lean manufacturing. Producing vehicles is certainly different from producing small items such as bolt, nut, washer, etc. Indeed, production of such products is very inefficient when it is done in a small lot size. It must be performed in a large lot size. In other words, large quantity of items must be produced together. It was reviewed by CEV4, *"For example, the production of nut and bolt. Surely, nothing could be done with the small lot production system. It must be performed in large batch. In one batch, it could be thousands."* In contrast, automobile production is not effective when the production is performed in a large quantity per batch as explained in Section 6.6.1.4. That's why Toyota applies small lot production.

6.6.4 Summary

In line with the quantitative findings, the qualitative phase revealed that all practices of lean manufacturing are mutually supportive and complement each other. Hence, the practices are recommended to be applied simultaneously in a holistic manner. How each practice is implemented was elaborated in Section 6.6.1. This supports the first proposition of the qualitative study, "*All the lean manufacturing practices are mutually supportive with one another and should be implemented holistically."* However, lean manufacturing implementation might be influenced by several factors emerged from the qualitative phase of the study. The factors consist of type of production process, technology, and type of product. The influences of these factors are recommended to be investigated in future studies.

6.7 Findings Related to Effect of Holistic Implementation of Lean Manufacturing on Operations Performance

The quantitative phase of the present study showed that lean manufacturing positively contributes to the enhancement of operations performance. It has also theorized that if lean manufacturing is implemented successfully, then all the indicators of operations performance could be improved. CEV1 said, *"The lean manufacturing triggers operations performance. It is a production system; it definitely is going to improve operations performance… So that, it is actually a method to improve operations performance, because muda (non-value added activities), mura (unevenness), and muri (overburden) present at the level of operations."* This is in line with the following statement provided by CEV2, *"If TPS is implemented as a total system, all the KPIs of Toyota (i.e., safety, quality, productivity, cost, and morale) will be achieved… With TPS, production problems can be subtracted… Hence, if it is applied properly, then all the KPIs would be achieved."*

However, the quantitative study is unable to explain the mechanism of how the lean manufacturing improves operations performance. Hence, to reach a deeper understanding regarding the general picture resulted from the quantitative study, a micro-level analysis through qualitative approach is required. This section will answer the second qualitative research question and confirm the second proposition (i.e., holistic implementation of lean manufacturing improves operations performance). For this purpose, the relationships between lean manufacturing and all the six indicators of operations performance (i.e., quality, manufacturing flexibility, lead time reduction, inventory minimization, productivity, and cost reduction) are presented.

6.7.1 Effect of Holistic Implementation of Lean Manufacturing on Quality

The main indicator used by Toyota Indonesia in assessing the quality performance is the customer claim. It is an expression of dissatisfaction from customer to a responsible party. The claim may come from both internal and external customers, as stated by CEV1, CEV2 and CEV9. CEV1 described, *"The main indicator of quality performance is customer claims (i.e., internal and external claims). Internal claims come from subsequent workstation within the plant, whereas external claims come from external customers…"* This argument was supported by CEV2. According to him, *"We assess quality performance based on customer voices. Complaints and claims mean that we are having quality problems."* To avoid the claims, it must be assured that products must confirm its pre-determined specification. In other words, no defects were produced in each production process. As described by CEV9, *"All processes must ensure that there is no defect that are processed and forwarded to the next workstation... At all processes, we ensure that quality problem is absent."* Fewer defect and high quality of product conformance imply that percentage of products that pass final inspection at the first time is high. In other words, first-pass quality yield is extraordinary.

How does lean manufacturing improve quality performance? Mainly, Toyota Indonesia improves its quality performance because of the implementation of the principles of quality control as set forth in the principles of TPS. Toyota applies *jidoka* (which is frequently known as quality at the source) and built-in quality, as stated in section 6.6.1.7. By implementing *jidoka*, if a quality problem is observed, then production process will automatically stop. Consequently, supply to customers will also stop. It stimulates improvement. Through the implementation of built-in quality, all the operators are fully liable on the products. It ensures that there is no defect received from previous workstation, produced, and forwarded to subsequent workstation. Producing in small lot size could support quality control activities. Quality control activities and problem tracking can be performed easily, if production is done in a minimum lot size. VA2 and CEV9 provided a similar vein. As an example, CEV9 commented, *"By* *implementing small lot production, we can identify quality problems easily, without producing defects in large quantity."*

However, to ensure quality performance; quality control does not work alone. All the lean manufacturing practices jointly work to improve quality. In Toyota, performing quality control is not started from its internal production process, but it is started from suppliers' internal production process. Toyota cultivates its suppliers' performance through a number of development programs, as described in Section 6.6.1.9. So that, it could be confirmed that suppliers are able to provide high quality of products. CEV5 explained, *"We are confident with product quality provided by suppliers, because we intensively provide them with guidances regarding the quality, and we develop them rigorously."* Thus, implementation of supplier networks (as presented in Section 6.6.1.9) may help to eliminate quality problems, such as defects and scraps.

In addition, through the implementation of the supplier networks, delivery from suppliers can be done in the JIT basis (i.e., small lot size, frequent delivery, as it is needed, in the right quality, quantity, and time). This supports the goal of minimizing inventory. Low inventory level may reduce the risk of supplying defects and encourage improvement in quality performance. Furthermore, inventory can also be minimized through the implementation of pull system, uniform production level, and small lot production. All the three practices are supported by the application of cellular layouts through close proximity between processes, and adjustable layouts and man power. The effect of lean manufacturing on inventory will be discussed in Section 6.7.4.

Interview session with CEV1 indicated that the existence of inventory tends to hide problems and variability in the shop floor. For instance, if some stocks are kept on hand, then quality problems would not be a big concern, because supplies to customers still can be continually performed by utilizing the existing stocks. In order to raise up root cause of the quality problem as well as to overcome it, production process must be stopped. Once it stops, recovery efforts would be made seriously. This was expounded by CEV1 as follows, *"Through the implementation of TPS; we expect zero stocks. If there is no stock, then if a quality problem is observed, production process will automatically be stopped. When the process stops, improvement and recovery must be performed immediately. Thus, the problem is directly be recovered... In contrast, if we have some stocks on hand, when an abnormality occurs, then it may not be considered as a serious problem. The item containing defects will be removed from the production line, and the stock can be used to replace that item. Hence, root cause to the problem will not be identified. The problem will not be overcome, and improvement may be considered unnecessary."*

More importantly, the implementation of TPM also positively influences quality performance. It assured that all the machines, tools, and equipment are in good condition and ready to use in production processes. Thus, it can be guaranteed that there will be no production disruptions caused by interference of machines, tools, and equipment. EP2 said, *"... in the machining process, we ensure the non-occurrence of defects during the machining process caused by broken, blunted and crooked tools."*

Equally important, multi-functional machines and multi-skilled workers have a positive contribution to the success of quality control activities. Multi-functional machines, besides serving for manufacturing process, it could also support *jidoka*, in which production processes will automatically stop when an abnormality occurs. CEV7 said, "*For example, if a tool is broken, then machine will stop.*" Likewise, multi-skilled workers may be assigned to perform built-in quality. This was indicated by EP3, "*We perform a built-in quality system, in which operators also perform quality checking...*"

Based on the above explanation, it shows that all the practices of lean manufacturing contribute to the enhancement of quality performance. Through the application of lean manufacturing, quality performance indicators (such as fewer defects, less scrap, higher yields and better quality of product conformance) could be enhanced. Thus, reworks and customer claims (both from internal and external customers) could be minimized. CEV2 explained that through lean manufacturing and continuous improvement, customer claims were almost non-existent. He stated, *"Now, our quality performance can be guaranteed. Previously, there were always claims from customers every month... However, now, almost no claims."*

CEV1 provided evidence regarding the quality benefits grabbed by Toyota Indonesia after the implementation of lean manufacturing as follows, *"Our defect/million (dpm) level is currently seven... From the seven dpm, defects caused by the logistical errors are only one or two dpm. So every million, the errors are only one or two. The remaining five dpm caused by function errors, such as handling dents, etc."* According to CEV1, the defect per million target would continuously be improved, until it reached the ideal level (i.e., zero defect). He said, *"Our dpm target in 2014 was one. Regionally (in the South-east Asia), the target is ten dpm. However, in Toyota Indonesia, especially in CEV, zero dpm is targeted in 2015. This is our spirit; indeed, there should be no defects. Our management always gives challenging targets. This* *encourages for continuous improvement; causes of defects must be eliminated; various improvements must be performed continuously all the time."*

In addition, EP4 told that in the engine production plant of Toyota Indonesia, inspection was done for every single piece of product. However, due to lean manufacturing is fully applied, and done with consistent improvements, inspection is done in a very minimum level, and Toyota is meanwhile getting closer to zero defects. EP4 said, *"In TPS, all are accounted for. Last time, 100% checking was performed, and as time goes by; we improved continuously. Now, we do not need to perform works that do not add value to the product.... We are getting closer to zero defects."*

6.7.2 Effect of Holistic Implementation of Lean Manufacturing on Manufacturing Flexibility

"To be the most flexible Toyota Company in Asia Pacific 2015-2016, and admired company in Indonesia." This is a vision that was plastered on the engine production plant of Toyota Indonesia. There are six types of flexibility attempted to achieve by Toyota Indonesia, namely volume flexibility; product mix flexibility, worker flexibility, machine/line flexibility, layout flexibility, and supply flexibility.

Production in a lean manufacturing system is driven by customer demand. So that, production volume depends on customer demand. Thus, a lean manufacturer must be able to adapt to fluctuations of demand. Therefore, regardless of the production volume, as long as it is still in the range of capacity of Toyota Indonesia, it should be able to absorb. This was explained by CEV1 and CEV2. As an example, CEV2 stated, *"Flexibility depends on incoming orders. In terms of volume, we can absorb any quantity of incoming orders. So, we should be able to handle the volume fluctuations."*

Thus, as manifested by CEV3, volume flexibility implies that, *"We can produce in any volume, but still efficient and remain effective, without expanding production area."* In case of the increase of production volumes, if it causes adverse consequences to production effectiveness and efficiency, then it does not fulfil criteria of flexibility.

Besides volume flexibility, Toyota is also flexible in terms of its ability to switch between products or models. It includes the ability to quick changeover between existing products, modification of existing products, and newly designed products. CEV2 reviewed this as follows, *"... it could be flexible in terms of model. Any model can be absorbed and processed."* VA2 explained from the context of vehicle assembly plant as follows, *"…, flexibility is also required in terms of variants/models. It can be that we produce at a fixed quantity, but with different models' composition... So, we strive to meet customers' demand in terms of volume and variants/models."* Similarly, AS5 pointed out that in terms of model, when customers request differently from the existing variants, Toyota can adjust it quickly. In addition, as explained in Section 6.6.1.6, Toyota performs mixed model production with *heijunka*. Thus, it requires setups between the products being manufactured in the production line. The setups are performed quickly, even up to the level of *"no setup"* is required. CEV9 expressed as follows, *"In the vehicle assembly plant; virtually, no setup is required. Changes between units that are being produced in a workstation do not require any setup. Whatever the models and variants, as long as they are still in our variant, then no setup is required."* However, model flexibility is dependent upon a number of contextual factors as presented in Section 6.6.3. It was stated by CEV2 as follows, *"In the context of CEV, especially in the part-by-part production line, any model can be processed. Conversely, in the assy set production line, we have to make a special arrangement."*

Achieving the two flexibility indicators (i.e., volume and model flexibility) is compulsory for a lean manufacturer, because production volume and the models being manufactured are pulled by customer demand. Because of this, according to EP3, *"If types of cars and volume that are being produced are changed in the middle of the month, Toyota should adapt quickly."* These flexibility indicators are mainly achieved through the application of uniform production levels and small lot production. With the application of uniform production level, Toyota manages its production system by leveling and smoothing production by volume and product type to guard against variability of demand. This was stated by VA3 as follows, *"Here, we implement heijunka. Wherein the composition of product being manufactured is arranged based on the composition of orders…, we produce in mixed. Heijunka considers all existing variants, including model, type, and so on."*

In addition, small lot production also plays important roles in achieving volume and product mix flexibilities. By implementing small lot production, when the composition of customer demand is changed, then production line can effortlessly be adaptable. Thus, production volume can be easily adjusted, and types of product being manufactured can simply be changed, without any major implications to production process and without storing any product as inventory. CEV3 explained, *"..., in case of arrival from suppliers is in large quantity per lot, we would have a lot of inventory. If production lot size is diminished, inventory will be zero."* Furthermore, CEV9 explained that because of the absence of inventory, model/product mix flexibility may be improved. According to him, *"..., for example, we have 300 units inventory for old model. When a new model is produced, then the old model will not be sold. It may be sold but at lower price. Of course, Toyota will lose. This is one of the reasons why we* *eliminate inventory."* Hence, the smaller the lot size, the lesser the inventory, the higher the volume and product mix flexibilities.

To support the volume flexibility and product mix flexibility, it is necessary to have flexible machines/lines, workers, supplies, and layouts. As mentioned in Section 2.4.1 and 6.6.1.1, the use of flexible resources (in terms of machines and workers) in a lean manufacturing system is a must. Associated with machines, Toyota uses multi-functional machines, which can perform multiple operations and capable of doing the jobs for variety of product. CEV9 stated, *"We use flexible machines and equipment, which can perform production processes for various types of product. Whatever the model, as long as the products requested by customers are still in the range of our variant, we can process it."* Likewise, one production line can be used to process all types of products. This was observed along the vehicle assembly line, all the variants were processed on the same line with the same machines and equipment, except for few processes that require special machines and equipment. According to VA2, one of the indicators of flexibility is low machines' setup time. In Toyota Indonesia, the ability to perform quick changeover between existing products is high. ST3 revealed that although the stamping plant is not as flexible as the vehicle assembly line (which implements one-piece flow production), but many types of products can be produced at one production lines, of course, with some setup processes for replacing dies.

Besides supported by flexible resources, machine flexibility is also supported by the application of TPM and *jidoka.* As elaborated in Section 6.6.1.8, the TPM activities can avoid production disruptions caused by interference of machines. EP2 said, *"If TPM is not performed well, then there are high possibilities of machines' breakdown. Consequently, we cannot produce and we are not able to supply to* *customers."* Similarly, *jidoka* also plays the similar role to prevent machines' damage, as presented in Section 6.6.1.7. CEV7 explained the purposes of *jidoka* application as follows, *"The first goal of jidoka application is to produce with 100% good quality. Second, to prevent machines' damage."*

To enhance manufacturing flexibility, Toyota strives to improve its worker flexibility by ensuring that all the workers have a number of expertise. As shown in Section 6.6.1.1, this was done by applying *tanoko* skill mapping system, job rotation, and training. With multi-skilled workers, Toyota can fit the requirement of workers to production volumes. EP4, CEV2, and CEV7 expressed a similar point of view regarding this issue. As an example, EP4 stated, *"..., indeed one operator can work on many processes. Number of machines handled by operators and number of operator itself are driven by production volume. If the volume is low, number of operator may be decreased. One operator may handle more than 10 machines."* In short, number of workers employed on a production line is adjustable depending on production volume. Technically, CEV7 explained, *"On 25th every month, we are usually given a production schedule for the subsequent months. Our group leader will plan the requirement of workers. If production volume is high, it is possible to add workers, otherwise overtime."*

Adjustment of the number of workers employed in a workstation is facilitated by standardized work. Toyota has work standards that were prepared based on production volume and number of workers to be assigned in a particular workstation. In the document, all the jobs are detailed and responsibilities of each worker are listed down. Cycle time, takt time, and position of tools should follow the standard. CEV7 explained, *"How to make it easy? We should have standardized work documents to* *guide us. Based on the document, we may plan the requirement of workers easily. We have standardized work documents for the different number of workers. For example, production volume will be high next month; it may take ten workers. We will use the standard for 10 workers. In it, responsibilities of each worker were listed down, including location of tools. If ten workers employed, then tools' position must be here. If five workers, tools' position is there."*

This brings various benefits for Toyota leading to reduction of production costs. A multi-skilled worker can be placed in any process, without taking long adaptation phase. If one worker is absent, then other workers could take over his/her duties. CEV2 explained, *"If an operator is multi-skilled, he/she can be placed in any process. If a worker is absent, certain workers can take over the tasks. In contrast, if a worker is absent, then production may be stopped."* Additionally, with flexible workers, one worker can handle several different jobs, as explained by EP3 as follows, *"This is related to our facility layouts. One operator can handle multiple activities and machines. Each job is standardized. By arranging our facilities in U-shape, every second can be maximized, so no one is idle during the working hours. What should they do in every second, has been standardized as stated in the standardized work table."* To support the worker flexibility, as explained in Section 6.6.1.1, training plays an important role. Training may ensure that the skills of all workers are at the desired level. EP2 conveyed, *"This is the importance of trainings. An operator in one production line, at least he should be able to do the jobs in three or four different workstations."*

In addition, to support volume and product mix flexibility, Toyota emphasizes to be flexible in terms of supply. Suppliers should be able to deliver parts and materials in the JIT basis, without increasing lead time and cost. VA2 stated, *"If they can deliver* *parts and materials in JIT basis, they are flexible… The simplest example is that when our production is done in different takt times, suppliers' delivery speed must follow."* Thus, delivery from suppliers must be in line with the speed of production processes. Supply flexibility could be ensured by the implementation of supplier networks. Toyota Indonesia is implementing three delivery systems, namely milk run, *jundate* and *jumbiki*. By implementing these delivery systems, as stated in Section 6.6.1.9, delivery from suppliers can be carried out in a JIT basis; perfect quality, in the exact quantity (neither too much nor too little), exactly when needed (not too early or too late), and exactly where required. The delivery systems may lead to supply flexibility.

Associated with layout flexibility, Toyota Indonesia possibly performs layout adjustment when production volume increases or decreases. In the context of CEV, layout adjustment can be performed easily as stated by CEV9, *"…, we also can adjust production layouts effortlessly. When the production volume increases or decreases, we can adapt easily."* It is possible, because most of the equipment and tools are movable. In fact, according to CEV2, sometimes layout adjustment should be done for the purpose of improvement. He said, *"…, changing the layout is occasionally a necessity, especially for improvement. So, we can act as a will, as long as it leads to the better productivity and efficiency."*

In the context of vehicle assembly plant. CEV7 stated, *"As in vehicle assembly plant, when demand exceeds the current capacity, layouts may be adjusted."* VA2 stated that one of the reasons of adjusting the current layout is to increase production capacity. He said, *"Additional on production capacity may affect takt time as well as the logistic area, which should be more widespread."* Additionally, layout adjustment may also be done for the purpose of improvement, for example, shortening takt-time.

VA2 explained, *"It is also due to shortening takt time. Thus, production line should be extended… The implication of shortening takt time is, of course; we should adjust the operating conditions in the plant, including facility layouts..."*

How to change the layout in the vehicle assembly plant? VA2 explained, *"The change in process requirements should be performed when we produce a new model of vehicle or when we set a new takt time. New takt time can change the process. For example, initially, takt time for installing ten parts was 2.5 minutes. If it is shortened to 2 minutes, then only eight parts can be installed. The change of layout can only be done on certain production lines, because in some area, it is impossible. For example, workstations that only one operator can work over there. However, there is certain workstation, in which two operators can work together. So that, the production line may not be extended. In other words, at the workstations in which more than one operator can work together at the same time, number of operator may be added. Thus, although initially, 2.5 minutes are required to install 10 parts, with a new takt time, possibly more than 10 parts installed with the additional operator. It certainly needs layout adjustment. In the main line, layout of racks or shelves may be changed."* Thus, in case of improvement in the production process, typically, a major change involving the main production line is not performed. In other words, layout adjustment is only performed for minor changes involving sub line and arrangement of racks and shelves.

The concept of layout adjustment explained by VA2 is in line with the concept of *shojinka* (refer to Section 6.6.1.1 and 6.6.1.2), in which number of workers assigned in a workstation is driven by production volume. By applying *shojinka*, production can be performed in any number of worker without reducing productivity. *Shojinka* would be very effective when it is supported by flexible machines, equipment, lines, and workers. In addition, *shojinka* should be supported by adjustable layout and the use of U-shaped line through the implementation of cellular layouts.

Based on the above explanation, ability to change the layout on each plant is different. In some plant, it can be done easily, as in CEV. However, it is rather difficult for stamping plant and machining area of engine production plant, because of the use of large-size of machines. In addition, the ability to adjust to changes of production routing in case of machine breakdown is not fully applicable for all the plants in Toyota. However, some of the plant such as stamping plant is having back up machine that can be operated in case of machine breakdown as stated by ST2 and ST3. For instance, ST2 explained, "*…, we have back up machines... When a machine is having trouble, we have back-ups. In other words, the other machines can be used to produce the same product. This means that we have a flexible process and machine. So, if one machine is in overhaul, then it can be replaced by other machines."*

In summary, it can be alleged that application of lean manufacturing strongly supports the achievement of higher manufacturing flexibility (in terms of volume, product type/model, machine and line, worker, layout/routing, and supply).

6.7.3 Effect of Holistic Implementation of Lean Manufacturing on Lead Time Reduction

The Toyota's production is driven by customer demand, which is handled with *heijunka* and small lot size production, as described in Section 6.6.1.4 and 6.6.1.6. According to CEV4, producing with JIT system should follow the pace of sales. To ensure this, it is necessary to shorten lead time. CEV4 explicated, *"JIT is to produce based on customers' request, by following pace of sales. Previously, if we buy a car, we* *had to wait for two to three months until the car is delivered to us. This was improved by Toyota by reducing lead time. So that, production at Toyota today can follow the pace of sales."* Generally speaking, Toyota defined lead time as processing time plus stagnation time. The processing time is the time spent in the activities that add value to the product. Whereas, stagnation time is the time used for non-value added activities, including setup time, moving time, and waiting time. CEV7 explained, *"Actually, lead time is processing time plus stagnation time. Both must be identified, how much time is spent for value added activities and how much time is used for non-value added one..."*

To shorten processing time, Toyota performed a number of strategies. Among them is to produce just as needed with *heijunka* and small lot production. These minimize inventory. The existence of inventory leads to the longer production lead time. CEV1 explained, *"If the stock is eliminated, transportation of parts/materials to the subsequent workstation will be faster… If inventory does not exist, total lead time could be cut... Otherwise, if the parts/materials are in stock for two hours, then they will move into the first process after two hours. It means that lead time becomes longer."* In line with CEV1, CEV7 expounded that in most other companies, inventory is stored for some time before the subsequent process is carried out. According to him, *"Toyota production is done in small lot size. Toyota does not keep any stock... Lead time at Toyota is shorter than others, because there is no time wasted for stock handling."* Thus, through the implementation of lean manufacturing, the stock is minimized, and lead time can be shortened.

Toyota also emphasizes to simplify its production processes. In simplifying the processes, Toyota performs "*yosedome"* as voiced by CEV3, *"The steps and processes that were previously long, not anymore right now. The concept of yosedome is to* *compact our processes. How to make the process simpler and more effective. Through yosedome, distance between the workstations is approximated." Yosedome* is done by reducing cycle time through a series of improvement. It is supported by the use of multi-skilled workers, multi-functional machines, small lot production, quick setup, supplier networks, etc. During the observation in the engine production plant of Toyota Indonesia; EP3 showed evidence regarding the benefits of lean manufacturing implementation in terms of cycle time reduction. He particularized, *"This is what we call as sigma cycle time (sigma CT). This is history of the result of improvement done in engine production plant; sigma CT always decreased from year to year. In 2010, our sigma CT was 1,828 seconds. In 2014, it is 1,525 seconds. So, we can reduce the sigma CT as much as 300 seconds (or 5 minutes). Sigma CT was reduced through continuous improvement. All the processes are improved, possibly by simplifying processes, replenishing equipment, and so on. Equipment or machines are cultivated to be able to process multiple jobs. Furthermore, from the side of the workers, they should also be multi-skilled… Now, our sigma CT is 1,525 seconds. It is still expected to reduce."*

In the context of assembly lines (vehicle and engine assembly lines), to simplify the process, Toyota also puts over some assembly activities in the main line to several sub lines. This is addressed to reduce assembly processes time in main line, because production lead time is calculated based on the time spent on the processes in main line, not the processing time along the sub lines. This was explained by CEV4 as follows, *"For example, instrument panel (dashboard) was previously installed one by one in the main line. Now, not anymore, it is prepared in a sub line. So that, times spent in the main line become shorter, because lead time is the time used in main line. Consequently, processing time in main line is shortened."* By transferring some processes to sub lines, processing time in the main line, waiting time of product to be processed in the subsequent workstation, and moving time to the next process can be shortened to a very minimum level. Finally, manufacturing lead time becomes shorter.

Application of cellular layouts could also reduce lead time. This practice ensures that workstations, machines and equipment are arranged into a sequence in order to support smooth flow of materials. As pointed out by CEV5 and VA1, by implementation of cellular layouts, distance between processes is shortened. So that, moving time from one workstation to the next workstation becomes shorter. Equally important, TPM significantly contributes to lead time reduction. By implementing TPM, risks of production interruptions due to machines' malfunction can be avoided. In the absence of line stops or disturbances in a production activity, production flow will run smoothly, leading to shorter processing time, waiting time, and moving time. CEV1 stated, *"With regard to the process, we also consider line stops. Through TPS, line stops are cultivated to reduce. If line stops do not exist, lead time could be shorter."*

As explained in Section 2.4.5, setup time is the time required in preparing equipment, materials and workstations for an operation. As explained in Section 6.6.1.5, in the context of assembly lines of Toyota Indonesia (either vehicle or engine assembly lines), setups are not required. According to VA2, the setup process is not required because Toyota uses flexible production lines with flexible machines and equipment. He stated, *"Flexible production line must be able to cover all types of vehicle entering into the production line, without requiring any setup."* Besides the use of flexible production lines, setup time was reduced through several improvement activities. In the context of stamping plant, wherein the setups are inevitable; SMED was applied by converting most of the internal setups to external setups. So that, most of the setup activities were performed while machines are processing the previous product (see

Section 6.6.1.5). Hence, improvement through SMED and the use of flexible production lines (including machines and workers) contribute to setup time reduction.

In addition, to be able to follow the pace of sales, delivery lead time from suppliers must be reduced. This was elucidated by VA2 as follows, *"When our takt time is adjustable, delivery speed from suppliers should follow…"* To ensure the short delivery lead time from suppliers; milk run, *jundate*, and *jumbiki* delivery systems were applied in Toyota as described in Section 6.6.1.4 and 6.6.1.9. By applying these delivery systems, JIT delivery could be maintained. JIT delivery together with quality control (see Section 6.6.1.7) may shorten the time needed for inspection and even up to the level of no inspection is needed, not only inspection for items delivered from suppliers but also inspection in production processes. Therefore, these two lean manufacturing practices (supplier networks and quality control) may lead to the shorter lead time.

Based on the above explanation, all lean manufacturing practices collaborate together to reduce lead times through reduction in processing time, moving time, waiting time, and setup time. With full implementation of lean manufacturing and consistent improvement, manufacturing lead time could be deducted significantly.

The significant effect of lean manufacturing on lead time reduction was explained by EP3. As enlightened earlier, sigma CT of engine production plant was always decreased from year to year. Even within five years (from 2010 to 2014), the sigma CT can be reduced as much as five minutes. Similarly, According to CEV9, takt time in the vehicle assembly was also reduced significantly. CEV9 stated, *"Our takt time is 1.5 minutes in the vehicle assembly plant. Previously, in the 1990s, the takt time was five minutes, and the time taken for producing a car from the beginning to the end* *was two days. Now, it is only eight hours. So, at the moment, if the first production process is started in the morning, its process could be finished in the afternoon."*

Nowadays, in Toyota Indonesia, all the processes have a standard lead time. So that, Toyota can deliver its product on time to customers. The spirit of Toyota is to adhere to its motto, *"delivery quality excellent."*

6.7.4 Effect of Holistic Implementation of Lean Manufacturing on Inventory Minimization

One of the main objectives of lean manufacturing implementation is to minimize inventory. It seems that there is a consensus among the interviewees that all the lean manufacturing practices lead to the minimization of inventory. CEV9 stated, *"When the TPS is implemented perfectly, there will be no more inventory. So, TPS causes the loss of inventory."* The existence of inventory is avoided by Toyota because the inventory inhibits improvement activities, as described by CEV1 as follows, *"Well, if we have a lot of stock, then the source of production problems will be covered. Let's say, if the line stop happens, then we just use the stocks to continuously supply our customers. So, the root causes of problems do not arise. When there is no stock; if a line stop happens, then we cannot supply our customers anymore. Consequently, root cause of the problem must be sought and resolved."* Likewise, if there is a defective product, then the stock may be replaced it. So that, the root cause of defects would not be resolved. CEV1 stated, *"In contrast, when we have some stocks; if there is a defective item, no problem. That defect is removed from the production line, and stock will replace it. Thus, improvement on the cause of the defect is not done immediately, or* *covered by stocks."* Accordingly, the absence of the stocks encourages improvement. That's why inventory is considered as an *"evil"* by Toyota.

It was repeatedly highlighted by CEV1, *"Through the implementation of TPS; we expect zero stocks. If there is no stock; when a problem suddenly occurs, then production process will automatically stop. Line stop means that improvement must be done immediately... Stock causes improvement to be jammed. When production ceased, all problems will arise. This is the basic philosophy of improvement in Toyota. In addition, the stock itself is a waste, and it requires a high cost to maintain."* For Toyota, if there is a problem, then production must be stopped, and supply to customer will automatically stop; this leads to improvement. CEV1 went on to explain, *"In TPS, in case of abnormality; production must be stopped. If it is stopped, it must be immediately recovered and improved. Especially, if main line is in a problem, then all will be thinking about how to solve the problem. Top managements will intervene. If we have a lot of stock, top management will not be aware of the problem."*

How does the lean manufacturing minimize inventory? Producing based on customer orders, no more and no less, may encourage of having inventory in a very minimum level, even zero inventory. It is certainly different from a push system, which requires a certain amount of stock. CEV1, CEV5, and VA1 provided a similar vein. As an example, VA1 explained, *"Applying the push system means that we should maintain a certain amount of stock. We produce, but no one is pulling from the front... Push is not the production principle of Toyota. So, it is impossible to be applied here. Push system is like "Padang Restaurant", the workers predict the foods, and then they put on the table. If it runs out, nice. If it does not run out, then remain."*

Toyota produces in very minimum lot size. When production is done in a large lot size, then the inventory will increase. CEV7 described, *"Toyota does not produce in large batch size, in which large quantity of product is processed at the same time. For example, there are three types of parts to be produced (parts A, B, and C). In a batch system, all the part A will be completed first, then part B, and part C. As a result, inventory is high, not only materials but also WIP and finished goods."* In order to reduce inventory, Toyota emphasizes the principle of small lot size and high frequency of production (see Section 6.6.1.4). Likewise, in terms of arrival of parts and materials from suppliers, this principle must also be applied. CEV3 expounded, *"In TPS; we have to produce in small lot size and high frequency. This means that we divide our production volume into a number of smaller quantities, but its frequency is multiplied. Similarly, delivery from suppliers, we normally divide it into several times of arrival depending on the requirement of our production process."* Therefore, production and delivery from suppliers are performed in small quantity per lot.

JIT delivery from suppliers is enhanced through supplier networks by applying milk run, *jundate*, and *jumbiki*, as described in Section 6.6.1.4 and 6.6.1.9. If production and delivery from suppliers are conducted in large lot size, then there will be a build-up of inventory, thus requiring more space. CEV3 expressed, *"If arrival of parts and materials from suppliers is in a large volume, then we will have a lot of inventory… If lot size is reduced, then space usage may shrink. At the same time, the process is also in small lot size. Thus, inventory will become zero."*

The effort of reducing the inventory level is also supported by uniform production level (see Section 6.6.1.6). This practice ensures that production runs smoothly through *heijunka*, uniform workload, and mixed model production. CEV5 explained, *"Production at Toyota is done by applying heijunka systems with small lot size, instead of large. Large lot size means, for example, today only part A will be produced, tomorrow only part B alone. So that, stock may be high, not only materials and WIPs, but also finished products. At Toyota, inventory should be zero. It can be realized through heijunka and small lot production."* The effect of uniform production level was also addressed by CEV1 and VA1. As an example, CEV1 said, *"If we produce in large lot size, for example, AAAAA BBBBB CCCCC… In this case, if A is being processed, then B and C are waiting, then there will be a build-up of stock on the edge along the production line. If we apply heijunka ABC ABC ABC, then we can certainly minimize the stock."* Section 6.6.1.4 presented a significant different between producing in small lot size with *heijunka*, and producing in large lot size without *heijunka*. Inventory remained zero if small lot production with *heijunka* is applied. In contrast, producing in large lot size without *heijunka* causes build-up of inventory (materials, WIPs, and finished products). Thus, small lot production and uniform production level work together in reducing inventory. However, these two practices must be supported by quick setup. This is in line with what was pointed out by ST3, *"So, one way to reduce inventory is to accelerate uchi dandori (internal setup). The faster the uchi dandori, the smaller the lot size,... Finally, inventory for each type of item can be suppressed. If we do not perform this strategy, our storage may not be enough."*

Through the implementation of uniform production level, workload could be uniformed, and line balancing could be achieved. Thus, production process could be carried out smoothly. This avoids the existence of inventory, as revealed by CEV7 as follows, *"Workload from day to day should be uniform. It is not preferable to have a high loading day, but low loading on another day. If a job is targeted to complete within three days, but it is completed within one day, then there is no work on the second and* *the third day. Both are the waste. If the work is completed on the first day, then we will have a lot of stock. On the subsequent day, workers are idle."*

Inventory minimization is also supported by flexibility of production lines, machines, and layouts. These flexibilities are supported by all the practices of lean manufacturing, especially flexible resources and cellular layouts as explained in Section 6.7.2. CEV3 explained, *"If we do not pay attention to flexibility, then we might add space when production volume increases. It is not preferable in Toyota. We need to improve our flexibility. So that, when production volume increases, there will be no effect on space requirement."* Flexibility is strongly supported by production in small lot size as stated by CEV3 and ST1. For example, ST1 commented, *"... For example, there are two conditions. The first one, production volume is large, let's say 1000. The second one, production volume is only 10. Small quantity is indeed more flexible right? Once there is a change, we want to replace orange with apple. Once oranges finish, apples will be going in. If orange was ordered 1000, then there is an ever-changing of demands to apple, then what should be done with the stock of 1000 oranges? We will allow them to be rotten? In addition, the 1000 oranges require larger space."* Thus, the more flexible the production system, the smaller the amount of inventory that must be maintained. However, this flexibility (especially machines flexibility) is strongly supported by the quick setup, as earlier presented in Section 6.7.2; the quicker the setup process, the more flexible the production system, and the lesser the inventory.

The existence of sound quality control activities (through *jidoka* and built-in quality) may diminish the inventory level. Logically, performing quality control may reduce defects and reworks (see Section 6.6.1.7). So that, there is no need to keep a certain amount of buffer stocks (in terms of WIPs and finished products) to replace the defects. Similarly, besides quality control, TPM may give a substantial effect on inventory minimization, because as presented in Section 6.6.1.8, it attempts to avoid interruption to production process caused by malfunction of machines and equipment.

Equally important, inventory minimization in Toyota Indonesia cannot be separated from continuous improvement activities. As observed by the author in CEV; inventory can be minimized fantastically after applying direct stacking in its production process. Direct stacking is an improvement conducted by CEV in order to simplify and compacting its production processes. Through the direct stacking, several production processes are simplified. More importantly, storing, picking, and handling activities are eliminated. Consequently, inventory was reduced to a very minimum level. CEV3 stated, *"... with the direct stacking, our inventory is reduced drastically. Previously, before the direct stacking was implemented, we could maintain the stock up to one day (8 hours and 50 minutes) because of the stagnation in the flow racks. Now, stagnation is totally eliminated."*

Based on the above elaboration, in a nutshell, all lean manufacturing practices together with continuous improvement activities done by Toyota contribute to the enhancement of inventory performance.

6.7.5 Effect of Holistic Implementation of Lean Manufacturing on Productivity

One of the pillars of Toyota performance is productivity. Based on the discussion with CEV3, the concept of productivity is that, at a particular time, production line should be able to produce as many as the pre-determined quantity. If cycle time of one process is one minute, then the process must be completed within one minute, not more than the pre-determined cycle time. If it takes more than one minute, then productivity is low. CEV3 explained; *"Productivity means that at every single minute, I have to produce a product. This means that if a line stop occurs, then I will lose. How do I avoid the line stop? Improvement is indeed compulsory."* In a similar vein, EP2 said, *"We have the daily productivity target, 95% for machining, and 98% for assembling. For example, total production target is 100 units per day; machining department should be able to produce at least 95 units per day, while assembling is 98 units per day."* CEV7 explicated that achieving the pre-determined efficiency and productivity is identical with a group of people that are rowing a boat, *"We can be imagined as a group of people rowing a boat. All the rowers must have the same directions. If there is no uniformity among the rowers, the efficiency and productivity may be low."*

Toyota divides productivity into two, namely real productivity and pseudo-productivity. CEV7 explained, *"We recognize real productivity and pseudo-productivity. For example, order from a customer is 100 units. Ten workers can complete these 100 units within one day. However, they impose themselves; they produce as many as 120 units a day. It is a pseudo-productivity, because the requirement is only 100 units, the remaining 20 units are the waste. The real productivity is obtained by improving tools and/or production processes. So that, it leads to man power saving, from ten to nine."* Toyota always performs improvement to achieve the real productivity, and avoid pseudo-productivity.

An important benchmark for productivity in Toyota Indonesia is man hour/unit. It refers to the total man hour that is required to produce one unit of product. According to CEV3, *"…, one of the indicators that are widely used in Toyota is man hour/unit…*

It indicates productivity. For example, we targeted to produce 30 units per day with man hour/unit is .30. If production volume increases to 50 units, it may imply to the increasing number of man power. However, man hour/unit must remain the same (i.e., .30), regardless the production volume. Although the volume decreases, man hour/unit should remain the same..." Thus, according to CEV3, *"... If I produced one unit, it takes one man power, then it somehow must be one. If he works so slowly, then one unit may take 1.2 man powers, or two man powers are needed. Consequently, I will lose, because the number of unit being produced remains, sales also remain, but I need more than one man power to produce."* Consequently, for improvement purpose, man hour/unit should be reduced as highlighted by CEV1 and CEV3. As an example, CEV3 stated, *"... we have to lower man hour/unit. So that, productivity is increased"*

The importance of estimation of man hour/unit was interestingly explained by CEV3 as follows, *"From the man hour/unit, let's say one unit was previously done by two man powers, then this should be lowered. Previously, if there are 100 units being produced, then I need 200 man powers. One man power is paid IDR 1 million. In total, I have to pay IDR 200 million. If man hour/unit is reduced to 1.5, then I should pay IDR 150 million. If an inflation happens, let's say 10%; I have to pay, for example, IDR 160 million. I have gained a profit of IDR40 million. Next, man hour/unit is again reduced to 1; I may gain even more. If 100 units, I pay IDR 100 million per man power. Let's say inflation has been 10% + 10% (for two years); I still win."* Hence, reducing the man hour/unit may increase productivity, and at the same time, it may reduce production costs and increase profitability.

Besides man hour/unit, Toyota Indonesia assesses its productivity by using efficiency in terms of quantity and working hours. This was detailed by CEV1 as follows, *"…, if takt time is set for 5 minutes, then we should be able to produce 12 units in one hour. If we produce only 11 units, then efficiency is low (i.e., 91.67%). This is in terms of quantity. In terms of working hours, efficiency can also be assessed. The formula is total working hour minus total line stops, divided by total working hours. So, if our working hour is 455 minutes per day and line stop is 25 minutes. Then, efficiency is 94.50%"*. These two indicators (i.e., man hour/unit and efficiency) are enhanced by the implementation of lean manufacturing intensively. So that, production lines could achieve 100% productivity. In general, the interviews conducted in Toyota Indonesia implied that all the lean manufacturing practices contribute to productivity, as described by CEV2, *"TPS definitely improves productivity. High productivity means no delay, no line stop, no shortage, etc. So that, actual time spent for production is in line with standard time."*

The use of flexible resources contributes substantially to productivity of a production line. Flexible workers have rich skills. So, if an operator is absent, the work can be handled by other operators, without any effect on productivity. It was conveyed by CEV4 as follows, *"The existence of multi-skilled workers may affect productivity in a great extent. If an operator is absent, then he/she can be replaced by other operators. Logically, if the operator is replaced, the productivity is reduced. However, with multi-skilled workers, productivity can be maintained."* Productivity is also supported by the implementation of *shojinka*, as described in Section 6.6.1.1 and 6.6.1.2. CEV7 explained, *"By applying shojinka, we can produce in any number of worker without reducing productivity." Shojinka* would be very effective when it is supported by flexible resources (in terms of machines, equipment, lines, and workers). In addition, the use of adjustable layout and U-shape line, which are part of cellular layouts' activities, may contribute to the success of *shojinka* application as previously stated in

Section 6.6.1.2. Thereby, by implementing flexible resources and cellular layouts, resources' utilization may be increased. At the same time, man power and energy could be saved. These, of course, lead to the better productivity.

Especially for the production that requires setup processes (such as in the stamping plant); through the implementation of quick setup, the setup process can be done more efficient and quicker. The quicker the setup process, the more the time can be used for productive jobs. ST1 pointed out, *"... the lower the setup time, the higher the efficiency. If efficiency increases, number of items that can be produced each day may be increased, consequently, productivity may improve."*

High utilization of machines and equipment is also driven by sound TPM activities. By implementing TPM, it is expected that production disruptions caused by machines and equipment problems can be minimized. Thus, line stop could be reduced. CEV1 explained, *"If the line stop is reduced, then the more the time for production activities. This means that man hour/unit would be lower."* Additionally, TPM also contributes to higher OEE (overall equipment effectiveness). It also means that utilization of machines, equipment, production lines, and man power could be increased even further. More importantly, quality control activities also help to ensure that the pre-determined quality standards can be achieved without performing a long process of inspection. Thus, disruptions on the production process caused by quality problems may be avoided. It may increase productivity.

Equally important, through the implementation of uniform production and small lot production, the production process can be performed more efficient. The implementation of these two production principles contributes greatly to the increase of productivity. As presented in Section 6.6.1.4 and 6.6.1.6, through the implementation of the two practices, production processes can be smoothed. In other words, disruptions to production in terms of waiting, delay, and so on could be avoided. It was pointed out by CEV5 as follows, *"If not heijunka, then there is the possibility of one process will delay. Let's say, we have five processes, if one is not heijunka, it is possible that one workstation will be delaying or waiting. These may cause muda (non-value added activities)."* Delay and waiting negatively affect productivity. The smoothness of production flow is supported by JIT delivery from suppliers. Applying supplier networks ensures that JIT delivery performs well. Supported by milk run, *jundate* and *jumbiki*, supply parts and materials from suppliers can be done effectively and efficiently, as previously described in Section 6.6.1.9. This certainly brings a positive effect on productivity as a whole.

In addition, an important idea was conveyed by CEV7. He stated that outstanding productivity at one workstation must be followed by improvement in previous and subsequent workstations. If not, it may slightly affect production smoothing, and may reduce the total productivity. Therefore, *"yokoten"* activity is required. *Yokoten* means best-practice sharing from one workstation to other workstations. CEV7 described as follows, *"For example, if improvement in a particular workstation has led to shorter cycle time; then in other workstations, the same improvement must also be performed. This is called as "yokoten". If not, it may cause a build-up of material in a particular workstation, and it may result in temachi (waiting) because of delays in the previous process. It deals with the takt time. If you improve, you have to be aware of its effect on the previous and subsequent workstations."* Through *yokoten* activities, the best practice may also be transferred between plants or between companies. ST1 stated, *"If you want to implement lean manufacturing in other plants, logically you should also be able to increase its productivity..."*

In summary, the above explanation showed that each element of lean manufacturing contributes to productivity of production lines. This is possible because efficiency and utilization of machines and labors are improved, setup may be quicker, moving and waiting time could be shortened, defect and rework may be reduced; production processes become more efficient, and JIT delivery from suppliers can be performed. This accumulation may convey a huge effect on productivity.

6.7.6 Effect of Holistic Implementation of Lean Manufacturing on Cost Reduction

EP3 expounded, *"The ultimate goal of TPS is costs reduction."* Lean manufacturing practices are the series of activities that promote costs reduction through the elimination of waste. The costs are directly related to profit. The profit-making concept of Toyota is through cost reduction. In other words, to maximize profit, costs must be reduced. The smaller the costs, it is most likely, the higher the profit. This concept was conveyed by CEV3, CEV8, and VA1. For instance, according to CEV8, *"We cannot increase our price, because it is driven by market. Therefore, we must control our costs, especially production costs. The production costs include the cost of labor, materials, inventory, logistics, etc. To reduce the costs; improvement must be done. So that, profit could rise, because of the lower cost."*

Efforts to reduce the costs are also motivated by the increase of inflation from year to year, because it may affect the company's profit. ST1 enlightened, *"Because of inflation, the cost will go up, but the price is not easy to be increased. What should be* *done? Cost reduction."* Exchange rate may also affect the costs to be incurred by the company, as manifested by ST1, *"Exchange rate affects the cost."* This is reasonable because most of the materials and parts used in Toyota Indonesia are imported, purchasing is done by using foreign currency. Due to the factors mentioned above (i.e., price, inflation, and exchange rate) are beyond the control of a company, it is uncontrollable. This was stated by EP2 as follows, *"The thing that can be controlled by the company is only to lower costs through a series of internal improvement activities."*

Implementation of lean manufacturing, in fact, leads to lower costs. This was expounded by VA1 and CEV5. As an example, VA1 stated, *"Cost reduction triggers a company to be lean. Lean leads to cost reduction significantly."* In order to reduce production cost, Toyota Indonesia has a targeted monthly cost. As emphasized by CEV1, in particular, if costs exceed the target, Toyota will evaluate why it was happened. If the actual cost is consistently lower than the target, the target will also be evaluated and may be downgraded. This is not only done at company and division levels, but also at the level of the production line. CEV5 simplified, *"Every month, we set a benchmark in all production line. Improvement is regularly performed, which is addressed to reduce our costs."*

How does lean manufacturing influence the costs? The study shows that all the practices of lean manufacturing gear towards cost reduction. One of the significant effects of lean manufacturing is cost reduction through inventory minimization. CEV9 elaborated as follows, *"Toyota does not only consider lead time, but also costs incurred by inventory, such as ordering cost, holding costs, labor costs, warehouse costs, electricity costs, etc."* CEV7 agreed that inventory contributes significantly to the costs.

CEV7 stated, *"Toyota prefers not to keep any stock... Production is driven by customer demand… No demand, no production... Thus, Toyota produces in lower costs."*

Equally important, the implementations of flexible resources and cellular layouts also subsidize a substantial effect to costs reduction. Through the implementation of flexible resources, workers are multi-skilled, and machines have the ability to perform a number of basic operations. Thus, it may contribute to man power saving. Consequently, labor costs can be lowered. It was highlighted by CEV7 as follows, *"Other companies usually require a lot of workers. In contrast, Toyota requires fewer workers."* CEV3 explained that with the effort to attain multi-skilled workers, Toyota Indonesia managed to reduce the number of workers significantly. In the context of CEV, CEV3 explained, *"In 2010, we employed 460 workers. Now, only 351. Within four years, number of workers can be reduced by more than 100."* CEV9 also stated similarly, *"It is good for Toyota... Previously, in total, we required 1500 man powers. However, now, when tanoko is implemented, coupled with improvement in production lines; man power can be reduced up to 500. So, it is very useful. Another 1000 man powers can be allocated to other tasks. So, no need for recruiting new workers, because we improve the existing workers to be multi-skilled. Lastly, costs are reduced."* Man power saving can also be done through the improvement made in production lines, for example, by shortening and simplifying the processes. ST1 and CEV3 provided somewhat similar idea. For instance, CEV3 stated, *"... for example, shortening the processes. Previously, we needed a special worker to do handling; it is currently not needed anymore… We also cut cycle time. As a result, number of workers will inevitably be reduced. Through simplification of process, number of workers can also be reduced."* Therefore, by implementing lean manufacturing, number of man power could significantly be reduced.

Likewise, the use of flexible machines, coupled with the implementation of quick setup, close proximity between processes, and adjustable layouts, can shorten the manufacturing lead time. It may contribute towards costs reduction. It was emphasized by CEV1 and VA1. For instance, VA1 said as follows, *"It could also be, for example, by closing the distance between workstations and shortening setup time, cycle time, and takt time. Because at the time and distance, there is the value of money."* In addition, TPM also contributes to the costs reduction. Through sound maintenance activities, it is expected that line stops could be reduced, breakdown maintenance could be eliminated. Thus, maintenance costs caused by line stop and breakdown maintenance could be decreased. Furthermore, with the lower line stops, inventory can be minimized to a very minimum level, because it is no longer necessary to have safety stock to adapt such abnormalities. CEV1 stated, *"If abnormality, such as line stop, is avoided; the costs would be reduced... By avoiding line stop, increasing efficiency, minimizing inventory, and man power saving; the cost will surely be reduced."*

Quality control also plays a very significant role to reduce manufacturing costs. Performing effective quality control strategies (through *jidoka* and built-in quality) lead to reduction on cost incurred by poor quality of product. This type of cost is named as COPQ (cost of poor quality). This is in line with what was explicated by VA1, *"..., we do not receive any defect from suppliers or previous workstations; we do not process any defect, and we do not pass any defect to the subsequent workstations."*

Therefore, all the lean manufacturing practices contribute towards the reduction of manufacturing costs, as described by CEV1, *"..., by implementing lean, we can produce at lower costs."* All the practices corroborate together to achieve minimum costs. So, in Toyota, to gain a high profit, the first that must be adjusted is cost. The cost reduction encourages improvement. CEV1 stated, *"So, with this price, we should be able to produce a car at this cost. Thus, all should move forward to minimize the costs. We should play with the costs. This is to encourage continuous improvement…"*

Producing in lower cost is also a benefit gained from continuous improvement activities carried out by Toyota. CEV1 stated, *"To get a high profit, everything must be improved... So, the cost must be suppressed anyway."* CEV2 elaborated the concept of continuous improvement done in Toyota as follows, *"For each process and activity; we always think; it should continuously be improved. The current process is not the best process. Albeit if the cost is minimum, Eiji Toyoda (former president of TMC) said, "If you put your mind to it, water can be wrung even from a dry towel." So, improvement is a never-ending process. There is no best process, but there is always a better process. Maybe, this process is currently the best, but not necessarily tomorrow. So, no one can say that improvement has already exhausted. Oh... Not going to be exhausted."* Hence, application of lean manufacturing and supported by continuous improvement will gear toward cost reduction. CEV3 stated, *"…, in production, most of our activities lead to costs reduction. Productivity, safety, quality, lead time reduction, flexibility, inventory reduction, and all, lead to the cost reduction."*

6.7.7 Summary

The effect of holistic implementation of lean manufacturing on operations performance as found in the quantitative study was explained, corroborated, confirmed, and triangulated in the qualitative phase. Lean manufacturing increases quality, manufacturing flexibility, and productivity. At the same time, it decreases inventory, lead time, and costs. How the practices advance each indicator of operations performance was detailed from Section 6.7.1 to 6.7.6. In summary, the second proposition is supported, "*holistic implementation of lean manufacturing improves the operations performance.*" The relationships among operations performance measures are presented in the next section.

6.8 Relationship among Operations Performance Indicators

There are relationships among the indicators of operations performance, as previously found in the quantitative phase of the study. This was also highlighted by some of the informants during the interview. Interestingly, all the operations performance indicators (i.e., quality, flexibility, inventory, productivity, and lead time) lead to cost reduction. Improvement in operations performance, in terms of quality, manufacturing flexibility, productivity, inventory, and lead time; ultimately may lead to costs reduction. ST1 said, *"The main objectives of TPS are to improve quality, productivity, flexibility, and to minimize inventory. These all gear towards cost reduction. If costs are reduced, then profit will increase."* Thus, most of the improvement made in the shop floor should be able to lower the production costs. These were done by Toyota to achieve the cost effective.

It seems that there was a consensus among the informants in the case study, that the existence of inventory may incur higher costs to a company. The costs can be in terms of either the real costs or hidden costs. CEV1, CEV3, CEV9, VA1 and VA2 revealed the similar opinion regarding the costs incurred by inventory. For instance, CEV1 explained, *"Besides the stock itself, maintaining that stock incurs costs. The stock itself is a huge cost; labor costs, maintenance, space, and many more hidden costs are caused by the existence of inventory."* Therefore, to achieve cost effective, inventory must be reduced. This was explained by VA1 as follows, *"... if the stock is reduced, the cost could be reduced."* In other words, inventory minimization has a positive effect on costs reduction.

In terms of quality, poor quality contributes to high cost. As explicated by VA1, quality is strictly controlled by Toyota. According to him, the basic principle of quality control in Toyota is that not receiving defects from previous workstation, not producing defects, and not forwarding defects to subsequent workstation. Thus, applying this principle may avoid COPQ. In line with VA1, CEV3 expressed somewhat similar point of view, *"If we are unable to identify any defect earlier, then I will pay 100 pieces. If the 100 pieces are processed, then only 90 pieces that meet the quality standards. After the process, only 80 pieces good in quality. After delivery to customer, he/she found defects 10 pieces. It means that the goods that can be sold only 70 pieces. So, I am loss..."*

Improvement on lead time may significantly affect production costs. The shorter the lead time, the lower the costs. This was exemplified by CEV3 as follows, *"... reducing lead time, for example, contributes to lower cost. Before the improvement, we assigned a special worker as a transporter, after shortening the process, the transporter is not required anymore."* Process simplification was also done in CEV. So that, it may reduce labor costs. CEV3 stated, *"... last time, we have a picking process here. Now, it is no longer needed. After boxing, the parts are directly sent to the shooter by using a conveyor. So that, we saved man power."* Thus, after simplifying the process, production time is shortened, and man power can be saved. Eventually, the total cost may also reduce. In addition, by shortening delivery lead time from suppliers; Toyota could minimize inventory that may contribute towards the costs. It was stated by CEV5, *""Nasi Padang" has a long lead time. So that, stock is a must."* The longer the lead time, the stock becomes indispensable. Equally important, if lead time is short, then *jumbiki* system can be implemented. Thus, no need for warehouse. CEV9 explained, *"... if the delivery lead time from suppliers can be shortened, we can implement jumbiki."* Hence, costs for managing warehouse could be eliminated. Furthermore, in the context of spare part management; if lead time is short, the company does not need to maintain spare parts as inventory. CEV4 explained, *"If abnormality happened, and spare part replacement is required; if lead time is short, we can directly order to suppliers, and spare parts can be delivered quickly. So that, maintaining spare parts as stock is not required."* Thus, by shortening lead time, costs are reduced.

Equally important, the higher the manufacturing flexibility, the lower the costs. This is due to the effect of flexibility on inventory, lead time, and productivity. The relationships between flexibility and inventory were described by CEV2 and CEV3. For instance, CEV3 explained, *"If we do not pay attention to flexibility, then we might always add space when new products/models are produced. This was not done in Toyota. So, we have to improve manufacturing flexibility. When a new model is produced, and production volume is increased; there will be no effect on the space."* This suggests that if flexibility is high, then any model can be produced without inventory and additional space.

In addition, there is a relationship between manufacturing flexibility and lead time. Effect of lead time on manufacturing flexibility was described by VA1 and CEV3. As an example, VA1 stated, *"Flexibility is commonly associated with lead time. If lead time is short, when suddenly there is a demand for a new variant; we can respond to it in a very short time."* Thus, as explained by the CEV3, the shorter the lead time, the higher the flexibility. Conversely, the more flexible the production process, the shorter the lead time. Hence, high flexibility and short lead time positively affect cost reduction.

Furthermore, high manufacturing flexibility reflects high productivity. If flexibility is low, then productivity tends to be low. CEV3 explained this as follows, *"We are able to absorb any production volume, but man hour/unit must be fixed."* ST1 also explained the same argument, *"I talked that man hour/unit is constant. Whereas, production volume is variable. If the volume is increased, number of man power should be added. However, man hour/unit should remain constant. This is what we have to maintain. However, our target is to reduce man hour/unit."* Therefore, the more flexible the production line, the higher the flexibility.

A system is considered productive if it can produce according to the pre-determined targets all the time. Frequent production disruptions may lead to the losses to a company. Productivity itself also influences production costs. The more productive the production system, logically, the lower the costs. Productivity is influenced by line stop. Low line stop points to high productivity. CEV1 believed, *"..., when the line stop is reduced, man power is also reduced; efficiency will increase, then surely the cost will reduce."* CEV3 also explained, *"If we want to improve quality, reduce costs and space requirement; then man hour/case should still be maintained."*

The above explanation shows that there are relationships among the measures of operations performance. As a summary, these relationships are schematically presented in Figure 6.6.

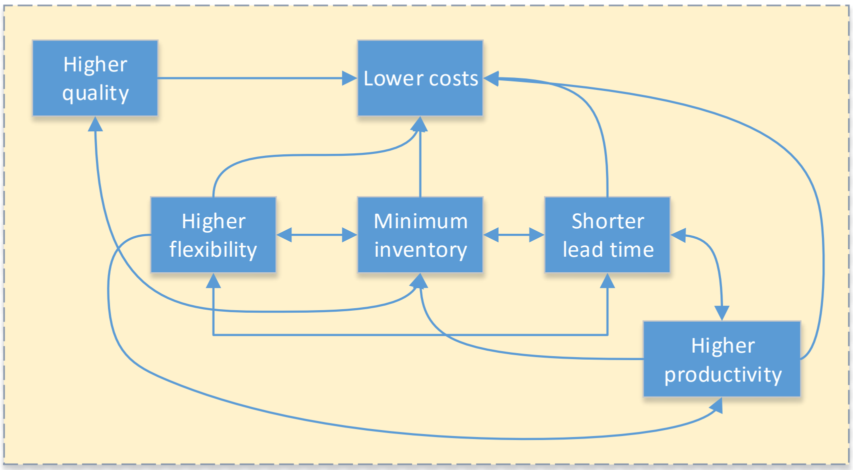

Figure 6.6
Relationships among Operations Performance Measures

In the subsequent section, the effect of holistic implementation of lean manufacturing on business performance is presented.

6.9 Findings Related to Effect of Holistic Implementation of Lean Manufacturing on Business Performance

The quantitative research formulated that lean manufacturing significantly affects not only operations performance, but also business performance. The quantitative phase also concluded that lean manufacturing improves business performance either directly or indirectly. The indirect effect is through operations performance as a mediating variable. Qualitative research seeks to explain deeper and to confirm these phenomena. The following research question will be answered in this section, *"How does lean manufacturing improve business performance?"* At the same time, the third proposition of the case study; *"holistic implementation of lean manufacturing improves business performance directly, and indirectly through the improvement of operations performance"* is attempted to be confirmed.

The qualitative phase provided evidence that there is no direct relationship between lean manufacturing and business performance. In other words, the relationship tends to be indirectly, in which the operations performance serves as a mediating variable. According to CEV1, *"Lean manufacturing is for triggering the operations performance. Lean manufacturing is a production system, which is definitely going to improve operations performance."* CEV1 stated that lean manufacturing would not improve business performance directly. He further explained, *"So, lean manufacturing will not improve business performance directly, but through improvement of operations performance... Thus, lean manufacturing affects operations performance, subsequently the operations performance affects business performance."*

Similarly, CEV9 elaborated that although lean manufacturing has a significant effect on business performance, but it will first improve the indicators of operations performance. According to CEV9, *"I think, there is no direct relationship, because TPS is implemented to improve operations performance. But at the end, it would improve profitability. Even, if there is a direct relationship between lean manufacturing and profitability, it is only in terms of direction, only as a hint, just as a vision. If you want to increase profitability, you have to apply TPS."* It seems that after achieving the better operations performance in terms of quality, manufacturing flexibility, inventory, lead time, productivity, and cost; it can be ascertained that business performance will subsequently increase. CEV9 elucidated, *"Firstly, TPS improves operations performance. This improvement leads to better profitability. Profit may be high if quality is high, high flexibility, shorter lead time, lower costs, and higher productivity."*

According to CEV1, the results of the quantitative research showing the direct effect of lean manufacturing on business performance may be caused by other aspects of lean manufacturing, which could increase business performance directly. However, he still emphasized to the opinion that lean manufacturing must first affect operations performance, instead of affecting business performance directly. He described, *"It probably depends on perception looked like. Probably, there are certain aspects of lean manufacturing that affect business performance directly. For us, as plant workers, lean is a technique, method, or system that is used for production. It helps to achieve a better operations performance. So, to say that lean manufacturing can boost business performance, this is the benefit from the enhancement of operations performance. It needs references, there may be other aspects that might directly connect lean manufacturing with business performance."*

In this regard, CEV9 viewed that it is possible that the direct effect of lean manufacturing on business performance is likely influenced by the nature of business and type of production process. CEV9 explained, *"... I think, it depends on nature of business, lengths and complexity of the process."* In other words, the direct effect may be due to a number of contextual factors. The informant was not sure enough how the direct relationship was happened. However, this is beyond the context of the study and suggested for future research. The following sections describe the effect of lean manufacturing on the respective indicators of business performance.

6.9.1 Effect of Holistic Implementation of Lean Manufacturing on Profitability

TPS or lean manufacturing is an effective approach to produce an ultimate goal of enhancing outstanding profit. In general, profit is influenced by revenues and costs. So that, to increase profits, there are three possible options that may directly increase the profit, namely increasing selling price, increasing volume, and lowering costs. In particular, CEV7 explicated, *"How can we increase our profit? One way is to increase our selling price. However, it is not effective; the buyer will precisely backwards, because of the existence of our competitors. The second way is by increasing our production volume, which is also related to costs and capacity. This is also not effective. We cannot keep on producing, while we cannot sell. It may cause higher costs. The third is to lower our costs..."* One of the principles held by Toyota in increasing the profit is through the principle of cost reduction. Toyota believes that the cost per unit of product at every company is different depending on how the production is conducted. CEV7 stated, *"... you should truly realize that cost per unit between one company and another company is different, depending on how they produce."* It seems that cost effective is one factor determining the survival of a company to compete in global markets.

Toyota upholds the following principle; price minus cost is profit. This principle encourages continuous improvement. To increase the profit, costs must be reduced. Maximizing profit cannot be done through increasing price, because price is controlled by the markets, in which Toyota is competing with other automakers. CEV1, CEV7, and VA1 mentioned somewhat similar idea regarding the strategy of maximizing profit in Toyota. CEV7 repeatedly mentioned this in our discussions, *"... we should be able to produce within this cost. All of us should struggle to minimize the costs... Because price is beyond our control, it is driven by the markets. We can only control our costs. This encourages continuous improvement. Commitment to reduce the costs also triggers a company to be lean. Lean production leads to costs reduction."* Hence, it seems that to reduce costs, lean manufacturing and coupled with continuous improvement must be performed. Subsequently, it increases profitability.

To sustain company's competitiveness, profit must be increased. For this purpose, there are a variety of ways, and the most effective way is to lower its costs. Costs can be reduced through lean manufacturing, as clearly described in Section 6.7.6. The following statement from EP2 strongly supports this opinion. EP2 said, "*Costs are reduced by completely eliminating all kinds of muda (waste). This is what the TPS attempting to do. The cost reduction may lead to the better profitability."*

The above explanation emphasizes that to increase profits, costs must be decreased. EP3 stated that an outstanding profit was generated through cost reduction. It seems that there was a consensus among the interviewees regarding this issue, as elucidated by CEV1, CEV9, and VA1. For instance, CEV9 said, *"Actually, there is no direct relationship. The lean manufacturing improves operations performance first; the ultimate result is to increase the profit. Profit can be high when performances in terms of quality, flexibility, lead time, productivity, and costs are improved."*

Nevertheless, the amount of profit earned by a company is also influenced by other factors that are beyond the control of the company, such as fluctuations of currency exchange rate. VA1 explained, *"It is possible that there are other factors influencing the profits, such as exchange rates… We have set the price, but the exchange rate may cost us higher because our currency is dropped. Consequently, the prices of the imported goods are increased."* Another factor that also possibly affects the profit is inflation. Toyota should raise the salary of workers by following inflation rate. To increase salary, it should not be done by reducing profit, but must be through costs cutting. CEV9 expounded, *"Anually, we must raise salaries to reflect the inflation. Increasing workers' salary by reducing profit is not preferable, it could lead to the losses to us. We are trying to reduce the cost as much as possible…"* This indicates the importance of improvement within a production system. Without improvement, costs incurred by the uncontrollable factors may injure acquisition of profit.

Therefore, it can be concluded that the lean manufacturing has no clear direct effect on the profitability of the company. The relationship tends to be indirectly through improvement in operations performance as a mediating factor.

6.9.2 Effect of Holistic Implementation of Lean Manufacturing on Sales

Producing in the JIT basis means producing based on customer requests, at the right time, and at the right quality. However, this definition was extended by Toyota, as described by CEV4 as follows, *"This definition was protracted by Toyota by adding, "by following pace of sales."* To be able to produce based on customer requests and to follow the pace of sales, Toyota should implement the JIT production system holistically. CEV4 went on to explain, *"Last time, when we buy a car, there is a period of waiting for two to three months. This was improved by Toyota through holistic implementation of JIT. Consequently, lead time was reduced. Nowadays, we can follow the pace of sales."*

To win today's competition in global market, Toyota, strived to increase its sales volume and market share. So that, revenue could be increased. By increasing revenue and lowering costs, profit can be augmented. Therefore, producing by following the pace of sales is very important for Toyota. Lead time is reduced. This is guaranteed by application of lean manufacturing as elaborated by CEV9, *"…, because the system guaranteed that we can perform on-time delivery, we emphasize lead time reduction."*

In addition, sales are also influenced by product quality and manufacturing flexibility. The higher the product quality, the higher the sales. Improvement in quality is guaranteed by lean manufacturing, as described in Section 6.7.1. CEV9 also explained, *"Quality is also guaranteed at every stage within our process."* In terms of manufacturing flexibility; the more flexible the production system, mass customization production system could be applied successfully. Therefore, sales could be inflated. Product mix flexibility can be achieved through holistic implementation of lean manufacturing. This was described in detail in Section 6.7.2.

In line with the above matters, VA1 concluded that sales can be increased if quality and flexibility are improved. At the same time, lead time is shortened. VA1 stated, *"..., with good quality of product, short lead times and high flexibility, sales would rise."* As particularized in Section 6.8, these three factors (i.e., quality, flexibility, and lead time) are affected by other operations performance measures. This shows the relationships among the measures of operations performance. To ensure high operations performance and subsequently high business performance, lean manufacturing should be applied in a holistic manner. Through achievement of operations performance in terms of quality, flexibility, and lead time; sales volume could be increased. However, in Toyota Indonesia, market share has not shown significant improvement. For the local market, Toyota is still leading in terms of market share among the automakers. VA1 explained, *"In terms of sales volume and market share, we are number one in Indonesia. However, the presence of Honda Mobilio, Suzuki Ertiga, and others, certainly affects our market share. We remain at the level of 35%. Previously, it increased, but now it returned down to the level of 35%. Sales volume was increased, but market share still remains. We targeted to increase the share, but not significant, because competitors filled market segments with new models."* It seems that one of the factors causing the non-significant improvement in market share is not because of its internal production process, but because of external factors, especially existence of competitors.

In summary, it seems that the case study did not find any direct relationship between lean manufacturing and sales. The relationships tend to be indirectly through operations performance as a mediator, which is a direct outcome from lean manufacturing employment.

6.9.3 Effect of Holistic Implementation of Lean Manufacturing on Customer Satisfaction

Toyota has always sought to guarantee customer satisfaction. Customers referred to by Toyota is not only external customers, but also internal customers. External customers are parties that use a company's products. Meanwhile, according to ST1, internal customer is next process or subsequent workstation. He revealed, *"..., the concept of TPS is the next process is our customer. For example, the next customer of stamping plant is vehicle assembly plants. As there is no claim from the two plants, then we are happy."* In Toyota, satisfactions of the two customers are entirely considered.

In this study, the main focus is on external customers who buy the Toyota's products. Toyota committed to ensure the customer satisfaction. Observation in the shop floor of engine production plant found a slogan *"a good car is a car that satisfies customers and gives satisfaction."* In addition, Toyota considers customer satisfaction as a very important goal, as it was displayed in the shop floor of CEV, *"Once we lost the customers' reliance, it will take a very long time to recovery."*

There are several factors affecting customer satisfaction, such as product quality, price, response to sales inquiries, after-sales service, ability to fill orders quickly, and on-time delivery. This is in line with what expressed by CEV9 as follows, *"Toyota has always observed attitude of its customers. They decide to use Toyota or other automakers' products, because of considering several factors. There are several aspects, such as perception, taste, and trust. For example, we promise them that the car will be delivered on so and so, that's for sure, because the system has already guaranteed. We guarantee the on-time delivery, because lead time is set at the minimum level. Quality is also guaranteed in every single process. So, we are very confident that delivery can be done on-time, unless there are other factors beyond our control."*

Achievement on customer satisfaction is influenced by operations performance, such as quality, costs (which are related to competitive price), manufacturing flexibility, and lead time. In terms of quality, the activity board of engine production plant of Toyota stated a question, *"how the quality affects the customers?"* Three categories of product quality and its effects on customers were stated, namely plus quality (customers satisfied and impressed, and want to buy it again), common sense quality (customers take it for granted and expect no defect), and minus quality (customers feel disappointed and don't want to buy it again). EP3 also stated, *"We need to deliver cars with plus quality to customers. We cannot deliver the common sense and minus quality."* It seems that the quality of product is the most important factor affecting the customer satisfaction. However, quality is not the only factor affecting customer satisfaction. CEV4 stated, *"In addition to quality, some issues related to customer satisfaction are lead time, price, and delivery."* CEV1 and VA1 provided a similar opinion. As an example, CEV1 explained, *"If customers are given precise lead time, they will be happy. If we can customize the products, they are also being happy... If they* *are served as such, they would be satisfied... The higher the quality and the shorter the lead time, the higher the customer satisfaction."*

Therefore, to achieve better customer satisfaction, operations performance indicators (e.g., high quality, low costs, high manufacturing flexibility and short lead times) must first be achieved. No doubt, to achieve an outstanding operations performance, it is necessary to implement lean manufacturing practices as a whole, as described in Section 6.6.2. In other words, holistic implementation of lean manufacturing improves operations performance, and subsequently; it increases customer satisfaction. Interview sessions done at Toyota Indonesia could not pinpoint a direct relationship between lean manufacturing and customer satisfaction. The relationships tend to be indirect through operations performance as a mediating factor.

6.9.4 Summary

In a schematic form, the relationships between lean manufacturing, operations performance and business performance are shown in Figure 6.7. The figure indicates that lean manufacturing may improve business performance both directly and indirectly. However, possibly there may be other factors influencing the results of the quantitative phase of the study indicating a direct relationship. The direct relationship between lean manufacturing and business performance (illustrated by dashed arrows in Figure 6.7) depends upon other aspects such as contextual factors as described in Section 6.6.3. Indirectly, lean manufacturing improves operations performance, and subsequently; the operations performance contributes to business performance. Hence, this findings support the last proposition that "*holistic implementation of lean* *manufacturing improves business performance directly, and indirectly through improvement of operations performance."*

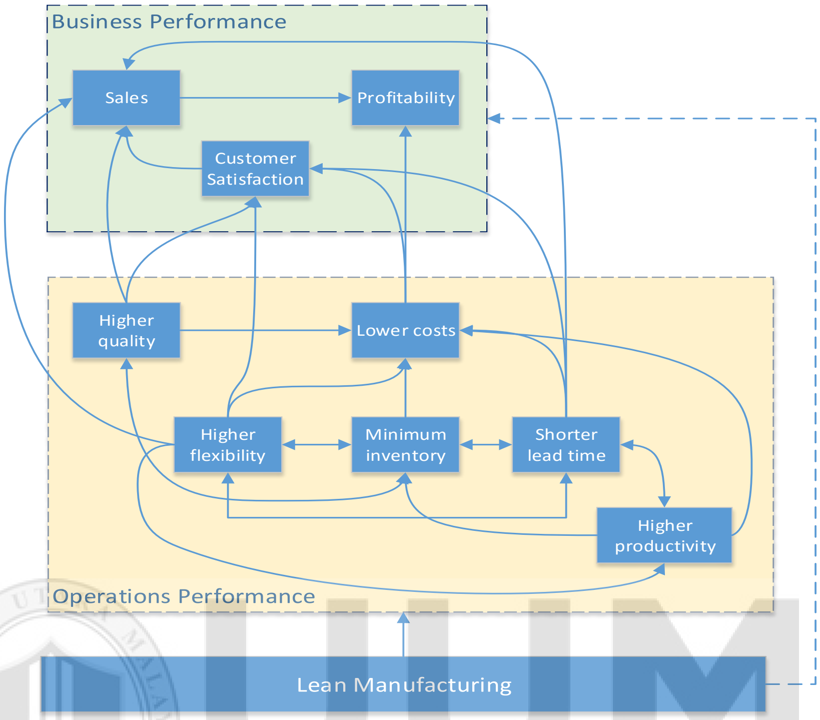

Figure 6.7
Framework of Relationship among Lean Manufacturing, Operations Performance, and Business Performance

6.10 Chapter Summary

This chapter presented the qualitative phase of the study. It is addressed to explore how lean manufacturing is implemented in Toyota (first research question), and how lean manufacturing improves operations performance (second research question) and business performance (third research question). In line with the research propositions, the qualitative phase of the study leads to the following conclusions:

1. All the lean manufacturing practices must be implemented holistically, because the practices are mutually supportive. The absence of one practice may negatively affect

the implementation of others. The achievement of lean manufacturing cannot be outstanding with the absence of particular practices (piecemeal adoption).

2. Holistic implementation of lean manufacturing directly improves all the indicators of operations performance (i.e., quality, manufacturing flexibility, lead time reduction, inventory minimization, productivity, and cost reduction). The better the implementation of lean manufacturing, the better the operations performance.

3. Holistic implementation of lean manufacturing tends to affect business performance indirectly through improvement of operations performance. In other words, lean manufacturing, firstly, improves operations performance. Subsequently, the operations performance advances business performance. Even though there is no direct effect of lean manufacturing on business performance, it is suspiciously that the direct effect is dependent upon other aspects named as contextual factors.

CHAPTER SEVEN
DISCUSSION AND CONCLUSION

7.1 Introduction

Generally, this mixed methods sequential explanatory study was addressed to investigate the effect of lean manufacturing on organizational performance in terms of operations performance and business performance. To achieve the study objectives, an analytical review on related literature had been conducted as reported in Chapter Two. Based on the literature review, there are nine common practices of lean manufacturing, which were frequently proposed in previous studies. The practices are flexible resources, cellular layouts, pull system, small lot production, quick setup, uniform production level, quality control, total productive maintenance, and supplier networks. Meanwhile, reviews on lean manufacturing literature disclosed that there are six common measures of operations performance namely quality, manufacturing flexibility, lead time reduction, inventory minimization, productivity, and cost reduction. In terms of business performance, prior studies on lean manufacturing indicated that profitability, sales, and customer satisfaction were commonly used to measure business performance. The present study assigned lean manufacturing as independent variable, business performance as a dependent variable, and operations performance as a mediator between the independent and dependent variables.

In attempting to fill the gap regarding the limited studies on lean manufacturing area contextualized in the developing countries, and to offer a way of resolving the technical efficiency problems in manufacturers in Indonesia; at the quantitative phase of the study, large manufacturers in Indonesia were designated as population of the study. In selecting the sample of the study, a stratified random sampling procedure was applied. A total of 174 large companies were involved. All the companies are categorized as discrete process industries consisting of repetitive process (33.33%), batch (27.01%), mass customization (28.16%), and job shop (11.49%). According to Shah and Ward (2007), at these types of production processes; lean manufacturing is more frequently implemented than at other types of the production process (e.g., project and continuous process). The respondents are operations/production manager (63.79%), head of operations/production department (22.41%), director of operations/production (9.20%), and other middle management positions under operations/production department (4.60%). Detail of data analysis results was reported in Chapter Five.

At the qualitative phase, in order to obtain a deeper understanding regarding the implementation of lean manufacturing and its effect on organizational performance, the author was attached in Toyota Indonesia from 4th to 29th August 2014. A case study with series of interviews as main data collection method was successfully conducted. A number of interview and observation sessions were done. The results were reported in detail in Chapter Six.

The overall findings of both quantitative and qualitative phases indicated that the results of the two phases are consistent. There is no contradiction between them. In other words, the qualitative phase supports the findings obtained from the quantitative phase. Generally, key findings of the two phases are summarized as below:

1. Lean manufacturing practices must be implemented holistically. Piecemeal adoption is not preferable.

2. The holistic implementation of lean manufacturing improves all the measures of operations performance.

3. The holistic implementation of lean manufacturing improves business performance directly and indirectly through operations performance as a mediator.

This final chapter provides an in-depth discussion on the key findings. Subsequently, it is followed by implications, limitations, and possible suggestions for further research. Finally, the report will be ended at a conclusion.

7.2 Discussion on Holistic Implementation of Lean Manufacturing

The quantitative and qualitative phases postulated that lean manufacturing practices must be implemented in a holistic manner. In the quantitative phase of the study, Pearson's correlation analysis showed the highly positive and significant association among the practices (i.e., $.703 \leq r \leq .917$). According to Cohen (1992), these *r*-values are considered practically significant and meaningful. In addition, factor loadings indicating the contribution of each manifest variable (lean manufacturing practices) to the latent variable (lean manufacturing) are also high (i.e., greater than .800). These loading values are considered practically significant (Hair et al., 2010). The high and positive correlation coefficients and high factor loadings indicated that implementation of a practice influences the others and vice-versa. It, indeed, tends to suggest a holistic implementation of lean manufacturing practices (Furlan et al., 2011a; Furlan et al., 2011b). In other words, in order to achieve a maximum return of lean manufacturing implementation, all the practices are suggested to adopt comprehensively. Piecemeal adoption is not preferable.

In line with the quantitative results, the qualitative phase of the study revealed similar results; all the lean practices must be implemented simultaneously, because all the practices are supporting each other. Implementing the practices in isolation negatively influences the implementation of others. The mutually supportive nature among the practices and how the practices interact with each other were depicted in Figure 6.5. In short, implementing the concept of lean manufacturing could not be done by halves. However, the qualitative research conducted in four plants in Toyota Indonesia (i.e., stamping plant, component export and vanning plant, engine production plant, and vehicle assembly plant) tends to suggest that implementation of the practices depends on some contextual factors, namely type of products, type of production process, and technology used by the plants. These contextual factors could influence the way a company implementing lean manufacturing as well as the extent of its implementation.

Several studies, such as Bayo-Moriones et al. (2008), Chen and Tan (2013), Hadid and Mansouri (2014), Losonci and Demeter (2013), and Shah and Ward (2003), investigated influences of the contextual factors to the level of implementation of lean manufacturing as well as its effect on organizational performance. The studies revealed that there is no single agreement regarding the influences of contextual factors. However, the research context itself and its settings could also affect the results. Regardless the contextual factors, there is a consensus among practitioners and academicians that lean manufacturing practices must be implemented holistically as a total system. Conversely, the way a plant in implementing the practices and the level of its implementation in each plant tend to be varied depending upon its context. However, addressing this issue in detail is beyond the scope of this study. It will be taken to future work.

This study provides evidence that lean manufacturing practices are mutually supportive and should be implemented holistically and comprehensively. This finding tends to encourage mutual dependency by connecting all the practices as a total system to enhance organizational performance. Several studies supported this finding. Chen and Tan (2011) claimed that no matter what kind of industry and its scale of sale are; adoption of the aggregate bundle of lean manufacturing practices significantly benefited company's performance. The finding from Shah and Ward (2003) was indeed supported by Mackelprang and Nair (2010) and Chen and Tan (2011), argued that integration among the lean manufacturing practices leads to the improvement in companies' performance and competitive advantage. Hence, the way the quantitative and qualitative findings highlighted the mutually supportive nature among the lean manufacturing practices is perfectly consistent with the basic ideas of RBV theory (Barney, 1991; Wernerfelt, 1984), ABV theory (Porter, 1985), and complementarity theory (Edgeworth, 1881).

As the importance of holistic adoption of lean manufacturing practices has been discoursed, Dal Pont et al. (2008), Furlan et al. (2011a) and Furlan et al. (2011b) highlighted interdependencies among the practices by relying on complementarity theory. As explained earlier, the theory revealed that two practices are complementary when implementation of one could increase marginal return of another practice. Hence, this theory is useful to provide a rigorous explanation to synergic effects among lean manufacturing practices. Through their studies, Furlan et al. (2011a) and Furlan et al. (2011b) provided evidence that implementation lean manufacturing practices in a holistic manner maximizes the overall operations performance, because of the complementarity among the practices. Similarly, Hofer et al. (2012) also established that synergies exist among lean manufacturing practices. The authors then tested the synergic effect of the practices to inventory leanness. They found that the bundle of practices increases the ability of companies to minimize inventory, which in turn, positively affects financial performance.

The study conducted by Nordin, Deros, Wahab, and Rahman (2012) provided somewhat similar argument that if lean manufacturing practices are implemented in a piecemeal approach, the potential benefits of its implementation could not be realized. Each practice is essential to the accomplishment of other practices' deployment. Hence, lean manufacturing should be implemented comprehensively in terms of scope and content to achieve the desired performance level, instead of piecemeal.

As indicated by the quantitative data in this study, although some manufacturers in Indonesia have been implementing lean manufacturing in a holistic approach, some of them have not. Thus, it is greatly suggested that manufacturing companies should not implement the lean manufacturing practices in isolation. In its history, western manufacturers started to implement some of the lean practices in an isolated way, but did not achieve the expected results (Dombrowski, Mielke, & Engel, 2012). Related to the piecemeal adoption, one of the possible causes of its failure was because of the practices did not belong to a comprehensive plan addressing achievement of company's performance (Alves, Milberg, & Walsh, 2012). Hence, the positive interaction effect among lean manufacturing practices suggests that the practices should not be considered as independent resources; they are interdependent with each other. Therefore, the manufacturing companies should implement all the practices (strategic resources) concurrently, simultaneously, and holistically rather than picking one over the other.

7.3 Discussion on Effect of Holistic Implementation of Lean Manufacturing on Operations Performance

One of the objectives of this study is associated with the first hypothesis; stating that lean manufacturing has a positive relationship with operations performance. Pearson's correlation coefficients indicated that all the practices are positively associated with all the operations performance measures ($.535 \leq r \leq .750$). These magnitudes are considered high and practically significant (Cohen, 1992). Furthermore, the analysis with SEM tended to support that holistic implementation of lean manufacturing contributes significantly to operations performance. This was indicated by β-value of .816 with confidence interval ranging between .735 and .877. The analysis revealed that if the implementation level of lean manufacturing goes up by one standard deviation, operations performance increases by .816. The R^2 indicating the contribution of lean manufacturing to operations performance was .670. This implies that lean manufacturing explained 67% of the variance of operations performance.

In line with the quantitative phase, the case study concluded similar results; the holistic implementation of lean manufacturing positively influences all the operations performance indicators, in terms of quality, manufacturing flexibility, inventory, lead time, productivity, and cost. Qualitatively, the detail of the effects of lean manufacturing on these operations performance measures was reported in Chapter Six.

The outcome of the present study provides further confirmation of previous studies, such as Dal Pont et al. (2008), Furlan et al. (2011a), Furlan et al. (2011b), Khanchanapong et al. (2014), Shah and Ward (2003), Singh et al. (2010b), and Singh and Ahuja (2014). Even, Kannan and Tan (2005) found that lean manufacturing is a powerful strategy in realizing strategic goals at operations level. Several authors established a number of rational considerations. According to Abdel-Maksoud et al. (2005) and Rahman et al. (2010), lean manufacturing practices are habitually applied in a shop floor and associated to operations. Bartezzaghi and Turco (1989) and Chang and Lee (1995) also postulated that operations performance was reflected by some internal properties within a manufacturing system, which are affected by production practices implemented.

Nakamura (1999) had done his research to examine the extent to which lean manufacturing practices have been implemented Toyota Astra Motor (TAM) by applying the work organization approach and utilizing the data provided by Toyota Astra Motor (TAM), which is now well-known as Toyota Indonesia. Even though his research was done in 1999, the study revealed that a number of lean manufacturing practices such as *heijunka* or flexible leveled production, flexible resources, quality control (e.g., *jidoka*, quality circle, process control, and *pokayoke*) were well-functioned at TAM. According to him, the implementation of these practices brought several benefits in terms of better quality, higher flexibility, lower cost, and shorter takt time. However, Nakamura (1999) has done his research in a very limited subset of measurement. Thus, the study did not grab a clear picture regarding the lean manufacturing and its effect on operations performance. Using a more comprehensive measurement, the present study conducted by the author attempted to investigate the current implementation of lean manufacturing in Indonesian manufacturing companies and examine its effect on organizational performance. Nowadays, lean manufacturing becomes a culture of the company. The practices are now implemented holistically and have brought the company to become the most successful automaker in Indonesia. Lean manufacturing has extraordinarily increased its performance.

The significant relationship between holistic implementation of lean manufacturing and operations performance was supported by Shah and Ward (2003) who used the term of *"lean bundles"* to represent the holistic lean manufacturing. Their hierarchical regression analysis led to a postulation that lean bundles meaningfully influence operations performance indicators in terms of labor productivity, unit manufacturing cost, scrap and rework costs, first-pass quality yields, customers lead time, and cycle time. Similarly, Dal Pont et al. (2008) assessed interrelationship among lean bundles and examined their effects on operations performance by applying SEM with LISREL. The survey involving 266 plants in nine countries (i.e., United States, Japan, Finland, Sweden, Italy, Germany, Korea, Austria, and Spain) across three different industries (i.e., electronics, machinery, and transportation) provided empirical evidence that the lean bundles lead to operations performance.

In a similar vein, Furlan et al. (2011a) and Furlan et al. (2011b) employed complementarity theory to underpin their research in assessing the effects of lean bundles on operations performance, indicated by quality, flexibility, delivery, and cost. Employing OLS regression analysis technique, Furlan et al. (2011a) found that internal, upstream, and downstream lean manufacturing practices complement each other in maximizing the operations performance measures. All the lean practices must be adopted as a whole to achieve the desired operations performance. Correspondingly, with the same regression analysis technique, Furlan et al. (2011b) demonstrated that the implementation of lean manufacturing bundles (i.e., JIT and TQM) synergistically maximizes the overall operations performance.

Recently, in the context of Indian manufacturing industries, Singh and Ahuja (2014) also evaluated the effect lean manufacturing implementation on operations performance. The study revealed that the effective implementation of lean manufacturing significantly contributes towards enhancing operations performance measures. The study also concluded that holistic lean manufacturing outscored the traditional manufacturing practices towards cultivating operations performance. In addition, in a developing country, Malaysia, Wong et al. (2009) highlighted that it was very clear that respondent companies successfully gained various benefits from lean manufacturing implementation in terms of reduced cost, non-value added activities, and inventory; faster response time; and increased quality, flexibility, productivity, and profitability. Wong et al. (2009) also suggested that lean manufacturing should not be adopted in isolation. Rigorous implementation was highly recommended.

Extensively, Khanchanapong et al. (2014) provided empirical evidence regarding the complementary effects of lean manufacturing practices and manufacturing technology on operations performance. Underpinned by the RBV and complementarity theory, their study led to a postulation that lean manufacturing practices, with mutually support from manufacturing technology, synergistically affect quality, lead time, flexibility, and cost. According to them, lean manufacturing and manufacturing technology are strategic resources that must be implemented as a whole in a holistic manner. The absence of one could diminish the effect of another.

7.4 Discussion on Effect of Holistic Implementation of Lean Manufacturing on Business Performance

Based on the theoretical framework and the result of quantitative analysis, lean manufacturing could affect business performance in both direct and indirect manners. Similarly, even though the qualitative results tend to suggest the indirect effect through improvement in operations performance, the possible direct contribution of lean manufacturing on business performance does exist. The next sections will discuss the effects of lean manufacturing on business performance.

7.4.1 Discussion on Direct Effect of Holistic Implementation of Lean Manufacturing on Business Performance

In the quantitative phase of the study, a positive relationship between lean manufacturing and business performance was hypothesized. The results of Pearson's correlation analysis showed that all the practices of lean manufacturing positively associated with all the measures of business performance ($.570 \leq r \leq .743$). Cohen (1992) guided that the correlation coefficients are considered high in magnitude and practically significant. The direct relationship between lean manufacturing and business performance was positive and significant (see Figure 5.2). The structural direct effect of lean manufacturing on business performance was .271 with a low standard error (i.e., .060) and significant critical ratio (i.e., 3.489).

In the qualitative phase, the interview sessions suggested that lean manufacturing indirectly affected business performance, through the improvement of operations performance. The possible direct effect is due to other aspects of lean manufacturing, which could increase business performance directly. The study also revealed that the direct effect was influenced by the nature of business, type of production process, and complexity of the process.

Numerous examinations in previous studies have been conducted to confirm the effect of lean manufacturing on the ability of companies to enhance business performance in terms of profitability, sales, and customer satisfaction. Having understood that Forrester et al. (2010), Rahman et al. (2010), Wong et al. (2009), and Yang et al. (2011) supported the positive and significant consequences of lean manufacturing practices on business performance. Correspondingly, Agus and Hajinoor (2012) discovered that enhancements of business performance among Malaysian manufacturers are confidently determined by the implementation of lean manufacturing practices. In addition, contextualized in agricultural machinery manufacturers in Brazil, Forrester et al. (2010) exposed the similar findings. The study concluded that a substantial enhancement in business performance is due to the implementation of lean manufacturing.

Fullerton et al. (2003), Green and Inman (2007), and Hadid and Mansouri (2014) suggested a significant effect of holistic implementation of lean manufacturing on profitability. As lean manufacturing practices aim to minimize wastes within a production system, the practices help companies to enhance their targeted profit through eliminating costs and increasing revenue. The more the revenue and the lower the costs, the higher the profitability. A number of studies such as Mia (2000), Kinney and Wempe (2002), and Callen et al. (2005) compared the profitability of lean and non-lean adopters. These studies provided a scant evidence that the lean adopters are more profitable than the non-lean adopters. The evidence implied that companies implementing lean manufacturing practices more comprehensive are more profitable. The study conducted by Wong et al. (2009) contextualized in electrical industries in Malaysia, hold that the improvement in profitability is as a result of lean manufacturing employment.

Sales performance, according to Parry et al. (2010), can be enhanced through cultivating production process. As lean manufacturing helps a company to cultivate its production process, it could escalate its sales performance. Eventually, customer satisfaction was also influenced by the employment of lean manufacturing. Predominantly, Krajewski and Ritzman (2005) stated that customers were satisfied when their expectations related to products and services are encountered. In the context of the lean manufacturing system, by reducing the costs, without compromising the quality; products could be marketed at competitive prices and ensured quick and efficient delivery. Hence, lean manufacturing implementation leads to high customer satisfaction. Involving small, medium and large manufacturers in Thailand, Rahman et al. (2010) observed that lean manufacturing practices offered a significant effect to the outstanding customer satisfaction.

7.4.2 Discussion on Effect of Operations Performance on Business Performance

Firstly, in the quantitative phase of the study, it is important to assess the association among the operations performance measures. The assessment led to the conclusion that correlation among the operations performance measures were found positive and statistically significant (i.e., $.778 \leq r \leq .888$). These coefficient values are practically significant (Cohen, 1992). In other words, all the measures are related each other. This suggests that a high performance on an indicator positively influences other indicators. So that, all the measures should be used to understand the operations performance comprehensively. This quantitative finding agreed with the qualitative results. As displayed in Figure 6.6, the operations performance indicators are related among them, one indicator could affect the others. This evidence is again supported by the complementarity theory; all the operations performance measures complement each other.

In achieving the third objective of the study, the relationship between operations performance and business performance was investigated through a quantitative and qualitative approach. In the quantitative phase, this is associated with the third hypothesis stating that there is a positive relationship between the two variables. Pearson's correlation analysis supported positive and significant associations between all the operations performance measures and all the business performance measures ($.616 \leq r \leq .778$). These coefficient values are practically significant as suggested by Cohen (1992). These associations were in line with the relationship between operations performance and business performance as latent variables. Structural relationship between the two variables indicated a positive relationship, with .663 standardized β-value, .062 standard error, and significant critical ratio (i.e., 7.846). In addition, the standardized β-value fall within the range between .526 and .789. This led to the conclusion that H_3 was supported; operations performance positively contributes to the business performance.

The positive relationship between the two variables is supported by the qualitative phase of the study. The higher the operations performance, the better the business performance. As known that business performance is indicated by profitability, sales, and customer satisfaction. To obtain an outstanding achievement on these three indicators, the operating conditions (in terms of quality, flexibility, inventory, lead time, productivity, and costs) must first be improved. Thus, the operations performance acts as an antecedent to business performance. Qualitatively, the effects of operations performance on business performance were discussed in Chapter Six.

The consensus about the effect of operations performance on business performance is indisputable. The result from this study was supported by Agus and

Hajinoor (2012), Bartezzaghi and Turco (1989), Chang and Lee (1995), Chenhall and Langfield-Smith (2007), Fullerton and Wempe (2009), and Moori et al. (2013). All the aforementioned researchers agreed that operations performance can drive broader business performance; the better the operations performance, the better the business performance. Therefore, manufacturers should emphasize not only in terms of business performance but the most important thing is also operations aspect.

7.4.3 Discussion on the Role of Operations Performance

The last objective of the quantitative phase of this study was to examine the possible mediating effect of operations performance in the linkage between lean manufacturing and business performance. In this regard, the last hypothesis (H_4), stating that lean manufacturing affects business performance directly and indirectly through operations performance as a mediating variable, was examined.

This study determined the existence of mediation or indirect effects based on the significance of the product of path *a* (i.e., connection between independent variable and mediating variable) and path *b* (i.e., connection between mediating variable and dependent variable). If *a* x *b* is significantly different from zero, then mediation or indirect effects do exist within the model. The SEM analysis indicated that the direct effect of lean manufacturing on operations performance (i.e., path *a*) equals to .816, and the direct effect of operations performance on business performance (path *b*) equals to .663; which were statistically significant at .05. Furthermore, with confidence interval between .434 and .666, the analysis showed that *a* x *b* was .541, which was also statistically significant at .05. This indicated that business performance was indirectly affected by lean manufacturing through operations performance. In other words, lean manufacturing affects the operations performance, and subsequently operations performance affects the business performance.

As discussed earlier, the analysis also specified that direct effect (path *c*) of lean manufacturing on business performance was found positive and significant. Zhao et al. (2010) guided; if both indirect effect (*a* x *b*) and direct effect (*c*) exist and point at the same direction (either only positive or negative sign), then the model fulfils the criteria of complementary mediation. The existence of mediating effect on the model was also supported by a two-tailed Sobel test indicating that the Sobel test statistic (i.e., 6.748) was significant. The analysis led to the conclusion of supporting the last hypothesis (H_4). As such, it is essential to reaffirm that lean manufacturing can enhance business performance directly, and indirectly through operations performance as a mediating variable.

More importantly, the quantitative analysis also indicated that operations performance enhances the total effect of lean manufacturing on business performance as a cumulative of direct and indirect effects to the level of .812. This implied that when lean manufacturing goes up by one standard deviation, business performance goes up by .812. In other words, the improvement in business performance measures is significantly determined by lean manufacturing and improvement in operations performance.

Such quantitative results are supported by the case study results. Majority of informants revealed that the implementation of lean manufacturing improves the business performance through the enhancement of operations performance. This is logically accepted, because all the lean manufacturing practices are commonly applied to the operations. It is a production system dealing with the operating condition. The more holistic the employment of lean manufacturing, the better the manufacturing system, the better the operations performance, and lastly the better the business performance. A framework of relationship between lean manufacturing, operations performance, and business performance was depicted in Figure 6.7. The framework indicated that the holistic implementation of lean manufacturing improves all the measures of operations performance. All the operations performance indicators are also mutually supportive in order to achieve the better business performance. In Toyota, to increase profitability, instead of increasing price, the effort is done through reducing costs; because the profit is the difference between price and costs. To reduce the cost, as indicated by Figure 6.7, all other operations performance measures must be outstanding. Successively, the lower cost would increase the profitability. In addition, complementarity nature among the operations performance measures contributes to the better sales and customer satisfaction.

A number of studies supported this empirical evidence. Agus and Hajinoor (2012), in the context of Malaysian manufacturing companies, have concluded that manufacturers must marshal their energy to apply a more effective lean manufacturing in order to improve product quality performance, and ultimately improve business performance. From their perspective, in order to achieve better business performance; product quality performance, which is a property of operations performance, must be enhanced. Similarly, Hofer et al. (2012) stated that lean manufacturing leads to the superior operations performance, such as higher quality, shorter processing time, minimum inventory, which in turn, cultivates financial performance. Equally important, Yang et al. (2011) also summarized somewhat similar; lean manufacturing affects financial performance through improving production processes, cost efficiencies, and labor and asset productivity.

Interestingly, this study strongly supported the evidence provided by Fullerton and Wempe (2009). They conveyed an important evidence about the role of non-financial performance (or operations performance) indicators in mediating the relationship between lean manufacturing and financial performance (or business performance). In line with this study, they revealed that without monitoring operations performance (in terms of equipment stoppage, throughput time, setup time, on-time delivery, inventory turnover, scrap, rework, manufacturing efficiency, labor productivity, and supplier performance (e.g., product quality and on-time delivery)), practitioners who are applying lean manufacturing could experience unsatisfactory business performance.

Supported by a number of previous studies, the present study revealed that achievements in all the indicators of operations performance enable the producers to serve customers in a profitable manner.

7.5 Implications of Study

Based on the discussion above, the findings of qualitative research are consistent and supporting the findings of quantitative research. This study conveyed several implications, not only for academicians but also for practitioners. The implications served as the contribution to the body of knowledge for academia and recommendation to practitioners in lean manufacturing. In this section, theoretical, practical, and methodological implications are presented.

7.5.1 Theoretical Implication

The relationship among the variables was theoretically and empirically supported. Thus, expectantly, this study conveys contributions to the body of knowledge, which are summarized into four different aspects.

Firstly, in developing the research framework, this study combined three different theories, namely RBV, ABV, and complementarity theories. In order to explain how all the three variables (i.e., lean manufacturing, operations performance, and business performance) interact with each other, the three theories must be in place. As elaborated in Chapter Three, the RBV suffers from at least three factors, namely lack of the link relating the resources and value creation (Priem & Butler, 2001), lacks of the concept of activities (Sheehan & Foss, 2007), and lack of complementarity concept (Chan et al., 2004). To overcome the deficiencies of the RBV, this study adopted the ABV and complementarity theories. It is expected that combining the three theories provided a more robust and strong theoretical framework.

As widely described in literature, the RBV theory emphases on picking the strategic resources that are crucial in cultivating organizational performance and competitive advantage. Based on the RBV perspective, lean manufacturing practices have become a set of essential resources in achieving outstanding organizational performance and competitive advantage. However, considering the above limitations of RBV, the ABV assisted to translate and transform the strategic resources (i.e., lean manufacturing practices) into several activities. Meanwhile, the complementarity theory supported the complementary among the activities and among the resources. As revealed by various advocates of these theories, these theories assumed close linkages between strategic resources and organizational performance.

Secondly, As the RBV and ABV theories viewed lean manufacturing practices as strategic resources for a firm, these two theories do not put forward a possible interaction among the resources in conveying the potential advantages to the firms, whereas this study suggested an interaction among the strategic resources (i.e., lean manufacturing practices). In this study, the author considered the lean manufacturing practices as a set of complementary resources, in which all the practices are mutually supportive among them. This means that implementation and potential return of one practice areinfluenced by other practices. In other words, a practice could augment the effect of others.

The complementarity theory suggests that contribution of a lean manufacturing practice to company's performance depends on its complementary practices. The theory advocates that adoption of one practice positively influences the marginal return of another practice and vice-versa. So that, the complement practices tend to be implemented simultaneously because of a mutually supportive nature of the practices. As such, failure in implementing one practice negatively affects the implementation of other practices. This leads to the disappointment of the entire efforts in presenting a desired performance. Sometimes, adopting a single practice could be unsuccessful in achieving the preferred improvement development, it even causes failures (Milgrom & Roberts, 1995; Tanriverdi, 2005). Therefore, complementarity resources must be positively correlated (Khanchanapong et al., 2014). This idea is consistent with RBV that individual practice (resource) has an inadequate capacity to enhance the competitive advantage in isolation; it could reduce the effect of others (Barney, 1995).

So that, due to the complementarity nature of lean manufacturing practices, any of them cannot be able to convey the maximum return without supports from others. As such, combining all the practice and implement them simultaneously as a system is a must.

Thirdly, as this study confirmed the linkages between lean manufacturing practices, operations performance and business performance, it contributed to the knowledge on how lean manufacturing practices cultivate organizational performance. This study conveyed a conception of integral practices of lean manufacturing and comprehensive method of performance measurement. As a production system, lean manufacturing should be viewed integrally as a total system rather than piecemeal. In addition, it was evidenced that lean manufacturing practices, through operations performance, had a stronger relationship with business performance, compared to the direct relationship between lean manufacturing and business performance. This articulated the important role of operations performance as a mediator between lean manufacturing practices and business performance. This is a clue about the importance of monitoring and evaluating operating condition in a comprehensive manner instead of purely relying on the business performance.

Fourthly, this study provides a detail and original analysis of lean manufacturing and organizational performance in the manufacturing sector of Indonesia. In the context of a developing country, this study enhances an understanding regarding the role of lean manufacturing implementation in increasing performance in the discrete and large manufacturers in Indonesia. A number of studies, such as Chen and Tan (2011) and Mazanai (2012), revealed that not much attention had been given on investigating how the lean manufacturing is implemented in the developing countries, as well as its potential effects on organizational performance. Even, the study by Phan and Matsui (2010) postulated that lean manufacturing has been implemented in different ways, and they further concluded that the lean manufacturing-performance relationships were contingent on national context. As a result, this study successfully filled this gap by providing an insight into the implementation of lean manufacturing and its effect on organizational performance in the context of a developing country. It is also imperative to highlight that this study expands the literature in operations management, especially in the context of developing countries.

7.5.2 Practical Implication

From the practical viewpoint, the results from this study offer a number of suggestions to practitioners. In terms of its implementation, lean manufacturing should be applied in a holistic manner because all the nine practices are interdependent, mutually supportive, and complement to each other. In other words, they are equally imperative in cultivating companies' performance. The absence of one practice could negatively affect the implementation of others. Thus, practicing lean manufacturing in isolation or in a limited subset potentially brings the company to the unsuccessful implementation and fails to grab the potential benefits of its operation. This answers the questions in a number of studies regarding why the implementation of lean manufacturing succeeds in one plant and fails in another.

Based on the results of the quantitative phase and reinforced by the qualitative phase; broadly speaking, if a company attempts to increase its performance by implementing lean manufacturing, then it should focus on the nine practices, namely flexible resources, cellular layouts, pull system, small lot production, quick setups, uniform production level, quality control, TPM, and supplier networks.

The manufacturers are suggested to ensure that most of the resources used to support the production processes are flexible. The resources intended here are in terms of workers and facilities (such as machines, equipment, tools, and production lines). Workers must be ensured to be flexible with multiple skills, in which they can perform several different jobs. To ensure the flexibility of workers; cross-trainings, job rotations, and capability map are a must. Machines, equipment, and tools should be general purpose that can be used for several functions. Similarly, the production line must be able to absorb all the variants of the product being manufactured.

In terms of facility layouts, manufacturers are advised to warrant the flexibility of layouts. The layouts must be easily re-arranged to adopt the changes in production volume, product design, and process improvement. So that, it is important to have machines, equipment, and tools that can easily move from one location to another. In addition, the distance between the processes should be contiguous to make transportation and material handling run simply. More importantly, even though the facility layout is highly dependent on a number of contextual factors, such as type of production process, type of product, and technology; the application of U-shape layouts are preferable in many types of the production process. This application is useful to close the distance between the processes. So that, application of *shojinka* (or flexible man power line) as elaborated in Section 6.6.1.1 and 6.6.1.2, can be supported. In this type of layout, workers can perform multiple operations and a number of different machines at the same time. In addition, number of workers at the shop floor can be altered (increased or decreased) when production volume changed.

One of the essences of lean manufacturing is the pull system. Applying the pull system implies that productions and material movements are only done based on the customer requests, just as needed, no more and no less. In order to maintain the discipline of pull system, kanban system must be in place. One that highly suggested by Toyota is the use of e-kanban system to authorize productions and material movements. With e-kanban system, kanban is emailed to suppliers (or previous workstations) with a virtual system. Regardless the contextual factors as mentioned in Section 6.6.1.3, the e-kanban is useful to shorten lead time and prevent loss of kanban.

Producing in a small lot size is preferable in lean manufacturing. The concept of small lot production is in line with the idea of producing in small lot size and high frequency. This study suggests; not only production that should be performed in a small lot size, but also delivery from suppliers. As successfully applied in Toyota Indonesia, milk run delivery is strongly recommended to be implemented as part of the efforts to enhance operations performance and business performance.

Lean manufacturing requires quick setup, because in a lean manufacturing system, production is performed based on customer demand with production levelling and small lot size. In other words, to uniform production level and to produce in small lot size, setup time must be shortened. It can be done through continuous improvement activities. Shortening setup time is commonly done through converting internal setups to external setups. Therefore, most of the setup processes are done outside the machine when the previous process is still running. The shorter the setup time, the smaller the lot size, and will be the more the variety of products can be produced. Hence, to produce at uniform level and small lot size, reducing setup time must be accomplished.

Production leveling *(heijunka)* is a pre-requisite for the passage of the lean manufacturing system. The success of a lean manufacturing system is dependent on the thoroughgoing conformance to uniform production level, which is addressed to reduce production variability caused by variability in customer demand. The higher the variability, the greater the incidence of creating waste. Hence, production leveling is a key of achieving production stability. In achieving uniform production level, manufacturers are suggested to perform a number of activities; starting from smoothing customer demand with accurate forecast, mixed-model production, daily schedule adherence, uniform workload, and repetitive production. All these activities lead to production stability, steady production, and support the implementation of the pull system.

A lean manufacturing system ensures high quality of product that confirms the required specification, no defect, and no reject. Taking the smart example from Toyota, the main principle of quality control is that not receiving defect, not producing defect, and not dispatching defect. For this purpose, the manufacturers should control the quality from the very beginning stage of the production process up to delivery to customers. Autonomation *(jidoka)* was applied in Toyota to control the quality, whereby when abnormality occurred, the machines or lines will automatically stop. Every operator is given the authority to stop the production process when abnormality is detected. By applying autonomation system, operators can easily identify the source of abnormality, so that necessary actions can be taken quickly. Other than autonomation, built-in quality system should be applied. Through the built-in quality; receiving the defective product from the previous workstation, producing defects, and forwarding defects to the subsequent workstation, could be avoided. In addition, statistical quality control, the use of standard operating procedure (SOP), and application of visual control systems help the manufacturers in controlling the quality. More importantly, taking example from Toyota, quality focused teams (i.e., quality control circle) should be established. These teams meet regularly to discuss about quality and other related issues.

To ensure that the machines, equipment, and tools are in a high state of readiness for production at all the time, TPM should be implemented. It supports the stability of the lean manufacturing system. There are three activities of TPM namely, preventive maintenance, predictive maintenance, and breakdown maintenance. However, in avoiding the breakdown maintenance; preventive and predictive maintenance activities must be performed for all the facilities, especially machines, equipment, and tools. One of the good examples of doing preventive and predictive maintenance in Toyota is ownership maintenance, in which all the operators are responsible in taking care of their own machines, equipment, and tools.

A lean manufacturing system must be supported by suppliers. It is compulsory to have suppliers who had high capability in providing the needs of manufacturers. So that, mutually supportive and long-term relationship between the manufacturer and suppliers should be established. Through this nature of relationship, manufacturer and suppliers jointly solve their problems and share each other through regular meetings. In addition, supplier development programs should also be performed. The program covers developments in terms of production process, logistics, and performance aspects such as safety, quality, productivity, delivery, etc.

However, implementation of lean manufacturing should be guided by standard operating procedures (SOPs). It is very important to establish standards. The SOPs describe the standard way to perform any activities in a production system. Toyota is a good example. It developed SOPs for most of the activities involved in the production line. SOPs described the current best practice, and therefore, the employees can work similarly and according to the one best practice. Toyota is extremely rigid in regard to its standards. To ensure that, SOPs are put in place to visualize at the activity control boards. More importantly, SOPs were used by Toyota for the basis of improvement. In other words, the first step towards improvement is standardization; without standards, no improvement can be performed. This is in line with the idea from Kristensen and Israelsen (2014); the SOPs help the employees to perform continuous improvement through systematic descriptions of value added, and non-value added activities. Consequently, the SOPs should be updated and circumvented if contingencies arise. Other documents, such as work instruction, work procedure, standardized work combination sheet, changing point management, and others, were also suggested by Inamizu, Fukuzawa, Fujimoto, Shintaku, and Suzuki (2014). Book edited by Japan Management Association (1989) entitled *"Kanban just-in-time at Toyota: Management begins at the workplace"* is a good guide for developing SOPs for a company implementing lean manufacturing.

Based on the results of this study, a general guideline for lean manufacturing implementation was developed by the author, as depicted in Appendix M. It provides a standard way to implement all the nine practices of lean manufacturing. This guideline may be useful for manufacturing companies, especially discrete manufacturing process (e.g., mass customization, job shop, batch, and repetitive).

In relation to organizational performance, the present study allows practitioners to gain a deeper understanding about lean manufacturing effect on organizational performance. It confirms that when lean manufacturing is implemented holistically, higher companies' performance in terms of better quality, higher manufacturing flexibility, lower inventory, shorter lead time, higher productivity, lower costs, higher profit, better sales, and outstanding customer satisfaction could be accomplished.

In terms of performance measurement, accomplishment of lean manufacturing in improving companies' performance should be measured not only at the business level but also at the operations level. Measuring performance at the operations level is more advantageous rather than at the business level. It is rationalized because lean manufacturing is an operations strategy that is usually employed in a production floor and directly influences operating conditions. Business performance could be considered at a higher level with operations performance as a mediating variable.

Practitioners can use these significant lean manufacturing practices and activities to obtain a more rigorous knowledge on the current status of lean manufacturing implementation. In addition, it can be used to allocate responsibilities within a company for accomplishing organization-wide enhancements in lean manufacturing implementation. Further, to measure the extent of lean manufacturing implementation, the questionnaire developed in this study (as depicted in Appendix B) could be used to assess and justify the practices that should be applied and improved in order to enhance the better organizational performance. The questionnaire is valuable to determine the company's areas that need more attention. Furthermore, it is also useful to measure, confirm, and convince the operations performance and business performance obtained from lean manufacturing implementation.

The findings of the study also imply that in order to survive in the world-wide competition, manufacturers in general should be fortified to apply lean manufacturing principles holistically because empirical evidence provided support of its ability to augment operations performance and business performance. A message for practitioners and managers throughout the world is that, lean manufacturing contributions toward operations performance and ultimately business performance are tremendous. Hence, those manufacturers employing lean manufacturing would benefit during a long term period. In line with this impression, Rahman et al. (2010) through their study in Thai manufacturers postulated that lean manufacturing is relevant not only for large companies but also small and medium companies. Other than that, Shah and Ward (2003) have underlined that although lean manufacturing is frequently employed in discrete part industries, its practices are also usually applied in process industries. In such a way, lean manufacturing is prevalent in all types of industries.

Lastly, this study provides a beneficial viewpoint for manufacturers all over the world to understand and corroborate potential benefits that lean manufacturing can convey if implemented. The author hopes that any suggestions and ideas given will help practitioners and managers in steering their companies towards being more competitive. Sustaining lean manufacturing as a production system is indeed a brilliant choice in order to enhance its performance and competitive advantage. It is hoped; practitioners and other stakeholders can drive the company with actively supporting into lean manufacturing approach, always searching for ways to eliminate waste, continuously improving the process, and getting employees to live and breathe lean manufacturing.

7.5.3 Methodological Implication

Driven by the research questions, the present study applied sequential explanatory mixed methods, in which the study was started by a quantitative phase and followed by a qualitative phase. The qualitative phase was addressed to explain further, validate, and triangulate the results of the quantitative study. This mixed methods focus not only on procedures of data collection, data analysis and possibly interpretation, but on every stage of the research process; from the beginning to the end of inquiry. Thus, integrating the two methods helps the researchers to reach a deeper understanding about the effect of lean manufacturing on company's performance.

Underpinned by philosophical assumptions, this study was designed thoroughly. In the quantitative phase, this study constructed a comprehensive measure of lean manufacturing and organizational performance through combining measurements from various past studies. The constructed measurements passed a series of validation efforts, and fulfilled the criteria of good measurement instrument. Data was analyzed by using SEM with AMOS software. Applying this approach, all the parameters involved in the study are simultaneously estimated, so that measurement errors were well controlled. SEM provides complete information regarding the extent to which a model is supported by data. So that, biasness were rigorously eliminated. More importantly, the study applied parceling method to increase stability of parameter estimates, to remedy small sample size, to reduce complexity of the model, to simplify interpretation, and to obtain model fits. This study provided strong justifications for applying this method, and has successfully obtained meaningful results.

In attempting to gain a better understanding about the effect of lean manufacturing on organizational performance, the quantitative result was further explained by qualitative phase through a case study method. The author was attached in Toyota Indonesia for one month. In this phase, the author personally saw how lean manufacturing is implemented, and successfully gained more insight regarding the lean manufacturing implementation and its effect on performance.

The author showed that applying mixed methods helps to compensate the weaknesses of each single method with the strengths of another (Jick, 1979). Quantitative method was frequently criticized because of lack of depth and understanding, whereas qualitative method was complained because of being anecdotal and difficult to generalize. Hence, combining the two methods conveys to more convincing results. The findings could enhance practitioners' confidence in implementing lean manufacturing.

It is hoped that this study contributes in enriching research methodology literature, especially sequential explanatory strategy mixed methods. In the area of lean manufacturing, to the author's knowledge, previous studies were dominated by a single method, either quantitative or qualitative. This study provides an insight of applying mixed methods in operations management, especially in lean manufacturing.

7.6 Limitation and Suggestion for Future Research

As with all research, this study is not without limitation. It is necessary to unveil these limitations. One of the important benefits is that limitations of the study should be considered when interpreting the findings and before taking any action from the outcomes from the research. At least, there are two important aspects that need to be addressed in this section, namely contextual and methodological aspects.

The first limitation is related to the context of the study. This study involved large manufacturers categorized under discrete process industries in a single country (i.e., Indonesia). The qualitative phase of this study tends to suggest that implementation of lean manufacturing, and its effect on organizational performance could be influenced by a number of contextual factors beyond the manufacturing process. Type of production process, size of company, type of product, technology used, etc. could affect the results of study. As it is habitual when data used in a study are from a particular context, the findings are probably irrelevant in other contexts. To some extent, the results may not be applicable beyond the context of the study. Undoubtedly, it would be advantageous to investigate the lean manufacturing implementation and its effect on organizational performance by considering those contextual factors.

Related to the context of the study, the case study was conducted in a single company (i.e., Toyota Indonesia). Even though the study was conducted in four different plants, the implementations of lean manufacturing in each plant are closely resembled because the plants are still under the same umbrella. It is well-known that Toyota was the pioneer of lean manufacturing philosophy, and surely it had been implementing lean manufacturing for a long time, and more importantly; lean manufacturing has become a culture within the company. It is undeniable that the implementation of lean manufacturing in Toyota had been perfectly done, and the benefits of its implementation had been fully realized. The implementation of lean manufacturing and its effect on performance are varied across the companies. Therefore, conducting a case study in other companies could be valuable. It is also suggested to conduct multiple case studies, so that the cross-comparison could be performed to obtain a more comprehensive understanding regarding the phenomena.

The quantitative phase of the study was a cross-sectional study, in which the data was collected once and represented a snapshot at one point in time. As discussed in the literature and supported by the result of qualitative phase of this study; lean manufacturing is a long-term initiative, and requires a long-term commitment (Jasti &

Kodali, 2014). Thus, the benefits of lean manufacturing implementation could not be realized in a short-term. Given that, implications of lean manufacturing on operations performance and business performance may be relative at the time of its implementation. So that, conducting a longitudinal study in a long term would be important to accurately investigate the relationship among the variables of the study.

In the quantitative phase, data pertaining to all the variables were collected using mail-based survey methodology. Single respondent represented the whole company. Even though the respondents were key persons of knocking the ropes of lean manufacturing and organizational performance in the surveyed companies, a number of factors might be influenced the answer, such as their experiences, knowledge, self-perception, work situation, and even personal condition. Therefore, although the questionnaire had passed the validity and reliability tests, and there was no issue of CMV in the data, respondents' answer may have differed from that intended. To avoid this limitation, the future studies can consider collecting quantitative data from multiple respondents in one company. In addition, future studies are also suggested to combine perceptual and objective measures to provide a more convincing conclusion. The objective measures could be obtained from companies' documents, such as operational report, annual report, and others.

7.7 Conclusion

This study contributes toward the understanding regarding the potential effect of lean manufacturing on operations performance and business performance. It was indicated that in order to achieve potential benefits of lean manufacturing, it must be implemented holistically, not piecemeal. Applying lean manufacturing practices in isolation or in a limited subset could be unsuccessful in achieving the desired performance, it even causes failures. The holistic implementation of lean manufacturing positively affects operations performance and business performance. In addition, operations performance positively contributes to the enhancement of business performance of the companies. More importantly, operations performance complementary mediates the relationship between lean manufacturing and business performance, in which both direct and indirect effects do exist and point at the same direction (i.e., positive relationship). Hence, the higher the level of lean manufacturing implementation, the higher the operations performance and business performance.

The findings of the study partially explain the mixed results from prior studies examining performance effects of lean manufacturing. Confidently, the present study could be a stepping stone in dealing with manufacturing issues, especially in the developing countries like Indonesia. It is also expected; the study can contribute theoretically and practically to the manufacturers throughout the world with the significant and necessary advantages to compete globally.

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Appendix A: Measurement Items

Appendix A.1: Measurement Items of Lean Manufacturing Practices

No	Item	Literature
Flexible Resources		
1	If a particular workstation has no demand, production workers can go elsewhere in the manufacturing facility to operate a workstation that has demand.	Finch (2008); Hirano (2009); Ketokivi and Schroeder (2004)
2	If one production worker is absent, another production worker can perform the same responsibilities.	Finch (2008); Hirano (2009); Sakakibara et al. (1993)
3	Production workers are cross-trained to perform several different jobs.	Shah and Ward (2007); Finch (2008); Furlan et al. (2011b); Ketokivi and Schroeder (2004)
4	We use general-purpose machines, which can perform several basic functions.	Russell and Taylor (2011); Hirano (2009)
5	Production workers are capable of performing several different jobs.	Sakakibara et al. (1993); Russell and Taylor (2011); Ketokivi and Schroeder (2004)
6	When one machine is broken down, different type of machine can be used to perform the same jobs.	Russell and Taylor (2011); Hirano (2009)
7	When one machine is stopped, production workers are not idle.	Russell and Taylor (2011); Hirano (2009)
Cellular Layouts		
1	Sequence of material flow can be changed in case of machine breakdown.	Rogers (2008); Hirano (2009)
2	Machines are in close proximity to each other.	Sakakibara et al. (1993); Abdallah and Matsui (2007); Matsui (2007)
3	Layout of workstations can easily be changed depending on sequence of operations required to make the product.	Rogers (2008); Hirano (2009)
4	Production facilities are arranged in relation to each other, so that material handling is minimized	Russell and Taylor (2011); Hirano (2009)
5	Machines can be easily moved from one workstation to another.	Sakakibara et al. (1993); Hirano (2009)
6	We group dissimilar equipment into a workstation to process a family of parts with similar requirements (such as shapes, processing or routing requirement).	Koufteros et al. (1998); Russell and Taylor (2011); Chase et al. (2004); Fullerton and Wempe (2009)
7	Production processes are located close together, so that material movement is minimized.	Sakakibara et al. (1993); Abdallah and Matsui (2007); Matsui (2007)
8	Families of products determine our factory layout.	Fullerton and Wempe (2009); Hofer et al. (2011)
Pull System		
1	Kanban system is used to authorize production (Kanban is a work signaling system such as cards, verbal signals, light flashing, electronic messages, empty containers, etc.).	Russell and Taylor (2011); Sakakibara et al. (1993); Flynn et al. (1995); Abdallah and Matsui (2007)
2	Production at a particular workstation is performed based on the current demand of its subsequent workstation.	Koufteros et al. (1998); Shah and Ward (2007)
3	We produce an item only when requested for by its users.	Russell and Taylor (2011); Shah and Ward (2007)
4	To authorize orders to suppliers, we use supplier kanban that rotates between factory and suppliers.	Russell and Taylor (2011); Aziz and Hafez (2013)
5	We use kanban system to authorize material movements.	Russell and Taylor (2011); Monden (2012)
6	We use pull system (producing in response to demand from the next stage of production process) to control our production rather than schedule prepared in advance.	Russell and Taylor (2011); Sakakibara et al. (1993)

Appendix A.1 (Continued)

No	Item	Literature
Small Lot Production		
1	We produce in more frequent but smaller lot size.	Russell and Taylor (2011); Agus and Hajinoor (2012)
2	We emphasize producing small quantity of items together in a batch.	Sakakibara et al. (1993); Flynn et al. (1995); Matsui (2007); Agus and Hajinoor (2012)
3	We aggressively work on reducing production lot sizes.	Sakakibara et al. (1993); Flynn et al. (1995); Agus and Hajinoor (2012); Zelbst et al. (2010)
4	We emphasize producing in small lot sizes to increase manufacturing flexibility.	Matsui (2007); Finch (2008); Furlan et al. (2011b); Agus and Hajinoor (2012)
5	We receive products from suppliers in small lot with frequent deliveries.	Bartezzaghi and Turco (1989); Monden (2012)
6	In our production system, we strictly avoid flow of one type of item in large quantity together.	Matsui (2007); Agus and Hajinoor (2012)
7	We produce only in necessary quantities, no more and no less.	Russell and Taylor (2011); Cheng and Podolsky (1993)
Quick Setups		
1	We converted most of machine setups to external setup that can be performed while the machine is still running with previous operation.	Sakakibara et al. (1993); Abdallah and Matsui (2007); Ketokivi and Schroeder (2004)
2	Production workers perform their own machines' setups.	Sakakibara et al. (1993); Flynn et al. (1995); Abdallah and Matsui (2007)
3	We aggressively work on reducing machines' setup times.	Sakakibara et al. (1993); Shah and Ward (2007); Zelbst et al. (2010); Ketokivi and Schroeder (2004)
4	We emphasize to put all tools in normal storage location.	Fynes and Voss (2002); Hirano (2009)
5	Production workers don't have trouble in finding the equipment they need.	Fynes and Voss (2002); Hirano (2009)
6	Production workers are trained on machines' setup activities.	Taj and Morosan (2011); Hirano (2009); Ketokivi and Schroeder (2004)
7	We can quickly perform our machines' setup if there is a change in process requirements.	Russell and Taylor (2011); Hirano (2009)
Uniform Production Level		
1	We produce more than one product model from day to day (mixed model production).	Sakakibara et al. (1993); Russell and Taylor (2011)
2	We emphasize on a more accurate forecast to reduce variability in production.	Russell and Taylor (2011)
3	Each product is produced in a relatively fixed quantity per production period.	Cheng and Podolsky (1993); Jones (2006); Coleman and Vaghefi (1994)
4	We emphasize to equate workloads in each production process.	Coleman and Vaghefi (1994); Russell and Taylor (2011); Monden (2012)
5	Daily production of different product models is arranged in the same ratio with monthly demand.	Russell and Taylor (2011); Jones (2006); Coleman and Vaghefi (1994)
6	We produce by repeating the same combination of products from day to day.	Sakakibara et al. (1993); Russell and Taylor (2011)
7	We always have some quantity of every product model to response to variation in customer demand.	Russell and Taylor (2011); Coleman and Vaghefi (1994); Jones (2006)

Appendix A.1 (Continued)

No	Item	Literature
Quality control		
1	We use statistical techniques to reduce process variances.	Russell and Taylor (2011); Ketokivi and Schroeder (2004)
2	We use visual control systems (such as *andon*/line-stop alarm light, level indicator, warning signal, signboard, etc.) as a mechanism to make problems visible.	Russell and Taylor (2011); Hirano (2009); Chase et al. (2004)
3	Production processes on production floors are monitored with statistical quality control techniques.	Russell and Taylor (2011); Shah and Ward (2007); Ketokivi and Schroeder (2004)
4	Quality problems can be traced to its source easily.	Russell and Taylor (2011); Chase et al. (2004); Ketokivi and Schroeder (2004)
5	Production workers can identify quality problems easily.	Russell and Taylor (2011); Hirano (2009)
6	Production workers are authorized to stop production if serious quality problems are occurred.	Sakakibara et al. (1993); Russell and Taylor (2011); Chase et al. (2004); Ketokivi and Schroeder (2004)
7	We have quality focused teams that meet regularly to discuss about quality issues.	Fullerton et al. (2003); Monden (2012)
8	Production workers are trained for quality control.	Cheng and Podolsky (1993); Monden (2012)
Total Productive Maintenance		
1	We ensure that machines are in a high state of readiness for production at all the time.	Sakakibara et al. (1993); Ahuja and Khanba (2007)
2	We dedicate periodic inspection to keep machines in operation.	Koufteros et al. (1998); Ahuja and Khanba (2007)
3	We have a sound system of daily maintenance to prevent machine breakdowns from occurring.	Koufteros et al. (1998); Russell and Taylor (2011)
4	We scrupulously clean workspaces (including machines and equipment) to make unusual occurrences noticeable.	Russell and Taylor (2011); Ahuja and Khanba (2007); Cheng and Podolsky (1993)
5	We have a time reserved each day for maintenance activities.	Sakakibara et al. (1993); Koufteros et al. (1998); Shah and Ward (2007)
6	Operators are trained to maintain their own machines.	Moayed and Shell (2009)
7	We emphasize good maintenance system as a strategy for achieving quality compliance.	Koufteros et al. (1998); Sakakibara et al. (1993)
Supplier Networks		
1	We facilitate suppliers to maintain a warehouse near to our plant.	Russell and Taylor (2011) Monden (2012)
2	We strive to establish long-term relationships with suppliers.	Sakakibara et al. (1993); Russell and Taylor (2011); Matsui (2007); Ketokivi and Schroeder (2004)
3	We emphasize to work together with suppliers for mutual benefits.	Monden (2012); Russell and Taylor (2011)
4	We regularly solve problems jointly with suppliers.	Monden (2012); Russell and Taylor (2011)
5	Development programs (such as engineering and quality management assistance) are provided to suppliers.	Russell and Taylor (2011); Cheng and Podolsky (1993)
6	We rely on a small number of high-performance suppliers.	Sakakibara et al. (1993); Ketokivi and Schroeder (2004)
7	Our suppliers deliver materials to us just as it is needed (on just-in-time basis).	Abdallah and Matsui (2007); Shah and Ward (2007); Matsui (2007)

Appendix A.2: Measurement Items of Operations Performance

No	Item	Literature
Quality		
1	The following quality performance indicators have significantly reduced.	
	a. Number of activities in fixing defective products to conform to quality specification (reworks).	Chong et al. (2001); Fullerton and Wempe (2009)
	b. Percentage of poor-quality products that must be discarded (scraps).	Callen et al. (2000); Upton (1998); Fullerton and Wempe (2009)
	c. Percentage of production outputs that do not meet quality specifications.	Bhasin (2008); Chong et al. (2001); Ahuja and Khanba (2007); Callen et al. (2000);
	d. Monthly defective rate at final assembly.	MacDuffie et al. (1996)
	e. Number of warranty claims per month.	Bartezzaghi and Turco (1989); Chong et al. (2001)
	f. Frequency of customer complaints per month.	Bartezzaghi and Turco (1989); Chong et al. (2001)
2	Percentage of products that pass final inspection at the first time (first-pass quality yield) has increased.	Shah and Ward (2003), Ahmad et al. (2004); Gurumurthy and Kodali (2009); Taj and Berro (2006); Taj and Morosan (2011)
3	We have superior product quality compared to competitors'.	Flynn et al. (1995); Bhasin (2008)
Manufacturing Flexibility		
1	The following indicators of manufacturing flexibility have significantly improved.	
	a. Ability to adjust to changes of product design/model in accordance with customer demand.	Ahmad et al. (2003); Bartezzaghi and Turco (1989); Taj (2005, 2008); Cheng and Podolsky (1993); Rogers (2008); Boyle and Scherrer-Rathje (2009)
	b. Ability to adjust to changes of production volume in accordance with customer demand.	Ahmad et al. (2003); Bartezzaghi and Turco (1989); Taj (2005, 2008); Rogers (2008); Boyle and Scherrer-Rathje (2009)
	c. Ability to adjust to changes of production routing in case of machine breakdown.	Rogers (2008); Boyle and Scherrer-Rathje (2009)
	d. Flexibility in work assignments to production workers.	Rogers (2008); Finch (2008)
	e. Flexibility in work assignments to machines.	Rogers (2008); Finch (2008)
	f. Ability of suppliers to deliver products on just-in-time basis (as it is needed, in the right quality, quantity, and time).	Rogers (2008); Abdallah and Matsui (2007); Shah and Ward (2007); Matsui (2007)
Lead Time Reduction		
1	The following components of lead time have significantly reduced.	
	a. Times between placing orders and receiving purchased items from suppliers.	Slack et al. (2010); Stevenson (2012)
	b. Times it takes for products to get through the factory.	Gaither and Frazier (2002)
	c. Machine setup times.	Upton (1998); Ahuja and Khanba (2007); Callen et al. (2000); Fullerton and Wempe (2009); Tersine (1994)
	d. Transportation times of an item between workstations.	Cheng and Podolsky (1993); Tersine (1994)
	e. Waiting times for an item to be moved to next operation.	Cheng and Podolsky (1993); Tersine (1994)
	f. Times required to move the finished goods from our plant to customers.	Wu (2003); Rogers (2008)
2	Most of production times have been used to perform value-added activities.	Cheng and Podolsky (1993); Heizer and Render (2011); Tersine (1994)

Appendix A.2 (Continued)

No	Item	Literature
Inventory Minimization		
1	The following inventory performance indicators have significantly reduced.	
	a. Work in process (WIP) inventory level.	Bhasin (2008); Chong et al. (2001); Taj (2008)
	b. Raw material inventory level.	Claycomb et al. (1999); Bhasin (2008); Chong et al. (2001); Taj (2008)
	c. Finished goods inventory level.	Bhasin (2008); Callen et al. (2000); ; Taj (2008)
	d. Overall inventory level.	Bhasin (2008); Claycomb et al. (1999)
	e. Storage space requirement.	Gurumurthy and Kodali (2009)
2	Inventory turnover has increased (inventory turnover is ratio of cost of goods sold and average aggregate inventory cost).	Chong et al. (2001); Bhasin (2008); Taj (2008); Fullerton and Wempe (2009)
3	Over productions that cause high inventory level have been successfully eliminated.	Garbie (2010); Wong et al. (2009)
Productivity		
1	Productivity of production line has increased due to:	
	a. Fewer interruptions by machine breakdowns.	Lazim and Ramayah (2010); Ahuja and Khanba (2007); Bamber et al. (1999); Lieberman and Demeester (1999)
	b. Shorter processing times.	Agus and Hajinoor (2012); Lewis (2000)
	c. More efficient production processes.	Fullerton and McWatters (2002)
	d. Reduced inputs (e.g., labor, energy, material and capital).	Callen et al. (2005); Abdel-Razek et al. (2007)
	e. More efficient setup processes.	Lieberman and Demeester (1999); Agus and Hajinoor (2012)
	f. Higher production worker flexibility (i.e., ability of workers to perform multiple tasks efficiently).	Rogers (2008); Abdel-Razek et al. (2007); Davis and Heineke (2005)
	g. Higher equipment flexibility (i.e., ability of equipment to perform multiple operations).	Rogers (2008)
2	Overall productivity of production line has been outstanding.	Stevenson (2012); Bartezzaghi and Turco (1989)
Costs Reduction		
1	The following costs performance indicators have significantly reduced:	
	a. Average unit manufacturing cost (the total cost for producing the units divided by quantity of units produced).	Cua et al. (2001); Shah and Ward (2003); Bhasin (2008); Ahmad et al. (2003); Chong et al. (2001)
	b. Average internal failure costs (i.e., cost of defect, scrap, rework, process failure, and downtime).	Russell and Taylor (2008); Omachonu, Suthummanon, and Einspruch (2004)
	c. Average external failure costs (i.e., cost of product returns, warranty claims, liability and lost sales).	Russell and Taylor (2008); Omachonu et al. (2004)
	d. Overall inventory costs.	Womack et al. (1990), Rahman et al. (2010); Rogers (2008)
	e. Labor costs.	Hirano (2009); Lieberman and Demeester (1999)
2	Our unit manufacturing cost is lower than competitors'.	Cua et al. (2001); Shah and Ward (2003); Bhasin (2008); Ahmad et al. (2003)

Appendix A.3: Measurement Items of Business Performance

No	Item	Literature
Profitability		
1	The following indicators of profitability have significantly increased:	
	a. Net profit margin (ratio of net income to total net sales).	Stratopoulos and Dehning (2000); Agus et al. (2011); Valmohammadi and Servati (2011)
	b. Return on investment (ratio of net income to total investment).	Stratopoulos and Dehning (2000); Claycomb et al. (1999); Green and Inman (2007); Ahmad et al. (2004); Chong et al. (2001); Anand and Ward (2004)
2	Profitability growth has been outstanding.	Green and Inman (2007); Claycomb et al. (1999); Anand and Ward (2004); Chenhall (1997)
3	Profitability has exceeded our competitors'.	Green and Inman (2007); Claycomb et al. (1999); Anand and Ward (2004)
4	Overall financial performance has exceeded competitors'.	Fullerton et al. (2003); Fullerton and Wempe (2009)
Sales		
1	The following indicators of sales performance have significantly increased:	
	a. Market share.	Green and Inman (2007); Kannan and Tan (2005); Bhasin (2008); Ahmad et al. (2004); Ahuja and Khanba (2007); Agus and Hajinoor (2012)
	b. Sales turnover (total amount sold).	Clark (2007); Küster and Canales (2011); Agus and Hajinoor (2012)
	c. Average annual sales per product model.	MacDuffie et al. (1996); White and Prybutok (2001); Rogers (2008)
	d. Ability to achieve the annual sales targets.	Kaynak (2002)
2	Sales (in dollars) growth has been outstanding.	Green and Inman (2007); Fynes and Voss (2002); Chenhall (1997); Anand and Ward (2004)
3	Sales volume growth has been outstanding.	Green and Inman (2007); Olsen (2004)
4	Market share growth has exceeded the competitors'.	Kannan and Tan (2005); Fynes and Voss (2002); Bhasin (2008); Agus and Hajinoor (2012)
5	We have generated a high level of sales.	Küster and Canales (2011)
Customer Satisfaction		
1	Customers are satisfied with our…	
	a. Overall product quality.	Bhasin (2008); Ahuja and Khanba (2007); Fynes and Voss (2002); Callen et al. (2000); Chong et al. (2001); Abdel-Maksoud et al. (2005)
	b. Products' competitive prices.	Bhasin (2008); Abdel-Maksoud et al. (2005)
	c. Response to sales enquiries.	Ahmad et al. (2004); Green and Inman (2007); Bhasin (2008)
	d. After sales services.	Ismail et al. (2006); Kaynak (2002); Bhasin (2008)
	e. Ability to fill their orders quickly.	Callen et al. (2000); Ahmad et al. (2004); Green and Inman (2007); Matsui (2007); Bhasin (2008)
	f. On-time delivery.	Sakakibara et al. (1997); Callen et al. (2000); Green and Inman (2007); Matsui (2007); Bhasin (2008); Abdel-Maksoud et al. (2005)

Appendix B: Survey Questionnaire

SURVEY QUESTIONNAIRE

Kuesioner Survey

Lean Manufacturing, Operations Performance and Business Performance in Manufacturing Companies in Indonesia

College of Business-Universiti Utara Malaysia

This questionnaire is distributed in dual language; you can select either English or Bahasa Indonesia

E N G L I S H

RESEARCH ON MANUFACTURING PRACTICES AND PERFORMANCE OF MANUFACTURING COMPANIES IN INDONESIA

General Information:
This is a PhD research to determine the effect of manufacturing practices, which are consistent with the just-in-time/lean manufacturing philosophy, on organizational performance. The researchers believed that the outcome of this research will be of immense benefit to improve performance in manufacturing sector in Indonesia. Your effort in filling the questionnaire is highly appreciated in order to produce a quality research.

General Instruction:
The questionnaire consists of four sections. Please read the items carefully before answering. You are expected to choose the answer that represents your opinion. Your answer plays an important role in the success of this study and you are assured that such information will be treated with **utmost confidentiality**. Please tick, circle the appropriate answer or complete the answer in the space provided.

Thanks for your participation.

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SECTION ONE: MANUFACTURING PRACTICES

Direction:
This section of the questionnaire focuses on manufacturing practices in the plant. It addresses the production attributes and activities implemented in your organization. On the following scale, please circle the appropriate number which best reflects your perception.

Strongly disagree					Strongly agree
1	**2**	**3**	**4**	**5**	**6**

Flexible resources						
1. If a particular workstation has no demand, production workers can go elsewhere in the manufacturing facility to operate a workstation that has demand.	1	2	3	4	5	6
2. If one production worker is absent, another production worker can perform the same responsibilities.	1	2	3	4	5	6
3. Production workers are cross-trained to perform several different jobs.	1	2	3	4	5	6
4. We use general-purpose machines, which can perform several basic functions.	1	2	3	4	5	6
5. Production workers are capable of performing several different jobs.	1	2	3	4	5	6
6. When one machine is broken down, different type of machine can be used to perform the same jobs.	1	2	3	4	5	6
7. When one machine is stopped, production workers are not idle.	1	2	3	4	5	6

Cellular layout						
1. Sequence of material flow can be changed in case of machine breakdown.	1	2	3	4	5	6
2. Machines are in close proximity to each other.	1	2	3	4	5	6
3. Layout of workstations can easily be changed depending on sequence of operations required to make the product.	1	2	3	4	5	6
4. Production facilities are arranged in relation to each other, so that material handling is minimized.	1	2	3	4	5	6
5. Machines can be easily moved from one workstation to another.	1	2	3	4	5	6
6. We group dissimilar equipment into a workstation to process a family of parts with similar requirements (such as shapes, processing, or routing requirement).	1	2	3	4	5	6
7. Production processes are located close together, so that material movement is minimized.	1	2	3	4	5	6
8. Families of products determine our factory layout.	1	2	3	4	5	6

Pull system						
1. Kanban system is used to authorize production (Kanban is a work signaling system such as cards, verbal signals, light flashing, electronic messages, empty containers, etc.).	1	2	3	4	5	6
2. Production at a particular workstation is performed based on the current demand of its subsequent workstation.	1	2	3	4	5	6

Strongly disagree					Strongly agree
1	**2**	**3**	**4**	**5**	**6**

3. We produce an item only when requested for by its users.	1	2	3	4	5	6
4. To authorize orders to suppliers, we use supplier kanban that rotates between factory and suppliers.	1	2	3	4	5	6
5. We use kanban system to authorize material movements.	1	2	3	4	5	6
6. We use pull system (producing in response to demand from the next stage of production process) to control our production rather than schedule prepared in advance.	1	2	3	4	5	6

Small lot production						
1. We produce in more frequent but smaller lot size.	1	2	3	4	5	6
2. We emphasize producing small quantity of items together in a batch.	1	2	3	4	5	6
3. We aggressively work on reducing production lot sizes.	1	2	3	4	5	6
4. We emphasize producing in small lot sizes to increase manufacturing flexibility.	1	2	3	4	5	6
5. We receive products from suppliers in small lot with frequent deliveries.	1	2	3	4	5	6
6. In our production system, we strictly avoid flow of one type of item in large quantity together.	1	2	3	4	5	6
7. We produce only in necessary quantities, no more and no less.	1	2	3	4	5	6

Quick setup						
1. We converted most of machine setups to external setup that can be performed while the machine is still running with its previous operation.	1	2	3	4	5	6
2. Production workers perform their own machines' setups.	1	2	3	4	5	6
3. We aggressively work on reducing machines' setup times.	1	2	3	4	5	6
4. We emphasize to put all tools in normal storage location.	1	2	3	4	5	6
5. Production workers don't have trouble in finding equipment they need.	1	2	3	4	5	6
6. Production workers are trained on machines' setup activities.	1	2	3	4	5	6
7. We can quickly perform our machines' setup if there is a change in process requirements.	1	2	3	4	5	6

Uniform production level						
1. We produce more than one product model from day to day (mixed model production).	1	2	3	4	5	6
2. We emphasize on a more accurate forecast to reduce variability in production.	1	2	3	4	5	6
3. Each product is produced in a relatively fixed quantity per production period.	1	2	3	4	5	6
4. We emphasize to equate workloads in each production process.	1	2	3	4	5	6
5. Daily production of different product models is arranged in the same ratio with monthly demand.	1	2	3	4	5	6

Strongly disagree					Strongly agree
1	2	3	4	5	6

6. We produce by repeating the same combination of products from day to day.	1	2	3	4	5	6
7. We always have some quantity of every product model to response to variation in customer demand.	1	2	3	4	5	6

Quality control						
1. We use statistical techniques to reduce process variances.	1	2	3	4	5	6
2. We use visual control systems (such as *andon*/line-stop alarm light, level indicator, warning signal, signboard, etc.) as a mechanism to make problems visible.	1	2	3	4	5	6
3. Production processes on production floors are monitored with statistical quality control techniques.	1	2	3	4	5	6
4. Quality problems can be traced to its source easily.	1	2	3	4	5	6
5. Production workers can identify quality problems easily.	1	2	3	4	5	6
6. Production workers are authorized to stop production if serious quality problems are occurred.	1	2	3	4	5	6
7. We have quality focused teams that meet regularly to discuss about quality issues.	1	2	3	4	5	6
8. Production workers are trained for quality control.	1	2	3	4	5	6

Total productive maintenance						
1. We ensure that machines are in a high state of readiness for production at all the time.	1	2	3	4	5	6
2. We dedicate periodic inspection to keep machines in operation.	1	2	3	4	5	6
3. We have a sound system of daily maintenance to prevent machine breakdowns from occurring.	1	2	3	4	5	6
4. We scrupulously clean workspaces (including machines and equipment) to make unusual occurrences noticeable.	1	2	3	4	5	6
5. We have a time reserved each day for maintenance activities.	1	2	3	4	5	6
6. Operators are trained to maintain their own machines.	1	2	3	4	5	6
7. We emphasize good maintenance system as a strategy for achieving quality compliance.	1	2	3	4	5	6

Supplier networks						
1. We facilitate suppliers to maintain a warehouse near to our plant.	1	2	3	4	5	6
2. We strive to establish long-term relationships with suppliers.	1	2	3	4	5	6
3. We emphasize to work together with suppliers for mutual benefits.	1	2	3	4	5	6
4. We regularly solve problems jointly with suppliers.	1	2	3	4	5	6
5. Development programs (such as engineering and quality management assistance) are provided to suppliers.	1	2	3	4	5	6
6. We rely on a small number of high-performance suppliers.	1	2	3	4	5	6
7. Our suppliers deliver materials to us just as it is needed (on just-in-time basis).	1	2	3	4	5	6

SECTION TWO: OPERATIONS PERFORMANCE

Directions:
On the following scale, please circle the appropriate number which best reflects your perception to indicate the operations performance of your plant during the past three years.

Strongly disagree					Strongly agree
1	**2**	**3**	**4**	**5**	**6**

Quality						
1. The following quality performance indicators have significantly reduced.						
a. Number of activities in fixing defective products to conform to quality specification (reworks).	1	2	3	4	5	6
b. Percentage of poor quality products that must be discarded (scraps).	1	2	3	4	5	6
c. Percentage of production outputs that do not meet quality specifications.	1	2	3	4	5	6
d. Monthly defect rate at final assembly.	1	2	3	4	5	6
e. Number of warranty claims per month.	1	2	3	4	5	6
f. Number of customer complaints per month.	1	2	3	4	5	6
2. Percentage of products that pass final inspection at the first time (first-pass quality yield) has increased.	1	2	3	4	5	6
3. We have superior product quality compared to competitors'.	1	2	3	4	5	6

Manufacturing flexibility						
1. The following indicators of manufacturing flexibility have significantly improved.						
a. Ability to adjust to changes of product design/model in accordance with customer demand.	1	2	3	4	5	6
b. Ability to adjust to changes of production volume in accordance with customer demand.	1	2	3	4	5	6
c. Ability to adjust to changes of production routing in case of machine breakdown.	1	2	3	4	5	6
d. Flexibility in work assignments to production workers.	1	2	3	4	5	6
e. Flexibility in work assignments to machines.	1	2	3	4	5	6
f. Ability of suppliers to deliver products on just-in-time basis (as it is needed, in the right quality, quantity, and time).	1	2	3	4	5	6

Lead time reduction						
1. The following components of lead time have significantly reduced.						
a. Times between placing orders and receiving purchased items from suppliers.	1	2	3	4	5	6
b. Times it takes for products to get through the factory.	1	2	3	4	5	6
c. Machine setup times.	1	2	3	4	5	6
d. Transportation times of an item between workstations.	1	2	3	4	5	6

Strongly disagree					Strongly agree
1	2	3	4	5	6

e. Waiting times for an item to be moved to next operation.	1	2	3	4	5	6
f. Times required to move finished goods from our plant to customers.	1	2	3	4	5	6
2. Most of production times have been used to perform value-added activities.	1	2	3	4	5	6

Inventory minimization						
1. The following inventory performance indicators have significantly reduced.						
a. Work in process (WIP) inventory level.	1	2	3	4	5	6
b. Raw material inventory level.	1	2	3	4	5	6
c. Finished goods inventory level.	1	2	3	4	5	6
d. Overall inventory level.	1	2	3	4	5	6
e. Storage space requirement.	1	2	3	4	5	6
2. Inventory turnover has increased (inventory turnover is the ratio of cost of goods sold and average aggregate inventory cost).	1	2	3	4	5	6
3. Over productions that cause high inventory level have been successfully eliminated.	1	2	3	4	5	6

Productivity						
1. Productivity of production line has increased due to:						
a. Fewer interruptions by machine breakdowns.	1	2	3	4	5	6
b. Shorter processing times.	1	2	3	4	5	6
c. More efficient production processes.	1	2	3	4	5	6
d. Reduced inputs (e.g., labor, energy, material and capital).	1	2	3	4	5	6
e. More efficient setup processes.	1	2	3	4	5	6
f. Higher production worker flexibility (i.e., ability of workers to perform multiple tasks efficiently).	1	2	3	4	5	6
g. Higher equipment flexibility (i.e., ability of equipment to perform multiple operations).	1	2	3	4	5	6
2. Overall productivity of production line has been outstanding.	1	2	3	4	5	6

Costs reduction						
1. The following costs performance indicators have reduced.						
a. Average unit manufacturing cost (i.e, total cost for producing the units divided by quantity of units produced).	1	2	3	4	5	6
b. Average internal failure costs (i.e., cost of defect, scrap, rework, process failure, and downtime).	1	2	3	4	5	6
c. Average external failure costs (i.e., cost of product returns, warranty claims, liability and lost sales).	1	2	3	4	5	6
d. Overall inventory costs.	1	2	3	4	5	6
e. Labor costs.	1	2	3	4	5	6
2. Our unit manufacturing cost is lower than competitors'.	1	2	3	4	5	6

SECTION THREE: BUSINESS PERFORMANCE

Directions:
On the following scale, please circle the appropriate number which best reflects your perception to indicate the business performance of your plant during the past three years.

Strongly disagree					Strongly agree
1	**2**	**3**	**4**	**5**	**6**

Profitability						
1. The following indicators of profitability have significantly increased.						
a. Net profit margin (ratio of net income to total net sales).	1	2	3	4	5	6
b. Return on investment (ratio of net income to total investment).	1	2	3	4	5	6
2. Profitability growth has been outstanding.	1	2	3	4	5	6
3. Profitability has exceeded our competitors'.	1	2	3	4	5	6
4. Overall financial performance has exceeded competitors'.	1	2	3	4	5	6

Sales						
1. The following indicators of sales performance have significantly increased.						
a. Market share.	1	2	3	4	5	6
b. Sales turnover (total amount sold).	1	2	3	4	5	6
c. Average annual sales per product model.	1	2	3	4	5	6
d. Ability to achieve the annual sales targets.	1	2	3	4	5	6
2. Sales (in dollars) growth has been outstanding.	1	2	3	4	5	6
3. Sales volume growth has been outstanding.	1	2	3	4	5	6
4. Market share growth has exceeded the competitors'.	1	2	3	4	5	6
5. We have generated a high level of sales.	1	2	3	4	5	6

Customer satisfaction						
1. Customers are satisfied with our…						
a. Overall product quality.	1	2	3	4	5	6
b. Products' competitive prices.	1	2	3	4	5	6
c. Response to sales enquiries.	1	2	3	4	5	6
d. After sales services.	1	2	3	4	5	6
e. Ability to fill their orders quickly.	1	2	3	4	5	6
f. On-time delivery.	1	2	3	4	5	6

SECTION FOUR: GENERAL INFORMATION

1. Nature of business

☐ Textiles, wearing apparel
☐ Tanning and dressing of leather
☐ Wood, products of wood (except furniture) and plaiting materials
☐ Machinery and equipment
☐ Electrical machinery and equipment
☐ Radio, television and communication equipment and apparatus
☐ Medical, precision and optical instruments, watches and clocks
☐ Motor vehicles, trailers and semi-trailers
☐ Other transport equipment
☐ Furniture
☐ Others (please specify): ____________________

2. Company's ownership

☐ State owned enterprise
☐ Private enterprise
☐ Foreign invested enterprise
☐ Joint venture
☐ Others (please specify): ____________________

3. Age of company

☐ Less than 3 years ☐ 3 – 5 years ☐ More than 5 years

4. Number of employees

☐ Less than 100 ☐ 100 – 300 ☐ More than 300

5. Type of production process

The following figure shows characteristics of five common production processes (i.e., job shop, batch, repetitive, continuous flow, and mass customization) in terms of production volume and degree of products' standardization.

		Products' standardization			
		Customized/ high variety	Semi-standardized/ medium variety	Standardized/ low variety	Highly standardized/ no variety
Production volume	Low	Job shop			
	Medium		Batch		
	High			Repetitive	
	Very high	Mass customization			Continuous flow

Based on the above figure, which one is best to represent your production process?

☐ Job shop
☐ Batch
☐ Repetitive
☐ Continuous flow
☐ Mass customization
☐ Others (plese specify): ____________________

6. Are you considering that your company is implementing lean/just-in-time (JIT) manufacturing system? (if "No", then jump to question number 11)

☐ Yes ☐ No

7. Was there any official declaration of lean/JIT manufacturing initiatives?

☐ Yes ☐ No

8. How long has your company been implementing lean/JIT manufacturing system?

☐ Less than 3 year ☐ 3 – 5 years ☐ More than 5 years

9.	**Are there any standard operating procedure guiding your company in implementing lean/JIT manufacturing system?** ☐ Yes ☐ No
10.	**Does lean/JIT manufacturing system contribute positively to your company's performance?** ☐ Yes ☐ No
11.	**Do you have any other systems/strategies that are implemented in your company?** (if "No", then jump to question number 13) ☐ Yes ☐ No
12.	**What systems/strategies that are implemented in your company?** (you can tick more than one) ☐ Flexible manufacturing ☐ Total quality control ☐ Cellular manufacturing ☐ Total productive maintenance ☐ *Heijunka* system ☐ Vendor management system ☐ Inventory management ☐ Single Minute Exchange of Dies (SMED) ☐ Total quality management ☐ Six Sigma ☐ Supply chain management ☐ Others (please specify): ____________
13.	**Your position in the company** ☐ Manufacturing director ☐ Manufacturing manager ☐ Head of production department ☐ Others (please specify): ____________
14.	**How long have you been in the current position?** ☐ Less than 1 year ☐ 1 – 3 years ☐ More than 3 years
15.	**How long have you been working in this company?** ☐ Less than 3 year ☐ 3 – 5 years ☐ More than 5 years

Please kindly send this completed survey booklet in the stamped enclosed self-address envelope provided before end of April 2013.

☐ Please tick here if you are willing to have a copy of the research report. Please enclose your business card and provide your e-mail address below.
Your email address: ________________________

Comments (optional):
____
____
____
____
____
____
____

Thank you for your participation…

Kuisioner ini disebarkan dalam dua bahasa, Bapak/Ibu dapat memilih satu diantaranya, Bahasa Indonesia atau Bahasa Inggris

BAHASA INDONESIA

PENELITIAN TENTANG AKTIVITAS-AKTIVITAS MANUFAKTUR DAN KINERJA PERUSAHAAN MANUFAKTUR DI INDONESIA

Informasi Umum:
Ini adalah penelitian S3 yang bertujuan untuk menentukan pengaruh aktivitas-aktivitas manufaktur, yang konsisten dengan filosofi *just-in-time/lean manufacturing*, terhadap kinerja organisasi. Peneliti yakin, penelitian ini berkontribusi besar dalam upaya peningkatan kinerja sektor manufaktur di Indonesia. Partisipasi Bapak/Ibu sangat berharga dalam menghasilkan penilitian yang berkualitas.

Instruksi Umum:
Kuesioner ini terdiri dari 4 bagian. Mohon dibaca dengan hati-hati sebelum dijawab. Bapak/Ibu diharapkan untuk memilih jawaban yang betul-betul menggambarkan pendapat Bapak/Ibu. Jawaban Bapak/Ibu memainkan peranan penting untuk suksesnya penelitian ini. Semua jawaban akan **dirahasiakan sepenuhnya**. Silahkan tandai, lingkari jawaban yang sesuai atau lengkapi jawaban pada tempat yang tersedia.

Terima kasih atas partisipasi Bapak/Ibu.

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BAGIAN SATU: AKTIVITAS-AKTIVITAS MANUFAKTUR

Petunjuk:
Bagian ini fokus kepada aktivitas-aktivitas manufaktur di pabrik, untuk menunjukkan aktivitas-aktivitas produksi yang diimplementasikan di perusahaan Bapak/Ibu. Pada skala berikut, silahkan lingkari angka yang sesuai untuk menunjukkan persepsi Bapak/Ibu.

Sangat tak setuju					**Sangat Setuju**
1	**2**	**3**	**4**	**5**	**6**

Sumber daya fleksibel						
1. Jika stasiun kerja tertentu tidak memiliki permintaan, operator dapat berpindah ke tempat lain di dalam fasilitas produksi untuk menjalankan stasiun kerja yang memiliki permintaan.	1	2	3	4	5	6
2. Jika seorang operator absen, operator lain dapat menggantikannya untuk menjalankan pekerjaan yang sama.	1	2	3	4	5	6
3. Pekerja produksi dilatih untuk melaksanakan beberapa pekerjaan berbeda.	1	2	3	4	5	6
4. Kami menggunakan mesin-mesin multi-fungsi yang dapat melakukan beberapa fungsi dasar.	1	2	3	4	5	6
5. Pekerja produksi mampu mengerjakan beberapa pekerjaan berbeda.	1	2	3	4	5	6
6. Ketika salah satu mesin rusak, mesin jenis lain dapat digunakan untuk pekerjaan yang sama.	1	2	3	4	5	6
7. Bila salah satu mesin berhenti beroperasi, operator tidak menganggur.	1	2	3	4	5	6

Tata letak seluler						
1. Aliran material dapat dirubah jika ada gangguan mesin.	1	2	3	4	5	6
2. Mesin-mesin kami berdekatan satu sama lain.	1	2	3	4	5	6
3. Tata letak stasiun kerja dapat dirubah dengan mudah tergantung urutan operasi pembuatan produk.	1	2	3	4	5	6
4. Fasilitas produksi disusun menurut hubungan satu sama lainnya, sehingga penanganan material terminimalkan.	1	2	3	4	5	6
5. Mesin-mesin dapat dengan mudah dipindahkan dari satu stasiun kerja ke stasiun kerja lain.	1	2	3	4	5	6
6. Kami mengelompokkan peralatan-peralatan berbeda pada stasiun kerja berdasarkan famili produk yang memiliki kesamaan (seperti kesamaan bentuk, proses, atau rute proses).	1	2	3	4	5	6
7. Proses-proses produksi saling berdekatan, sehingga pergerakan material terminimalkan.	1	2	3	4	5	6
8. Famili produk menentukan tata letak pabrik kami.	1	2	3	4	5	6

Sistem tarik						
1. Sistem kanban digunakan untuk mengotorisasi produksi (Kanban adalah sistem pemberian isyarat pekerjaan yang	1	2	3	4	5	6

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

dapat berupa kartu, tanda-tanda verbal, kedipan cahaya, pesan elektronik, kontainer kosong, dan lain-lain).						
2. Produksi pada stasiun kerja tertentu dilakukan menurut permintaan dari stasiun kerja berikutnya.	1	2	3	4	5	6
3. Kami berproduksi hanya jika diminta oleh penggunanya.	1	2	3	4	5	6
4. Untuk mengizinkan order kepada pemasok, kami menggunakan *"supplier kanban"* yang bergerak antara pabrik kami dan pemasok.	1	2	3	4	5	6
5. Kami menggunakan sistem kanban untuk mengotorisasi perpindahan material.	1	2	3	4	5	6
6. Kami menggunakan sistem tarik (berproduksi dalam merespon permintaan dari proses produksi selanjutnya) untuk mengontrol produksi, bukan berdasarkan jadwal yang dipersiapkan sebelumnya.	1	2	3	4	5	6

Produksi dengan ukuran lot kecil						
1. Kami berproduksi lebih sering tetapi dalam lot kecil.	1	2	3	4	5	6
2. Kami menekankan produksi sejumlah kecil item dalam satu batch.	1	2	3	4	5	6
3. Kami selalu berusaha menurunkan ukuran lot produksi.	1	2	3	4	5	6
4. Kami mementingkan produksi dalam ukuran lot kecil untuk meningkatkan fleksibilitas produksi.	1	2	3	4	5	6
5. Kami menerima produk dari pemasok dalam partai kecil dengan pengiriman sering.	1	2	3	4	5	6
6. Dalam sistem produksi kami, kami menghindari aliran satu jenis item barang bersama-sama dalam jumlah besar.	1	2	3	4	5	6
7. Kami berproduksi hanya dalam jumlah yang diperlukan, tidak lebih dan tidak kurang.	1	2	3	4	5	6

Setup cepat						
1. Kami mengkonversi setup mesin kepada setup eksternal yang dapat dilakukan saat mesin masih menjalankan operasi sebelumnya.	1	2	3	4	5	6
2. Pekerja produksi melaksanakan setup mesin sendiri.	1	2	3	4	5	6
3. Kami selalu berusaha untuk menurunkan waktu setup mesin.	1	2	3	4	5	6
4. Kami menekankan untuk menyimpan semua peralatan pada lokasi penyimpanan normal/standar.	1	2	3	4	5	6
5. Pekerja produksi tidak kesulitan untuk menemukan peralatan yang mereka perlukan.	1	2	3	4	5	6
6. Operator dilatih berkaitan dengan aktivitas setup mesin.	1	2	3	4	5	6
7. Kami dapat melaksanakan setup mesin dengan cepat jika ada perubahan kebutuhan proses.	1	2	3	4	5	6

Level produksi seragam						
1. Kami memproduksi lebih dari satu model produk dari hari ke hari (produksi campur merata/*mixed model production*).	1	2	3	4	5	6

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

2. Kami menekankan pada peramalan yang lebih akurat untuk mengurangi variabilitas produksi.	1	2	3	4	5	6
3. Setiap produk diproduksi pada kuantitas yang relatif tetap per-periode produksi.	1	2	3	4	5	6
4. Kami menekankan untuk menyamakan beban kerja pada setiap proses produksi.	1	2	3	4	5	6
5. Produksi harian untuk model produk yang berbeda disusun dalam rasio yang sama dengan permintaan bulanan.	1	2	3	4	5	6
6. Kami berproduksi dengan mengulangi kombinasi produk yang sama dari hari ke hari.	1	2	3	4	5	6
7. Kami selalu menyimpan setiap model produk dalam jumlah tertentu untuk merespon variasi permintaan pelanggan.	1	2	3	4	5	6

Pengendalian kualitas						
1. Kami menggunakan teknik-teknik statistik untuk mengurangi variasi proses.	1	2	3	4	5	6
2. Kami menggunakan sistem kontrol visual (seperti *andon*/tanda perintah menghentikan produksi, *level indicator*, sinyal peringatan, *signboard*, dan lain-lain) agar masalah kualitas terlihat jelas.	1	2	3	4	5	6
3. Proses produksi dipantau dengan teknik-teknik pengendalian proses statistik.	1	2	3	4	5	6
4. Masalah-masalah kualitas dapat ditelusuri ke sumbernya dengan mudah.	1	2	3	4	5	6
5. Operator dapat mengidentifikasi masalah kualitas dengan mudah.	1	2	3	4	5	6
6. Operator diberikan otoritas untuk menghentikan produksi jika terjadi masalah kualitas yang serius.	1	2	3	4	5	6
7. Kami memiliki tim kualitas terfokus yang bertemu secara reguler untuk membahas isu-isu kualitas.	1	2	3	4	5	6
8. Operator dilatih untuk melakukan kontrol kualitas.	1	2	3	4	5	6

Pemeliharaan produktif menyeluruh (TPM)						
1. Kami memastikan bahwa setiap mesin berada dalam kesiapan tinggi untuk berproduksi setiap saat.	1	2	3	4	5	6
2. Kami melaksanakan inspeksi berkala untuk menjaga mesin-mesin dapat beroperasi dengan baik.	1	2	3	4	5	6
3. Kami memiliki sistem pemerliharaan harian yang tepat untuk mencegah terjadinya kerusakan mesin.	1	2	3	4	5	6
4. Kami secara teliti membersihkan tempat kerja (termasuk mesin-mesin dan peralatan) agar kejadian yang tak biasa menjadi kentara.	1	2	3	4	5	6
5. Kami memiliki cadangan waktu setiap hari untuk aktivitas-aktivitas pemeliharaan.	1	2	3	4	5	6
6. Operator dilatih untuk menjaga mesin-mesin mereka sendiri.	1	2	3	4	5	6
7. Kami menekankan sistem perawatan yang baik sebagai strategi pencapaian standar kualitas yang ditetapkan.	1	2	3	4	5	6

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

Jaringan pemasok						
1. Kami menfasilitasi para pemasok untuk mengelola sebuah gudang berdekatan dengan pabrik kami.	1	2	3	4	5	6
2. Kami membangun hubungan jangka panjang dengan para pemasok.	1	2	3	4	5	6
3. Kami menekankan kerjasama yang saling menguntungkan dengan para pemasok.	1	2	3	4	5	6
4. Kami secara reguler memecahkan persoalan bersama-sama dengan para pemasok.	1	2	3	4	5	6
5. Program-program pembinaan (seperti bantuan teknik dan manajemen kualitas) diberikan kepada para pemasok.	1	2	3	4	5	6
6. Kami mengandalkan pemasok yang berkinerja tinggi.	1	2	3	4	5	6
7. Pemasok kami mengantarkan material yang dipasoknya kepada kami hanya pada saat dibutuhkan *(just-in-time)*.	1	2	3	4	5	6

BAGIAN DUA: KINERJA OPERASIONAL

Petunjuk:
Pada skala berikut, mohon lingkari angka yang paling mencerminkan kinerja operasional pabrik Bapak/Ibu **dalam kurun waktu tiga tahun terakhir ini**.

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

Kualitas						
1. Indikator-indikator kinerja kualitas berikut telah berkurang secara signifikan.						
a. Jumlah aktivitas untuk memperbaiki produk cacat agar memenuhi spesifikasi kualitas *(rework)*.	1	2	3	4	5	6
b. Persentase produk berkualitas rendah yang harus dibuang/tidak bisa di-*rework (scrap)*.	1	2	3	4	5	6
c. Persentase output produksi yang tidak memenuhi spesifikasi kualitas.	1	2	3	4	5	6
d. Tingkat produk cacat pada perakitan akhir per bulan.	1	2	3	4	5	6
e. Jumlah tuntutan garansi dari pelanggan per bulan.	1	2	3	4	5	6
f. Jumlah keluhan pelanggan per bulan.	1	2	3	4	5	6
2. Persentase produk yang lolos inspeksi akhir pertama *(first-pass quality yield)* telah meningkat.	1	2	3	4	5	6
3. Kualitas produk kami unggul dibandingkan kompetitor.	1	2	3	4	5	6

Fleksibilitas manufaktur						
1. Indikator-indikator fleksibilitas manufaktur berikut telah meningkat secara signifikan.						

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

a. Kemampuan merubah design/model produk sesuai permintaan pelanggan.	1	2	3	4	5	6
b. Kemampuan merubah volume produksi sesuai permintaan pelanggan.	1	2	3	4	5	6
c. Kemampuan menyesuaikan diri dengan perubahan urutan produksi jika terjadi kerusakan mesin.	1	2	3	4	5	6
d. Fleksibilitas dalam penugasan kepada pekerja produksi.	1	2	3	4	5	6
e. Fleksibilitas dalam penugasan kerja kepada mesin.	1	2	3	4	5	6
f. Kemampuan pemasok untuk mengirimkan produknya kepada kami secara *just-in-time* (sesuai kebutuhan, pada kualitas, kuantitas, dan waktu yang tepat).	1	2	3	4	5	6

Penurunan *lead time*						
1. Komponen-komponen *lead time* berikut telah berkurang secara signifikan.						
a. Waktu antara pemesanan dan penerimaan barang yang dibeli dari pemasok.	1	2	3	4	5	6
b. Waktu yang diperlukan bagi produk untuk melewati semua proses produksi.	1	2	3	4	5	6
c. Waktu setup mesin.	1	2	3	4	5	6
d. Waktu pemindahan item antar-stasiun kerja.	1	2	3	4	5	6
e. Waktu menunggu bagi suatu item untuk pindah ke operasi berikutnya.	1	2	3	4	5	6
f. Waktu yang diperlukan dari barang dikeluarkan dari pabrik sampai diterima oleh pelanggan.	1	2	3	4	5	6
2. Sebahagian besar waktu produksi telah digunakan untuk aktivitas-aktivitas produktif/bernilai tambah.	1	2	3	4	5	6

Pengurangan persediaan						
1. Indikator-indikator performansi persediaan berikut telah berkurang secara signifikan.						
a. Jumlah persediaan dalam proses.	1	2	3	4	5	6
b. Jumlah persediaan barang baku yang harus disimpan.	1	2	3	4	5	6
c. Jumlah persediaan barang jadi.	1	2	3	4	5	6
d. Jumlah persediaan secara keseluruhan.	1	2	3	4	5	6
e. Kebutuhan ruang penyimpanan.	1	2	3	4	5	6
2. Perputaran persediaan telah meningkat (perputaran persediaan adalah perbandingan antara harga pokok penjualan dengan rata-rata nilai persediaan (dalam rupiah)).	1	2	3	4	5	6
3. Produksi berlebih yang menyebabkan tingginya tingkat persediaan telah berhasil dieliminasi.	1	2	3	4	5	6

Produktivitas						
1. Produktivitas lini produksi telah meningkat karena:						
a. Lebih sedikitnya gangguan akibat kerusakan mesin.	1	2	3	4	5	6
b. Pendeknya waktu proses.	1	2	3	4	5	6
c. Lebih efisiennya proses produksi.	1	2	3	4	5	6

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

d. Berkurangnya input (seperti tenaga kerja, energi, material, dan modal).	1	2	3	4	5	6
e. Lebih efisiennya proses setup.	1	2	3	4	5	6
f. Lebih tingginya fleksibilitas pekerja produksi (kemampuan pekerja untuk melakukan banyak tugas secara efisien).	1	2	3	4	5	6
g. Lebih tingginya fleksibilitas peralatan (kemampuan peralatan untuk melakukan banyak operasi).	1	2	3	4	5	6
2. Produktivitas keseluruhan lini produksi telah cemerlang.	1	2	3	4	5	6

Penurunan biaya						
1. Indikator-indikator performansi biaya berikut telah berkurang secara signifikan.						
a. Biaya produksi rata-rata perunit (total biaya produksi semua unit dibagi dengan jumlah unit yang diproduksi).	1	2	3	4	5	6
b. Rata-rata biaya kerusakan internal (seperti biaya produk cacat, *scrap*, *rework*, kegagalan proses, dan kerusakan mesin).	1	2	3	4	5	6
c. Rata-rata biaya kerusakan eksternal (seperti biaya pengembalian produk, tuntutan garansi, penurunan harga dan kehilangan penjualan).	1	2	3	4	5	6
d. Biaya persediaan keseluruhan.	1	2	3	4	5	6
e. Biaya tenaga kerja.	1	2	3	4	5	6
2. Biaya produksi perunit kami lebih rendah daripada kompetitor.	1	2	3	4	5	6

BAGIAN TIGA: KINERJA BISNIS

Petunjuk:
Pada skala berikut, mohon lingkari jawaban yang paling mencerminkan kinerja bisnis perusahaan Bapak/Ibu **dalam kurun waktu tiga tahun terakhir**.

Sangat tak setuju					Sangat Setuju
1	**2**	**3**	**4**	**5**	**6**

Profitabilitas						
1. Indikator-indikator profitabilitas berikut telah meningkat secara signifikan.						
a. Marjin keuntungan bersih (rasio pendapatan bersih terhadap total penjualan bersih).	1	2	3	4	5	6
b. Pengembalian investasi/*return on investment* (rasio pendapatan bersih terhadap total investasi).	1	2	3	4	5	6
2. Pertumbuhan profitabilitas kami cemerlang.	1	2	3	4	5	6
3. Profitabilitas kami telah melebihi para kompetitor.	1	2	3	4	5	6

Sangat tak setuju					Sangat Setuju
1	2	3	4	5	6

4. Secara keseluruhan, kinerja finansial kami unggul dibandingkan kompetitor.	1	2	3	4	5	6

Penjualan						
1. Indikator-indikator profitabilitas berikut telah meningkat secara signifikan.						
a. Pangsa pasar.	1	2	3	4	5	6
b. Omset penjualan.	1	2	3	4	5	6
c. Rata-rata penjualan tahunan per-model produk.	1	2	3	4	5	6
d. Kemampuan untuk mencapai target penjualan tahunan.	1	2	3	4	5	6
2. Peningkatan penjualan (dalam Rupiah) telah cemerlang.	1	2	3	4	5	6
3. Peningkatan volume penjualan telah cemerlang.	1	2	3	4	5	6
4. Peningkatan pangsa pasar kami telah melebihi kompetitor.	1	2	3	4	5	6
5. Kami telah menghasilkan tingkat penjualan yang tinggi.	1	2	3	4	5	6

Kepuasan Pelanggan						
1. Pelanggan puas dengan …						
a. Kualitas produk kami secara keseluruhan.	1	2	3	4	5	6
b. Harga produk kami yang kompetitif.	1	2	3	4	5	6
c. Tanggapan kami terhadap permintaan keterangan penjualan.	1	2	3	4	5	6
d. Layanan purna jual yang kami sediakan.	1	2	3	4	5	6
e. Kemampuan kami untuk memenuhi permintaan pelanggan secara cepat.	1	2	3	4	5	6
f. Pengiriman kami yang tepat waktu.	1	2	3	4	5	6

BAGIAN EMPAT: INFORMASI UMUM

1. Area Bisnis Perusahaan

- ☐ Tekstil dan pakaian jadi
- ☐ Kulit, barang dari kulit, dan alas kaki
- ☐ Kayu dan produk dari kayu dan gabus (selain perabot) dan bahan anyaman
- ☐ Mesin dan peralatan
- ☐ Mesin listrik dan perlengkapannya
- ☐ Radio, televisi, alat komunikasi dan perlengkapannya
- ☐ Alat-alat medis, presisi, optik, dan jam
- ☐ Kendaraan bermotor, trailer dan semi-trailer
- ☐ Alat angkutan selain kendaraan roda empat atau lebih
- ☐ Perabot
- ☐ Lain-lain (silahkan nyatakan): ____________________

2. Struktur Kepemilikan Perusahaan

- ☐ Perusahaan pemerintah
- ☐ Perusahaan swasta
- ☐ Perusahaan investasi asing
- ☐ Usaha patungan
- ☐ Lain-lain (silahkan nyatakan): ____________________

3. Usia Perusahaan

☐ Kurang dari 3 tahun ☐ 3 – 5 tahun ☐ Lebih dari 5 tahun

4. Jumlah Pekerja

☐ Kurang dari 100 orang ☐ 100 – 300 orang ☐ Lebih dari 300 orang

5. **Tipe Proses Produksi**

Gambar berikut ini menunjukkan karakteristik dari 5 proses produksi (yaitu *job shop, batch, repetitive, continuous flow* dan *mass customization*) dalam hal volume produksi dan tingkat standarisasi produk.

		Standarisasi produk			
		Sesuai order/ Variasi tinggi	Semi-terstandar/ Variasi sedang	Terstandar/ Variasi rendah	Sangat terstandar/ Tidak ada variasi
Volume Produksi	Rendah	*Job shop*			
	Sedang		*Batch*		
	Tinggi			*Repetitive*	
	Sangat Tinggi	*Mass customization*			*Continuous flow*

Berdasarkan gambar di atas, proses produksi mana yang paling sesuai untuk menunjukkan proses produksi yang diterapkan di perusahaan Bapak/Ibu?

☐ *Job shop* ☐ *Continuous flow*
☐ *Batch* ☐ *Mass customization*
☐ *Repetitive* ☐ Lain-lain (silahkan nyatakan):
____

6. Menurut Bapak/Ibu, apakah perusahaan Bapak/Ibu telah menerapkan sistem *lean manufacturing/just-in-time?* (Jika "Tidak", silahkan langsung ke pertanyaan No. 11)

☐ Ya ☐ Tidak

7. Apakah ada deklarasi resmi penerapan *lean manufacturing/just-in-time* di perusahaan Bapak/Ibu?

☐ Ya ☐ Tidak

8. Sudah berapa lama perusahaan Bapak/Ibu menerapkan sistem *lean manufacturing/just-in-time?*

☐ Kurang dari 3 tahun ☐ 3 – 5 tahun ☐ Lebih dari 5 tahun

9. Apakah perusahaan Bapak/Ibu memiliki prosedur standar (seperti SOP) sebagai pedoman dalam mengimplementasikan *lean manufacturing/just-in-time*?

☐ Ya ☐ Tidak

10. Apakah sistem *lean manufacturing/just-in-time* yang diterapkan di perusahaan Bapak/Ibu berkontribusi positif terhadap kinerja perusahaan?

☐ Ya ☐ Tidak

11. Apakah ada sistem/strategi lain (selain *lean manufacturing/just-in-time*) yang diterapkan di perusahaan Bapak/Ibu? (Jika "Tidak", selesai)

☐ Ya ☐ Tidak

12. Selain *lean manufacturing/just-in-time*, sistem/strategi apa saja yang saat ini sedang diimplementasikan di perusahaan Bapak/Ibu? (Bapak/Ibu bisa memilih lebih dari satu jawaban) ☐ *Flexible manufacturing* ☐ *Total quality control* ☐ *Cellular manufacturing* ☐ *Total productive maintenance* ☐ Sistem *heijunka* ☐ *Vendor management system* ☐ Manajemen inventori ☐ *Single minute exchange of dies (SMED)* ☐ *Total quality management (TQM)* ☐ *Six Sigma* ☐ *Supply chain management (SCM)* ☐ Lain-lain (Silahkan nyatakan): ______________
13. Jabatan Bapak/Ibu di perusahaan saat ini ☐ Direktur produksi ☐ Manajer produksi ☐ Kepala departemen produksi ☐ Lain-lain (silahkan nyatakan): ______________
14. Sudah berapa lama Bapak/Ibu menjabat pada posisi yang sekarang? ☐ Kurang dari 1 tahun ☐ 1 – 3 tahun ☐ Lebih dari 3 tahun
15. Sudah berapa lama Bapak/Ibu bekerja pada perusahaan ini? ☐ Kurang dari 3 tahun ☐ 3 – 5 tahun ☐ Lebih dari 5 tahun

Mohon kiranya Bapak/Ibu sudi mengirimkan kembali kuesioner yang telah diisi lengkap di dalam amplop tertutup yang kami sediakan sebelum April 2013.

☐ Silahkan tandai disini jika Bapak/Ibu ingin memiliki salinan laporan penelitian ini.
Silahkan Bapak/Ibu sertakan kartu nama dan tuliskan alamat e-mail di bawah ini.
Alamat e-mail: ______________________

Komentar (opsional):
____
____
____
____
____
____
____
____

Terima kasih atas partisipasi Bapak/Ibu…

Appendix C: Letter for Quantitative Data Collection from OYA-GSB

UUM
Universiti Utara Malaysia

Othman Yeop Abdullah Graduate School of Business
Universiti Utara Malaysia
06010, Sintok Kedah Darul Aman,
Malaysia
Tel : (604) 9283901
Fax : (604) 9285220
Website: www.oyagsb.uum.edu.my

"KEDAH SEJAHTERA"

UUM/OYAGSB/K-14
06 March 2013

1. PRODUCTION DIRECTOR
2. PRODUCTION MANAGER
3. LEAN MANUFACTURING IMPLEMENTER
INDONESIAN MANUFACTURING COMPANIES

Dear Sir/Madam

DATA COLLECTION

PROGRAMME : DOCTOR OF PHILOSOPHY
SUPERVISORS : ASSOC. PROF. DR. LIM KONG TEONG/DR. SITI NOREZAM OTHMAN

This is to certify that the following is a postgraduate student from the OYA Graduate School of Business, Universiti Utara Malaysia. He is pursuing the above mentioned course which requires him to undertake an academic study at any organization. The details are as follows:

NO.	NAME	MATRIC NO.
1.	Gusman Nawanir	93557

In this regard, I hope that you could kindly provide assistance and cooperation for him to successfully complete his PhD Thesis entitled **"Lean Manufacturing Practices, Operations Performance, and Business Performance of Indonesian Manufacturing Companies"**. All the information gathered will be strictly used for academic purposes only.

Your cooperation and assistance is very much appreciated.

Thank you.

"SCHOLARSHIP, VIRTUE, SERVICE"

Yours faithfully

KARTINI BINTI DATO' TAJUL URUS
Assistant Registrar
on behalf of
Dean
Othman Yeop Abdullah Graduate School of Business

c.c - Student's File (93557)

The Eminent Management University

Appendix D: Application Letter for Quantitative Data Collection

UUM
Universiti Utara Malaysia

School of Technology Management and Logistics (STML)
UUM College of Business
Universiti Utara Malaysia
06010 UUM Sintok
Kedah Darul Aman, Malaysia
Tel: (604) 928 6857/6858
Fax: (604) 928 6860
www.uum.edu.my

March 6, 2013

1. Production Director
2. Head of Production Department
3. Production Manager
4. Lean Manufacturing Implementer

Indonesian Manufacturing Companies
c.q. ________________________________

Dear Sir/Madam,

REQUEST FOR PARTICIPATING AS RESPONDENT IN PhD RESEARCH

I am an Indonesian, who is now conducting research as a fulfillment to complete the program of PhD at the School of Technology Management and Logistics, Universiti Utara Malaysia.

This research aims to determine the impact of the manufacturing practices, which are consistent with the just-in-time/lean manufacturing philosophy, on organizational performance. The researchers believed that the outcome of this research will be of immense benefit to improve performance in the Indonesian manufacturing sector. Your effort in filling the questionnaire is highly appreciated.

The questionnaire consists of four sections. Please read the items carefully before answering. Where appropriate, please tick in the box, circle the number or complete the answer in the space provided. This questionnaire is published in dual language; you can select either English or Bahasa Indonesia.

Please return the completed questionnaire booklet in the stamped self-addressed envelope provided in the next 14 days if possible. If you would like to receive a summary of the research results, please enclose your business card in the returned envelope.

For your information, this research is conducted through a rigorous process, and it has been reviewed and approved by the review board of College of business, Universiti Utara Malaysia.

Thanks for your cooperation and participation.

Gusman Nawanir PhD Candidate	gsm1410@gmail.com s93557@student.uum.edu.my	+60146317166 +6049282490 +62752777103
Assoc. Prof. Dr. Lim Kong Teong Main Supervisor	ktlim@uum.edu.my	+6049287199
Assoc. Prof. Dr. Siti Norezam Othman Co-supervisor	norezam@uum.edu.my	+6049287141

The Eminent Management University

Appendix E: Overview of Toyota Indonesia

Toyota Indonesia was established on 12th April 1971. It means that Toyota Indonesia has worked for more than four decades to provide and present various types of vehicles. While Indonesia is the largest five Toyota market throughout the world, it has become a potential production field for Toyota, through production in Sunter (plant I and II), and Karawang (plant I and II). Toyota Indonesia is not only producing vehicles, but also the engines used in various types of commercial and passenger vehicles of Toyota. For supporting vehicle and engine productions, Toyota Indonesia is producing body parts, casting materials, dies and jigs. Besides production, it exports various types of Toyota vehicles' component. Hence, it produces a variety of products such as vehicles, components, jigs and dies, and service parts.

In brief, business process of Toyota Indonesia is presented in Figure F.1. Sunter plant is divided into five divisions, namely engine production division (EPD), component export vanning division (CEVD), casting division, dies and jigs design and fabrication division (DJDF), and stamping division. Karawang plants (plant I and II) are vehicle assembly plants. Karawang Plant I assembles Innova and Fortuner, and Karawang Plant II assembles Yaris, Vios, and Etios Valco. Figure F.1 also provides information regarding suppliers and customers of Toyota Indonesia. Suppliers and customers are not only domestic but also foreign countries.

This study focuses on implementation of lean manufacturing in the discrete part production. As the qualitative study is addressed to explain and confirm the quantitative findings, the discrete process plants (i.e., engine production, component export and vanning, stamping, and vehicle assembly plants) were selected. Profiles of the four plants are subsequently exhibited.

Figure F.1
Toyota Indonesia Production and Logistics

Stamping Plant

There are two stamping plants under the umbrella of Toyota Indonesia, one is located in Sunter II and another one is in Karawang (see Figure F.1). Stamping process is the first stage of making cars. Here, sheets of steel are molded into car body parts such as frames and doors, as well as sub-assembly body parts (such as cabins, decks, chassis frames, etc.). Main products of stamping plants are bodies for Toyota vehicles (i.e., Innova, Fortuner, Etios Valco, Avanza, Rush, and Dyna). The plants are also produced service parts for various types of Toyota vehicles.

As displayed in Figure F.4, production process is started in a metal cutting center, in which the basic material (in a coil form) is cut to become sheets of plate. The sheets are then stored in a material warehouse. Some of the material are sheared into smaller sheets in a plate shearing machine, because of its process requirement. Subsequently, the plates are flowed to stamping machine, and press/stamping process is then performed. The scrap of this process (i.e., small pieces plate left over after the greater part has been used) will either be re-used to produce other stamping products or recycled as material for casting products. After the stamping process, finished goods are subsequently stored before its delivery to customers (i.e., Karawang vehicle assembly plants, CEVD, Astra Daihatsu Motor (ADM), and Hino Motor Manufacturing Indonesia (HMMI)).

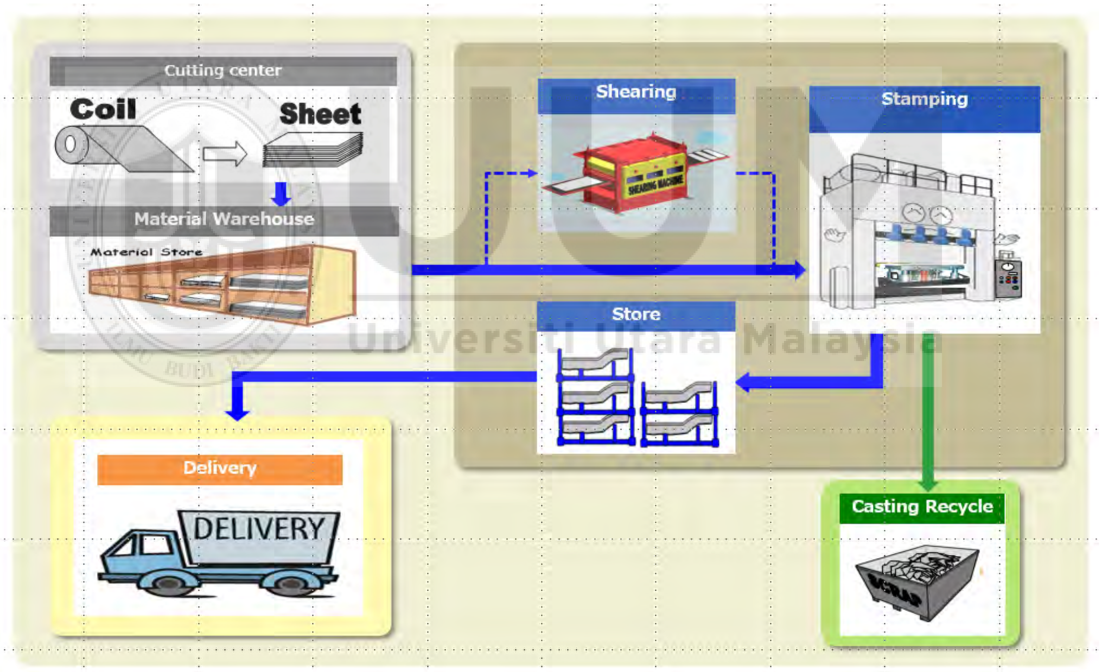

Figure F.4
Stamping Production Process

Production process in the stamping plant is characterized by batch production because of the needs of setup processes (i.e., dies change) in the early stage of every batch of product being manufactured.

Engine Production Plant

Toyota engine production was established on 1982 through Sunter Plant I. Various models of engine have been produced. In 1985, 5K engine model was produced and assembled. 7K engine model was successfully produced in 1995. In the same year, Toyota Indonesia started its first engine export to Japan. This success made Toyota Indonesia was assigned by its parent company (i.e., TMC) to produce TR engine model (used for Toyota Innova and Fortuner) in September 2004. Because of the high demand of domestic and global markets, the engine plant needs to increase its production capacity by constructing a new engine plant in Karawang. Its construction was begun on early 2014, and will start its operations in 2016.

Engines are produced through several production processes (see Figure F.2). The first process is casting, in which fusion of all basic engine material occurs. Five processes (i.e., core making, molding, melting, pouring, and finishing) are carried out in the casting plant. Quality of the basic materials are ensured through laboratory test to confirm metal structure, dimensions of engine block, and so on. Subsequently, the materials undergo machining processes to convert them to become main engine parts (i.e., cylinder block, cylinder head, cam shaft, and crank shaft). Lastly, the main and its supporting components are assembled to become an engine unit. Engines that have been completely assembled go through the process of quality assurance before being delivered to customers. Besides serving vehicle assembly plants, the engine plant also serves domestic and foreign markets.

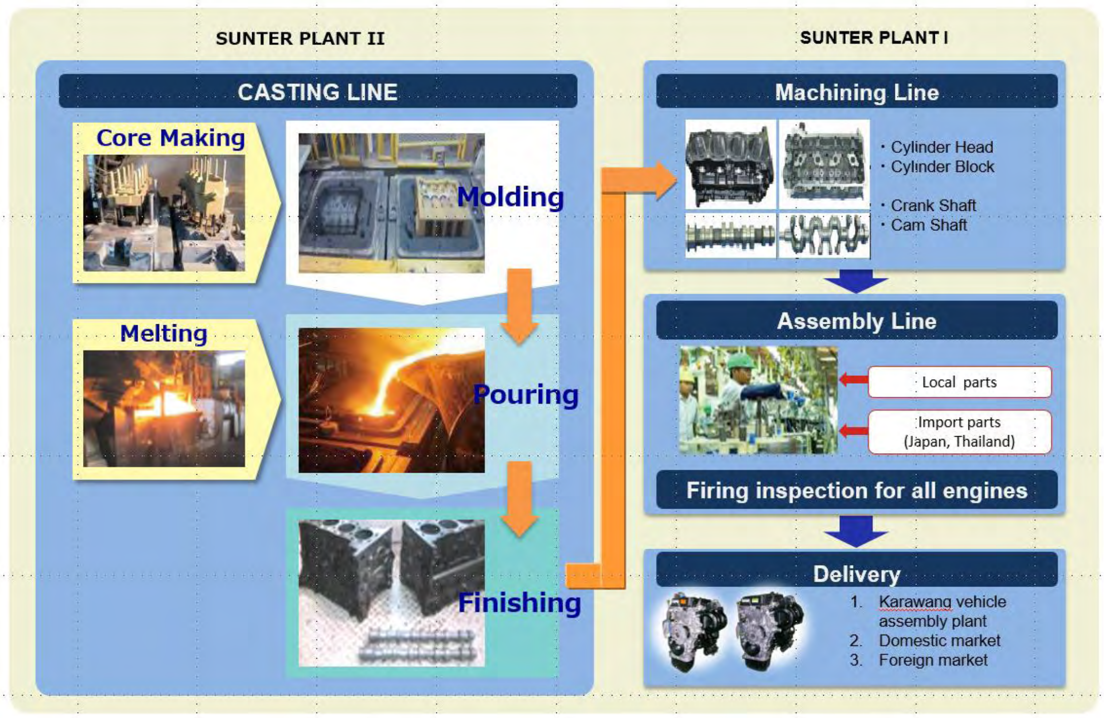

Figure F.2
Engine Production Process

Vehicle Assembly Plants

There are two vehicle assembly plants in Karawang, namely Karawang plant I and II. Karawang Plant I produces Innova and Fortuner, while the second plant produces Yaris, Vios, and Etios Valco. This classification is based upon the principle of group technology, whereby cars that have similar process requirements are produced at one plant at the same production line.

In general, manufacturing process of car is done through several stages as shown in Figure F.5. As explained above, the car-making process begins with stamping, or molding body part. Here, sheets of steel are molded into car body parts such as frames and doors, as well as sub-assembly body parts (such as cabins, decks, and chassis frames). The second stage is welding. Here, car body parts molded in the stamping plant are welded to become a complete car body. To ensure the high accuracy and precision, the welding shop is equipped with a main body jig, using the global body line that can process more than one model.

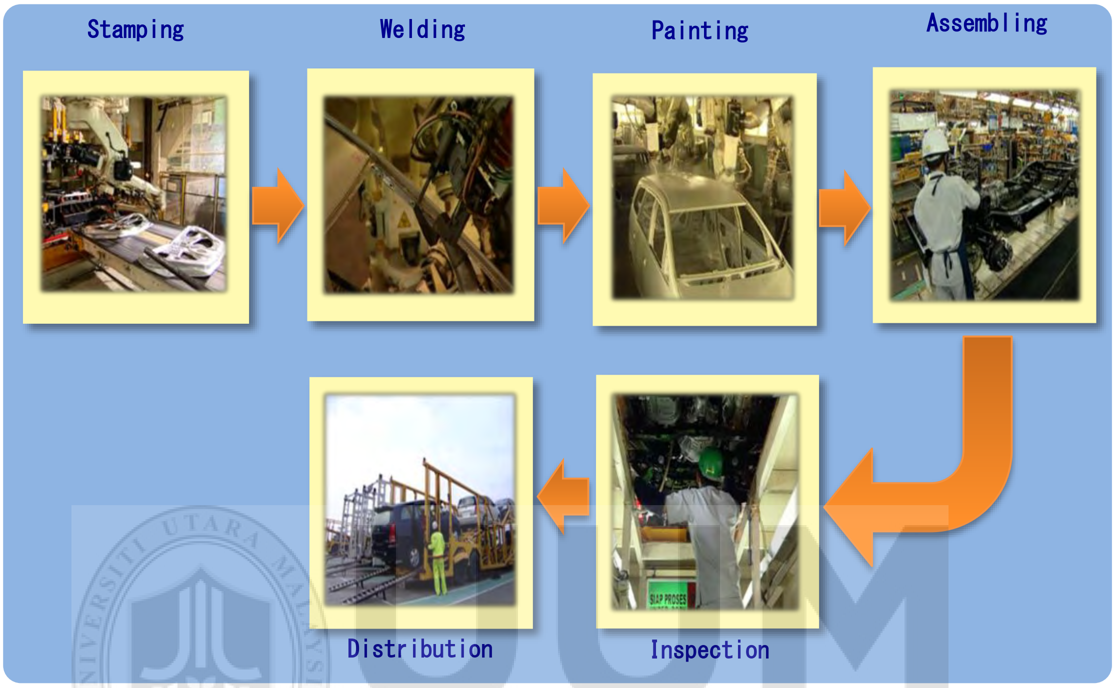

Figure F.5
Vehicle Assembly Process

After going through the welding process, the car body is transported to painting shop. The body will undergo electro deeping coating process to ensure the quality of anti-rust and gap filling process (chiller), so as not to leak when it rains or floods. After that, the car body will go through the process of primer coating and a top coat that uses a robotic system to ensure high-quality of paint, smooth and shiny.

From the painting shop, the car body is conveyed to assembling shop. Body is assembled with other parts such as engine, seats, wheels, lights, and others. JIT concept is strictly applied here. Parts to be assembled that come from suppliers must remain available in the required quantity and time. This is done by using kanban. Kanban gives instruction to produce and deliver the goods, as well as a visual control tool to check availability of the goods. The final gate of making car process is quality inspection. All cars undergo a final quality inspection process to achieve customer satisfaction. Drum test (speed test), break test, up to water leak test, must be passed by all the vehicles before being delivered to customers through Toyota dealers.

After the production process is finished, the next process is distribution to customers. Toyota upholds the principle of a fresh vehicle from factory through vehicle delivery quality improvement. Toyota vehicles are sent to two major markets, namely domestic and foreign markets. Currently, besides serving domestic market, Toyota Innova and Fortuner are exported to Asia Pacific and Middle East. Whereas Toyota Avanza, which is jointly produced with Astra Daihatsu Motor (ADM), is exported to Asia Pacific, Latin America, Africa, and Middle East. Vios, Yaris, and Etios Valco are currently serving domestic market.

Component Export and Vanning

Besides exporting cars in the form of complete knock down (CKD), Toyota Indonesia also exports various components of Toyota vehicles. Export of components is performed by a division, namely component export and vanning division (CEVD). Basic activities of CEVD are depicted in Figure F.3. Process is started with receiving parts from suppliers, followed by boxing, stacking, vanning, and shipment. Boxing is the process to arrange parts into boxes. Subsequently, stacking process is then performed by arranging the boxes into a pallet (which is commonly called as a module or case). After stacking process is completed, the modules are loaded into a container. This process is called as vanning. Finally, once the vanning process is completed, the container is then delivered to customers.

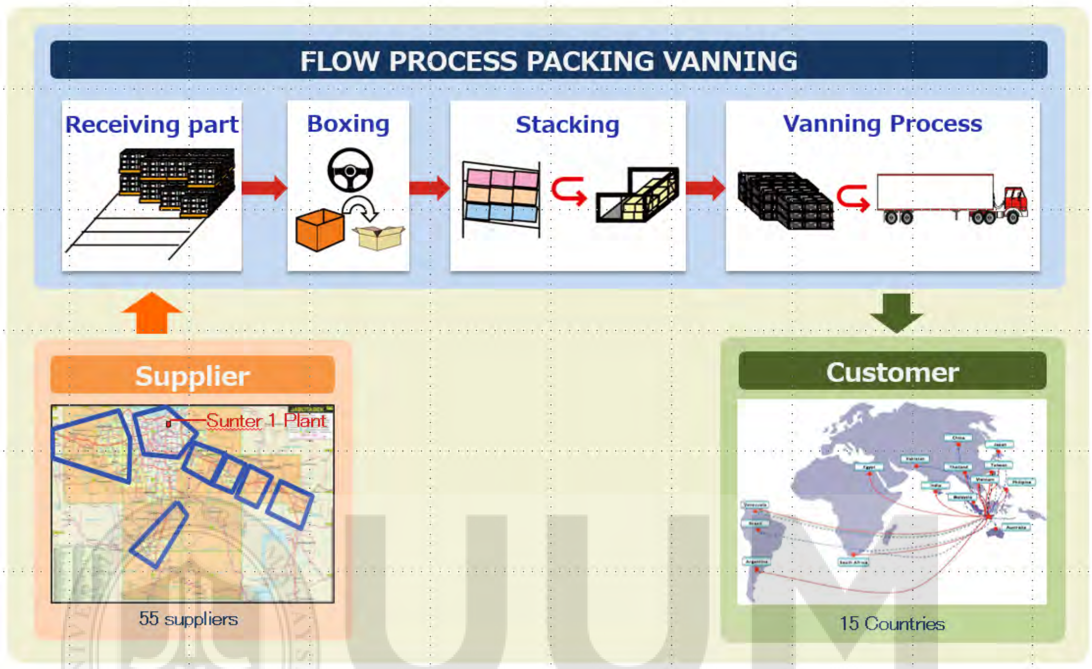

Figure F.3
Flow Process of Packing and Vanning

There are 1,700 over vehicle components that are currently exported to 15 countries around the world across four continents. They are Argentina, Brazil, Venezuela, South Africa, Egypt, Pakistan, India, China, Thailand, Malaysia, Japan, Taiwan, Vietnam, Philiphine, and Australia. The components are welding parts (i.e., body side panel, engine hood, etc.), engine assembly, and assembly parts (e.g., air filter, radiator, horn, speedometer, etc.). In the year 2013, CEVD exported more than 100,000 containers, with the highest export volume to Philiphine (i.e., 22%).

Appendix F: Letter for Qualitative Data Collection from OYA-GSB

OTHMAN YEOP ABDULLAH
GRADUATE SCHOOL OF BUSINESS
Universiti Utara Malaysia
06010 UUM SINTOK
KEDAH DARUL AMAN
MALAYSIA

Tel: 604-928 7118/7119/7130
Faks (fax): 604-928 7160
Laman Web (Web): www.oyagsb.uum.edu.my

KEDAH AMAN MAKMUR • BERSAMA MEMACU TRANSFORMASI

UUM/OYAGSB/K-14
20 May 2014

MANAGER OF HUMAN RESOURCE MANAGEMENT
PT. TOYOTA MOTOR MANUFACTURING INDONESIA

Dear Sir/Madam

REQUEST FOR DATA COLLECTION

PROGRAMME : DOCTOR OF PHILOSOPHY
SUPERVISORS : ASSOC. PROF. DR. LIM KONG TEONG
ASSOC. PROF. DR. SITI NOREZAM OTHMAN

This is to certify that the following is a postgraduate student from OYA Graduate School of Business, Universiti Utara Malaysia. He is pursuing the above mentioned programme which requires him to undertake an academic study at an organization. The details are as follows:

NO	NAME	MATRIC NO.
1.	Gusman Nawanir	93557

In this regard, I hope that you could kindly provide assistance and cooperation for him to successfully complete his PhD Thesis entitled "Lean Manufacturing and Its Potential Benefits to Production Industry: A Case Study". All the information gathered will be strictly used for academic purposes only.

Your cooperation and assistance are very much appreciated.

Thanks you.

"SCHOLARSHIP, VIRTUE, SERVICE"

Yours faithfully

ROZITA BINTI RAMLI
Assistant Registrar
for Dean
Othman Yeop Abdullah Graduate School of Business

c.c - File

Appendix G: Application Letter for Qualitative Data Collection

UUM
Universiti Utara Malaysia

School of Technology Management and Logistics (STML)
UUM College of Business
Universiti Utara Malaysia
06010 UUM Sintok
Kedah Darul Aman, Malaysia
Tel: (604) 928 6857/6858
Fax: (604) 928 6860
www.uum.edu.my

20 May 2014

MANAGER OF HUMAN RESOURCE MANAGEMENT
PT. TOYOTA MOTOR MANUFACTURING INDONESIA

Dear Sir/Madam,

REQUEST FOR PARTICIPATION IN DOCTORAL RESEARCH

I am an Indonesian, who is now conducting a research as a fulfillment to complete the PhD program at the School of Technology Management and Logistics, Universiti Utara Malaysia. The research aims to explore how lean manufacturing, which is consistent with the just-in-time and Toyota Production System philosophy, improves organizational performance. The research will hopefully contribute to the deep understanding regarding the lean manufacturing and its potential benefits to production industry, and so the value of the study is the improvement of lean manufacturing implementation in a manufacturing company.

The Toyota Motor Manufacturing Indonesia is invited to participate and considered very suitable for the research, because the company has been implementing lean manufacturing philosophy in the production system since long time ago, and already been gaining valuable benefits on the improvement of organizational performance after its implementation.

The research is a qualitative study by employing case study method with interview and observation as main data collection techniques. During the interview, the informant will be asked questions about his/her opinions relative to his/her experience in implementing lean manufacturing within your company. The duration of the interview will be approximately 60 minutes. The interview will be undertaken at a time and location that is mutually suitable. In addition, the informant's name will not be used at all on all transcriptions and data collected. The informant will be referred to only by way of the pseudonym.

Under no circumstance whatsoever will the company and the informants be identified by name in this study, or in any publication thereof. Every effort will be made that all information provided will be treated as strictly confidential. All data will be coded and securely stored, and will be used for professional purposes only.

For your information, this research is conducted through a rigorous process, and it has been reviewed and approved by the review board of College of business, Universiti Utara Malaysia.

Thanks for your cooperation and participation.

Gusman Nawanir, M.Sc PhD Candidate	gsm1410@gmail.com s93557@student.uum.edu.my	+60164161410 +6049287056
Assoc. Prof. Dr. Lim Kong Teong Main Supervisor	ktlim@uum.edu.my	+6049286952
Assoc. Prof. Dr. Siti Norezam Othman Co-supervisor	norezam@uum.edu.my	+6049286954

The Eminent Management University

Appendix H: Approval Letter for Qualitative Data Collection

TOYOTA

PT. TOYOTA MOTOR MANUFACTURING INDONESIA
Head Office, Jl. Laks. Yos Sudarso, Sunter II
Jakarta 14330 - Indonesia
Phone : 62-021-651.5551 (Hunting)
Facsimile : 62-021-651.5327

No : 0255 /P&A/TIIND/ VI / 2014

To :
Mrs. Rozita Binti Ramli,
Assistant Registrar
for Dean
Othman Yeop Abdullah Graduate School Of Business,
Universiti Utara Malaysia, 06010 UUM SINTOK,
Kedah Darul Aman,
Malaysia

Field Coordinator	: Mr. Dimas M.	- P A D Sunter I
Mentor	: Mr. Yulza A.	- C E V
Cc	: Mr. Djatmiko E.S.	- P A D Sunter I

Dear Madam,

Re : Internship

Replies to your letter No : UUM/OYAGSB/K - 14, regarding your application for your student experience (internship) in Toyota Motor Manufacturing Indonesia, herewith we inform that your student can partake the internship :

Name	: Mr. Gusman Nawanir	Matric No : 93557
Date of Internship	: August 4 - August 29, 2014	
Time of Internship	: 7.00 AM - 3.00 PM	
Place	: Component Export Vanning, Sunter I, Jl. Laks. Yos Sudarso, Sunter II, Jakarta Utara	

Therefore, we expect his total participation in this schedule.
If you need further information, please don't hesitate to contact Mr. M.A. Siddiq, Phone +6221 6511210 (ext. 4265).

Sincerely Yours
Jakarta, June 16, 2014

Appendix I: Interview Consent Form

INTERVIEW CONSENT

Part 1: Research Description

Principal Researcher	:	Gusman Nawanir
Main Supervisor	:	Assoc. Prof. Dr. Lim Kong Teong
Co-supervisor	:	Assoc. Prof. Dr. Siti Norezam Othman
Research Title	:	Lean Manufacturing and Organizational Performance

Dear Informant,
You are invited to participate in a research that explores how lean manufacturing contributes to company's performance. The research will hopefully contribute to the deep understanding regarding the lean manufacturing and its potential benefits to organizational performance. The research is conducted by the principal researcher, Gusman Nawanir, a PhD candidate at the Universiti Utara Malaysia.

Your participation in this study requires an interview during which you will be asked questions about your opinions relative to your experience in implementing lean manufacturing within the company. The interview will be undertaken at a time and location that is mutually suitable. With your permission, the interview will be audio taped and transcribed, the purpose thereof being to capture and maintain an accurate record of the discussion.

Under no circumstance whatsoever will you be identified by name in this research, or in any publication thereof. Every effort will be made that all information provided by you will be treated as strictly confidential. All data will be coded and securely stored, and will be used for professional purposes only.

The research is to be submitted in fulfillment of the requirement for the degree of Doctor of Philosophy at the Othman Yeop Abdullah-Graduate School of Business, Universiti Utara Malaysia. The results of the study will be published as a thesis. In addition, information may be used for academic purposes in professional presentations and/or academic publications.

Part 2: Informant's Rights

1. I have read and discussed the research description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding the study.
2. My participation in this research is voluntary. I may refuse to participate or withdraw from participation at any time without any effect to my job.
3. The researcher may withdraw me from the research at his professional decision.
4. Any information derived from the research that personally identifies me will not be voluntarily released or disclosed without my separated consent.
5. If at any time, I have any questions regarding the research or my participation, I can contact the researcher, *Gusman Nawanir*, who will answer my questions. The researcher's phone number is +60-164161410. I may also contact the researcher's main supervisor, Assoc. Prof. Dr. Lim Kong Teong at +60-49286952, or the researcher's co-supervisor, Assoc. Prof. Dr. Siti Norezam Othman at +60-49286954.

6. If at any time, I have comments or concerns regarding the research, or questions about my rights as a research subject, I should contact the Dean of Othman Yeop Abdullah Graduate School of Business Universiti Utara Malaysia at +60-49287130 or oyagsb@uum.edu.my.
7. Audio taping is part of this study. Only either the principal researcher or the members of the research team will have access to the written and taped materials. Please check one:
   (….) Only principal researcher can access the written and taped materials.
   (….) Principal researcher and the members of research team can access the written and taped materials.
8. I am willing to be interviewed by the researcher based on the following details:
   Day : ___________________________
   Date : ______/08/2014
   Time : ___________________________
   Place : ____

Informant's signature: _____________________________ Date: ____/ 08 /2014

Informant's name: ______________________________

Part 3: Researcher's Verification of Explanation

I, Gusman Nawanir, certify that I have carefully explained the purpose and nature of this research to ________________________________. He/she has had the opportunity to discuss it with me in detail. I have answered all his/her questions, and he/she provided the affirmative agreement to participate in this research.

Researcher's signature: ______________________________ Date: ____ / 08 /2014

Appendix J: Certification of Data Collection Completion

TOYOTA

PT. TOYOTA MOTOR MANUFACTURING INDONESIA
Jl. Laks. Yos Sudarso, Sunter II
Jakarta 14330 - Indonesia
Phone : 62-21-6515551 (Hunting)
Facsimile : 62-21-6515327

LETTER OF DECLARATION

No. 22 / TMMIN - PAD / Sunter I / VIII / 2014

Herewith we would like to declare that the below mentioned name:

Name	:	Gusman Nawanir
No. Matric	:	93557
University	:	Othman Yeop Abdullah Graduate School of Business, University – Utara Malaysia

Has finished his observation in **PT Toyota Motor Manufacturing Indonesia**
For University Dissertation need on:

Period	:	August 04, 2014 ~ August 29, 2014
Division	:	Componen Export Vanning Division
Thema	:	Observation & Interview Related to Lean Production (TPS), Operations Performance & Business Performance
Result	:	Good

This letter of declaration has been made for the purpose of his study and related.

August 29, 2014
PPA Department

PT. TOYOTA MOTOR MANUFACTURING INDONESIA
JAKARTA INDONESIA

D.E. Sukaton
Dept. Head

Appendix K: Interview Protocol

Appendix K.1: Interview Protocol with Key Persons of Lean Manufacturing Implementation

INTERVIEW PROTOCOL

Research Title	Lean Manufacturing and Organizational Performance
Researcher	Gusman Nawanir
Research Questions	1. How is lean manufacturing implemented? 2. How does lean manufacturing improve operations performance? 3. How does lean manufacturing improve business performance?
Informant	Key persons of lean manufacturing implementation

General question	
1	As we know, the company is currently implementing the lean concept, what are the general terms used to represent it?
2	When did the lean initiative start off in the company?
3	What were the main objectives of its implementation?
4	How was this initiative started?
5	What and how was the process in adopting the lean concept undertaken by the company? Please describe the phases involved!
6	Who did actually start this initiative?
7	Please describe the situation in the company during the initial stage of lean introduction! And what about the current situation?
8	Does the mother’s company implement lean in the same way with this company?
9	Who are the key persons involved in lean implementation in the company?

Lean Manufacturing Implementation	
1	Are all the units/departments implementing the lean manufacturing concept?
2	What are the lean practices that have been implementing in the company?
3	Why does the company focus on those practices?
4	What is the importance of each practice?
5	How does the company implement each of the practices? Please provide some examples! Any documentations that support your argument?
6	What are the guidelines used to implement the lean manufacturing?

Inter-relationship among lean manufacturing practices	
1	What are the relationships among the lean practices? Are they mutually supportive? Please provide some examples!
2	If the practices are mutually supportive, how should the practices be implemented? Must they be implemented simultaneously?
3	Does the company have the same emphasis to all the lean practices? Why?
4	Is it important that a practice be supported by other practices? Why? Please provide some examples!

The effect of lean manufacturing on company’s performance	
1	How important is the lean implementation for the company’s performance?
2	What are the potential benefits of lean implementation to company’s performance?
3	How does lean improve operations performance (in terms of quality, manufacturing flexibility, inventory minimization, lead time reduction, productivity, and production cost reduction)?
4	How does lean improve business performance (in terms of profitability, sales, and customer satisfaction)?
5	To your opinion, if the practices are implemented in isolation (mutually exclusive among them), what are their effects on performance?

Appendix K.2: Interview Protocol with Manufacturing Manager/Lean Implementers/Lean Engineers

INTERVIEW PROTOCOL

Research Title	Lean Manufacturing and Organizational Performance
Research Questions	1. How is lean manufacturing implemented? 2. How does lean manufacturing improve operations performance? 3. How does lean manufacturing improve business performance?
Informant	Manufacturing Manager/Lean Implementers/Lean Engineers

General question		
1	What were the main objectives of lean implementation for production?	
2	How was the lean initiative started?	
3	Please describe the situation in the company during the initial stage of lean introduction! And what about the current situation?	
4	Does the mother's company implement lean in the same way with this company?	
5	Who are the key persons of lean implementation in the production?	
Lean Manufacturing Implementation		
1	Are all the units/departments implementing the lean concept?	
2	What are the lean practices that have been implementing in the company?	
3	Why does the company focus on those practices?	
4	What is the importance of each practice?	
5	How does the company implement each of the practices? Please provide some examples! Any documentations that support your argument?	
6	What are the guidelines used to implement the lean?	
Inter-relationship among lean manufacturing practices		
1	What are the relationship among the lean practices? Are they mutually supportive? Please provide some examples!	
2	If the practices are mutually supportive, how should the practices be implemented? Must they be implemented simultaneously?	
3	Does the company have the same emphasis to all the lean practices? Why?	
4	Is it important that a practice be supported by other practices? Why? Please provide some examples!	
The effect of lean manufacturing on company's performance		
1	How important is the lean implementation for the company's performance?	
2	What are the potential benefits of lean implementation to company's performance?	
3	How does lean improve operations performance (in terms of quality, manufacturing flexibility, inventory minimization, lead time reduction, productivity, and production cost reduction)?	
4	How does lean improve business performance (in terms of profitability, sales, and customer satisfaction)?	
5	To your opinion, are there any direct effects of lean on business performance (in terms of profitability, sales, and customer satisfaction)?	
6	To your opinion, if the practices are implemented in isolation (mutually exclusive among them), what are their effects on performance?	
Additional Questions		
1	a.	Based on your experiences, what are the important ingredient/factors in ensuring successful implementation of lean?
	b.	How do those factors contribute to the successful implementation of lean?
2	a.	What are barriers in implementing the lean initiative?

	b. How does the company deal with the barriers/problems?
3	a. In its implementation, what changes are required to realize the lean concept in the company?
	b. How to deal with resistances to changes? What strategies that should be performed?
	c. To deal with the resistances, what are the resources and programs needed?
4	What are the strategies to ensure that lean practices are properly applied?

Appendix K.3: Interview Protocol with Production Workers/Production Supervisors/Lean Implementers

INTERVIEW PROTOCOL	
Research Title	Lean Manufacturing and Organizational Performance
Research Questions	1. How is lean manufacturing implemented? 2. How does lean manufacturing improve operations performance?
Informant	Production workers/Production supervisors/Lean Implementers

Lean Manufacturing Implementation	
1	What are the lean practices that have been implementing in the production area?
2	Why does the production area focus on those practices?
3	What are the importance of each practice?
4	How does the production area implement each of the practice? Please provide examples! Any documentations that support your argument?
5	What are the guidelines used in the production area to implement lean initiative?
Inter-relationship among lean manufacturing practices	
1	What are the relationship among the lean practices? Are they mutually supportive? Please provide some examples!
2	If the practices are mutually supportive, how should the practices be implemented? Must they be implemented simultaneously?
3	Does the company have the same emphasis to all the lean practices? Why?
4	Is it important that a practice be supported by other practices? Why? Please provide some examples!
The effect of lean manufacturing on operations performance	
1	How does lean improve operations performance (in terms of quality, manufacturing flexibility, inventory minimization, lead time reduction, productivity, and production cost reduction)?
2	To your opinion, if the practices are implemented in isolation (mutually exclusive among them), what are their effects on performance?
Additional Questions	
1	What are barriers in implementing the lean in the production area?
2	How does the company deal with the barriers/problems?

Appendix L: Certification of Key Informant Review

KEY INFORMANT REVIEW

I have already reviewed the case study report provided by **Gusman Nawanir**, a PhD student from Universiti Utara Malaysia. The case study on lean manufacturing, operations performance, and business performance has successfully been conducted in Toyota Motor Manufacturing Indonesia from 4th to 29th August 2014.

Herewith, I would like to declare that the information provided in the report is valid and accurate.

The researcher is allowed to disclose all the information provided in the thesis in the following publication or forums:

- ☑ Journal Article
- ☑ Conference
- ☑ Seminar

Jakarta, 29 May 2015

Signature : [signature]

Name : YULTA ALTADLI

Position : DIVISION HEAD

PT. TOYOTA MOTOR MANUFACTURING INDONESIA
JAKARTA - INDONESIA

Company's stamp : ______________________

Appendix M: General Guideline for Lean Manufacturing Implementation

Document # **[ID]**	**General Guideline for Lean Manufacturing Implementation**	Date Printed:
Revision # **1.0**	Prepared By: **Gusman Nawanir**	Date Prepared:
Effective Date:	Reviewed By:	Date Reviewed:
Standard:	Approved By:	Date Approved:

Definition and Objective

Lean manufacturing is an approach synergistically addressing to improve operations performance and business performance through waste elimination. This guideline endeavors to provide a general guide on how lean manufacturing practices are implemented in the context of discrete manufacturing process industry.

The concept of holistic approach

Lean manufacturing practices should be implemented holistically in order to achieve maximum advantages of the implementation. Its potential benefits may not be fully realized until all the practices are implemented integrally and holistically.

This makes sense as the relationship among the practices tends to be mutually supportive and complement each other. Contribution of one practice to performance depends on its complementary practices. Adoption of one practice may positively influence the marginal return of another practice and vice-versa.

Schematically, the mutual supportive nature of the relationships is depicted in Appendix 1 of this guideline. The supporting/supported practices for each practice are highlighted in the "related practices" listed in the beginning of the respective guideline.

Scope

Discrete manufacturing process (job shop, batch, repetitive, and mass customization).

Contextual Factors

Even though all the lean manufacturing practices should be adopted holistically, the implementation is contingent upon contextual factors. At least, there are three factors that may influence the implementation of each practice of lean manufacturing, namely type of production process, technology used in the shop floor, and type of product. Hence, implementation of the practices should consider these contextual factors in order to ensure the proper implementation.

Abbreviations

FR: Flexible resources
CL: Cellular layouts
PS: Pull system
SLP: Small lot production
QS: Quick setup
UPL: Uniform production level
QC: Quality control
TPM: Total productive maintenance
SN: Supplier networks

Practice 1 **Flexible resources**	
Definitions	*Flexible resource* is a practice of lean manufacturing focusing on achieving manufacturing flexibility of the production system.
Purpose	To achieve manufacturing flexibility through the use of multi-functional machines and equipment, and multi-skilled employees.
Related practices	It is supported by CL, TPM, and QC. It supports CL, SLP, PS, UPL, QS, TPM, and QC.

1.1	**Multi-skilled employees** [3, 4]
1.1.1	Capability/skill mapping • Capability or skill mapping is used to assess how mastery an operator in performing their jobs within a production line. • It is developed based on the number of jobs in one production line. • For each job, all operators are leveled from 1 to 4, based on the pre-determined criteria. • Level 1 reflects the worker who has been trained of doing a particular job. Level 2 indicates the worker who has been able to work under supervision and familiar with the job. Level 3 indicates the worker who has been able to work independently, no defect produced by him/her during the last six months. Level 4 reflects a worker who has been skillful to work alone without any supervision and can teach the jobs to others.
1.1.2	Job rotation • Job rotation and promotion are done based on the capability/skill map. • If a worker has mastered a job, he/she would be transferred to another workstation with different jobs. • A production worker is promoted, if he/she has been multi-skilled.
1.1.3	Cross-training • Manufacturing workers must undergo a number of intensive training to be able to perform multiple jobs. • The company should have a department, which is responsible to plan and organize various trainings.
1.2	**Multi-functional machines and equipment** [3, 4]
1.2.1	Production line should be able to perform multiple processes and to produce the variety of products.
1.2.2	Machines, equipment, and tools could be used to perform several different jobs and operations.
1.2.3	When one machine is broken down, different type of machine should be used to perform the same jobs.

Practice 2 **Cellular Layouts**	
Definitions	*Cellular layout* is a practice of lean manufacturing that combines flexibility of process layout with efficiency of product layout based on the concept of group technology. *Flexible man-power line* is attaining flexibility in the number of workers at a shop floor to adapt to demand changes. It is to alter (decrease or increase) the number of workers at a shop floor when the production demand has changed.

	Takt time is the interval at which a product is moved ahead to next workstation, which is calculated by dividing available production time per day with production volume per day.
Purpose	To achieve manufacturing flexibility through flexibility of production layouts.
Related practices	It is supported by FR It supports FR, PS, SLP, and UPL.
2.1	**Flexible man-power line** [4]
2.1.1	Flexible man-power line principle should be adopted. So that, number of operators can be altered (increased or decreased) when production demand has changed (increased or decreased).
2.1.2	Number of workers should be adaptable to demand changes.
2.1.3	Number of workers is determined based on takt time.
2.1.4	Standard operating procedure, work instructions, standardized works, and other documents must be prepared.
2.1.5	Production workers must be able to perform multiple jobs and operations.
2.1.6	Deploy multi-process handling by multi-skilled workers.
2.1.7	On the production lines, workers should handle a number of different machines, equipment, and tools.
2.1.8	Machines, equipment, and tools should be flexible and are able to perform a number of different jobs and operations.
2.1.9	Machines, equipment, and tools should be easily moved from one location to another.
2.2	**Facility layouts** [2, 3, 4]
2.2.1	Workstations, machines, equipment, and tools are arranged into a sequence (in relation to each other) in order to support smooth flow of materials with minimum transportation, movement and delay.
2.2.2	Dissimilar activities (together with machines, equipment, and tools) should be grouped into workstation that processes families of product with similar requirements such as sizes, shapes, routing, processing, or demand.
2.2.3	Factory layout should be determined based on product families.
2.2.4	To eliminate material movements, the distance between workstations should be set closer.
2.2.5	Facility layouts should be easily rearranged to adapt to changes in volume, design, or product development.
2.2.6	Production lines are usually laid out in a U-shape to improve workers' efficiency.

Practice 3 Pull/Kanban System	
Definitions	*Pull system* is a production system that performs production based on customer demand. *Kanban system* is an information system that harmoniously controls the production of the necessary products in the necessary quantities at the necessary time in every process of a factory and also among companies. It is used to authorize production and material movement.
Purpose	To ensure that production and material movement are performed based upon customer demand.
Related practices	It is supported by FR, CL, SLP, QS, UPL, TPM, and SN. It supports SLP, UPL, and SN.

3.1	**Pull system** [1, 2, 3, 4]
3.1.1	Production and material movement should be performed just as needed, in the right quality, the right quantity and the right time based on customer request.
3.1.2	Produce only when requested by its users, move to where it is needed just as it is needed.
3.1.3	Production in a final workstation is pulled by customer demand, and production in a particular workstation is triggered by request (demand) from subsequent workstation.
3.1.4	Suppliers should deliver parts and materials directly to its point of use.
3.1.5	Warehouse is not mandatory because inventory is less required.
3.2	**Kanban system** [1, 2, 3, 4]
3.2.1	*Kanban* system should be applied to maintain the pull system runs smoothly.
3.2.2	A *kanban* authorizes for production and material movement.
3.2.3	Instruction and authorization are given through a kanban signal, such as cards, verbal signals, light flashing, electronic messages, empty containers, etc.
3.2.4	*Kanban* is also used as visual control tools, to prevent overproduction, to monitor progress, and to identify delays and processes that are too fast.
3.2.5	A *kanban* specifies material order points, how much it is required, from where it is ordered, and to where it should be delivered.
2.2.6	A *kanban* card contains a number of information, such as *kanban* number, part number, brief description of the product, type of container, quantity per *kanban*, supplier, and preceding and subsequent workstation.
3.2.7	In general, there are two types of *kanban*. [4] • Withdrawal *kanban* specifies the kind and quantity of product, which the subsequent process should withdraw from the preceding process. To withdraw parts and materials from suppliers, supplier *kanban* is used. • Production-ordering *kanban* specifies the kind and quantity of product which the preceding process must produce.
3.2.8	Electronic *kanban* (*e-kanban*) should be used to order parts from suppliers, without passing any *kanban* cards to the handlers responsible for moving parts and materials, but uses information technology to send order information to suppliers electronically. [4] • Order information stated in e-*kanban* is sent to the supplier. • Subsequently, the e-*kanban* is printed by supplier. • Afterwards, the suppliers will process the order. • Finally, supplier delivers the parts and materials based on the information provided in the *e-kanban*.
3.2.9	There are several types of *kanban*, such as express *kanban*, emergency *kanban*, job-order *kanban*, through *kanban*, common *kanban*. etc. [4]

Practice 4 Small Lots Production	
Definitions	*Small lot production* is a type of a production process that produces small quantity of product at a time, with ideal lot size is one. *Lot size* is a quantity of items that are produced together.
Purpose	To produce more frequent in small quantity of items together in a batch.
Related practices	It is supported by FR, QS, PS, QS, UPL, QC, and SN. It supports PS, UPL, and QC.
4.1	**Small lots production** [1, 2, 3, 4]
4.1.1	Lot size should be set as small as possible. A lean manufacturer should aggressively work on reducing production lot sizes.

4.1.2	Production should be performed more frequent in small lot size. The ideal lot size of one is preferable.
4.1.3	Flow of one type of item in large quantity together should be strictly avoided.
4.1.4	Small lots production can be achieved by shortening setup time, and multi-skilled operators who work in a multi-process handling line.
4.1.5	Supply parts and materials to a production line must be done in small quantity with frequent deliveries.

Practice 5 Quick Setups	
Definitions	*Quick setup* is a practice of lean manufacturing that focuses on reducing setup time in a production system. *External setup* is setup process that can be performed while production for previous products is still running. *Internal setup* is setup process that must be performed while the machine is stopped from the operations.
Purpose	To reduce machine's setup time.
Related practices	It is supported by FR, and TPM. It supports PS, SLP, and UPL.

5.1	**Setup time reduction** [2, 3, 4]
5.1.1	Shortening setup time is essential to support small lots production. Setup time must be shortened when lot size is reduced.
5.1.2	If there is a change in process requirements, machines' setup should be performed quickly.
5.1.3	Setup time must be shortened consistently in the entire production line.
5.1.4	All the equipment and tools must be put in normal storage location. So that, operators don't have any trouble in finding equipment and tools they need.
5.1.5	Operators must be trained on machines' setup activities to ensure that the setup processes are performed appropriately, and the operators are able to conduct their own machines' setups.
5.2	**Converting internal setup to external setup** [2, 3, 4]
5.2.1	There are two types of setup, namely internal and external setups. Both must be separated.
5.2.2	Most of the internal setups should be converted to external setup. So that, most of the setup processes are done while the machine is running and internal setup can be performed quickly.
5.2.3	To improve the current setup process, all the activities are evaluated. Standardized work document for each setup process is also evaluated.
5.2.4	To ensure the effectiveness of the setup process, all the non-value added activities, unevenness, and overburden are eliminated.
5.2.5	Based on the evaluation, the setup activities are converted, improved, simplified, or removed. Finally, all the setup activities are standardized.

Practice 6 Uniform Production Level	
Definitions	*Uniform production level* is a practice of lean manufacturing aiming to reduce variability at the production level caused by variability in customer demand.

	Production smoothing is a technique used to reduce variability at the production level caused by fluctuations in customer demand. It is a critical factor to create a lean manufacturing system because it is a key of achieving production stability. *Takt time* is an interval at which a product is moved ahead to next workstation, which is calculated by dividing available production time per day with customer demand or production volume per day.
Purpose	To reduce variability at the production level caused by variability in customer demand.
Related practices	It is supported by FR, PS, QS, UPL, TPM, QC, and SN. It supports FR, CL, PS, SLP, QC, and SN.

6.1	**Production smoothing [3, 4]**
6.1.1	Demand rate for all products is used as main input for production planning.
6.1.2	Fluctuation in demand rate that possibly causes waste must be avoided.
6.1.3	An accurate forecast should be emphasized to reduce production variability.
6.1.4	Production system should be managed by leveling and smoothing production by volume and product type/model to guard against variability of demand.
6.1.5	To reduce variability in production, all the product variances (such as styles, color, and other options) must be taken into account.
6.1.6	Composition of product being produced should be arranged based on the composition of demand.
6.1.7	Daily production of different product models should be arranged in the same ratio with monthly demand.
6.1.8	To adapt the increased demand, capacity of the production line must be increased. The following options can be done: • Temporary workers are hired, and each worker handles fewer machines. • Introducing early attendance and overtime, which can fill up unscheduled hours between the shifts.
6.1.9	In case of the decreased demand, number of machines handled by each worker will increase, because temporary workers should be dismissed. The unutilized workers can be transferred to other production lines, which have demand increased. They can also be allocated to conduct maintenance activities, quality control circle, training, etc.
6.2	**Mixed model production [2, 3, 4]**
6.2.1	Production should be consistently done for each type of product in accordance with the demand ratio per production period.
6.2.2	More than one product model should be produced from day to day. At least, some quantity of each product is produced every day.
6.2.3	The same amount of each item is produced each day, and items produced are mixed throughout the day in small quantities.
6.2.4	Each product is produced in a relatively fixed quantity per production period.
6.2.5	Production is done by repeating the same combination of products from day to day.
6.2.6	The ratio of daily production volume should be equal to the ratio of monthly production.
6.2.7	Some quantity of items should be maintained to respond to demand variances.
6.2.8	Three stages of mixed-model production: [4] • Produce in sequence, lumping the total quantity of each model needed each month together. • Produce in sequence, lumping the average quantity of each model needed each day together.

	• Produce each model one unit at a time, matching the pace to the takt time of each model.
6.3	**Uniform workload** [2, 3, 4]
6.3.1	Production process should be ensured running stably with the uniform workload from time to time.
6.3.2	Workloads should be maintained at the same level every day. Variability of everyday workload must be avoided.
6.3.3	For works that are performed on a conveyor, uniformity of workload is done by considering takt time.
6.3.4	All the workstations in the main production line should have the same takt time to ensure production smoothing.
6.3.5	To equate takt time, it is necessary to improve the production line by way of leveling workload in all workstations.
6.3.6	In the workstations with longer takt time, some of its activities should be relocated to other workstations.

Practice 7 **Quality Control**	
Definitions	*Quality control* is a procedure or set of procedures intended to ensure that a manufactured product adheres to a defined set of quality criteria or meets the requirements of the customer. *Autonomous defect control system* is an automated mechanism that in cases of abnormality happens, the machines will automatically stop. [2, 3, 4] *Line-stop alarm light* is an indicator board that shows that an abnormality occurs at a particular location. [2, 3, 4] *Mistake proofing* is a mechanism that helps an operator to avoid mistakes. Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur. [2, 3, 4] *Go/NoGo* is a testing mechanism using two boundary conditions; pass and fail. The test is passed when the *Go* condition is met, and the *NoGo* condition fails.
Purpose	To ensure that the product is high in quality, no defect, no reject, and conforms to the required specification.
Related practices	It is supported by FR, SLP, UPL, and SN. It supports SLP and UPL.
7.1	**Autonomous defect control system** [1, 2, 3, 4]
7.1.1	Production workers should be authorized to stop production if serious abnormalities are occurred.
7.1.2	If the job is done by machine; once an abnormality occurs, the machine would automatically stop without any trigger from operators.
7.1.3	For most of the manual jobs, when an abnormality occurs, operators have authority to stop production line based on their own judgment by applying a switch button available at each workstation.
7.1.4	In cases of abnormality, operators should perform S-C-W (stop-call-wait). The S-C-W refers to an operators' responsibility to "stop" a process when abnormality occurs, "call" for requesting supports from the group leader, and "wait" for the support to arrive before proceeding.
7.1.5	Visual control systems (such as line-stop alarm light, call light, warning signal, etc.) are used as a mechanism to make problems visible. [2]

7.1.6	Line-stop alarm light has different colors to indicate the condition of a production line. Green light indicates normal operations. Yellow indicates a worker in the particular workstation is calling for help because of an abnormality. The yellow light will be lit once yellow button is applied by an operator. If trouble cannot be handled, a red light will come to show that production line has stopped.
7.1.7	When an abnormality occurs, operator can easily identify its source, and corrective actions can be taken immediately.
7.1.8	Mistake proofing and *Go/NoGo* mechanisms should be applied. They help an equipment, machines or operators to avoid mistakes.
7.1.9	With the mistake proofing mechanism, defects can be eliminated by preventing, correcting, or drawing attention to human errors as they occur.
7.2	**Built-in quality [3, 4]**
7.2.1	Implementing the built-in quality implies that all operators are responsible for all the jobs they do, and must ascertain the quality for each operation.
7.2.2	Those who are engaged in a manufacturing process are totally responsible for full quality assurance.
7.2.3	All the production workers must not receive defects, produce defects, and pass defects to the subsequent workstations.
7.2.4	Delivery of products to next workstation or customers must comply with specifications requested, in the right quantity, and no defects.
7.2.5	Self-inspection is a must for each operator before the product is passed to subsequent workstation. If an abnormality occurs, then autonomous defect control mechanism would be applied.
7.2.6	Any defects would never reach the subsequent process, because production workers must do everything right the first time.
7.3	**Quality checking [2, 3, 4]**
7.3.1	It is aimed to ensure a consistent quality of product conformance with predetermined specifications.
7.3.2	Quality checking should be done randomly with a sampling procedure, albeit some products may require total checking.
7.3.3	Inspection must be carried out according to the standard described on standard operating procedure (SOP) containing a detailed explanation of inspection activities that must be performed for every product.
7.3.4	The quality checking is done visually at the product's key point.
7.3.5	The results of quality checking should be recorded in a quality control sheet.
7.3.6	Statistical quality control is used only when an operation has been fully stabilized through careful maintenance of equipment and tools, and sporadic defects do not occur.
7.4	**Related activities**
7.4.1	To support quality control, the following supporting activities should be considered: • Quality focused teams (quality control circle) that meet regularly to discuss about quality issues. Through the meeting, quality problems can be arisen, strategies of problem solving can be designed accurately, and some suggestions can be addressed to management as an attempt to acquire superior quality. • Training for quality control activities. • Visual control boards, to describe current condition of a particular production line.

Practice 8 **Total Productive Maintenance (TPM)**	
Definitions	*TPM* is an approach to machines and equipment maintenance that strives to achieve perfect production (i.e., no breakdowns). *Predictive maintenance* is maintenance activities aimed to help in determining the condition of in-service equipment in order to predict when maintenance should be performed. *Preventive maintenance* involves periodic inspections and services to identify any potential failures and make minor adjustments to prevent major operating problems and breakdown maintenance occurred.
Purpose	To maximize effectiveness and readiness of all machines and equipment to perform all the production processes.
Related practices	It is supported by FR. It supports PS, SLP, and UPL.

8.1	**Predictive Maintenance [1, 3]**
8.1.1	Through predictive maintenance, the status of machines and equipment is clearly ensured before a breakdown occurs.
8.1.2	It is a complement of preventive maintenance. So that, the preventive maintenance can be accomplished before a breakdown.
8.1.3	Various tools, such as thermal imaging, vibration analysis, and so on, are used to predict when a breakdown may occur.
8.1.4	Predictive maintenance should not be performed only by maintenance technicians but also involving production workers.
8.2	**Preventive Maintenance [1, 3]**
8.2.1	Preventive maintenance is executed on machines or equipment to diminish possibility of its failing, which is done while they are still working.
8.2.2	To perform preventive maintenance effectively, its activities are grouped into two categories; (1) activities that should be performed by production workers (ownership/ autonomous maintenance), and (2) activities that must be carried out by maintenance technicians, which require special skills and tools.
8.2.3	Ownership maintenance • It is limited only for maintenance activities using human senses without special skills and tools. • Each operator is responsible for all the machines he/she operates. • It may avoid machines and equipment from severe damage and termination of the production process. • All operators should reserve a time to perform daily maintenance activities. • All operators should scrupulously clean their workspaces (including machines and equipment) to make unusual occurrences noticeable.
8.2.4	Periodic inspection must be dedicated to keep all machines and equipment are in a state of readiness to perform all the production processes.
8.2.5	Maintenance activities must have a set of complete guidelines, such as maintenance ledger, job instruction sheet, and maintenance *kanban*.
8.2.6	Maintenance ledger • It provides detailed information about machines and equipment, maintenance period, tools etc. • The maintenance period depends upon type of machines/equipment, and type of spare part.
8.2.7	Job instruction sheet • All the maintenance activities should be guided by job instruction sheet.

	• It provides instruction for each job in detail. Thus, it can be done by any operator.
8.2.8	Maintenance *kanban* • Maintenance *kanban* is used to instruct routine maintenance activities. • Each machine and equipment should have maintenance *kanban*. It informs about items that require checking in all machines and equipment. • At the beginning of every month, all *kanbans* are distributed to machines' operators. Based on the *kanban*, operators check the machine. Once completed, *kanban* will be placed into *kanban's* pigeonholes awaiting for next inspection as scheduled in *kanban.* • If any abnormality is detected, operator should report the problem together with possible corrective actions that have been or should be taken.

Practice 9 **Supplier Networks**	
Definitions	*Supplier network* is a strategic and mutual collaboration between suppliers and manufacturer with a goal of waste elimination. *Milk run delivery* is a delivery method for mixed loads from different suppliers. Instead of each of several suppliers sending a vehicle every week to meet the weekly needs of a customer, one vehicle visits each supplier on a daily basis and picks up deliveries for customer. *Jumbiki* is defined as pick in order of use. It is a delivery system that uses a fax order system according to patterns of production smoothing or products sequence passing through the main production line. In this system, parts are directly sent to the main line with the prior preparation of the sequence by suppliers according to the product to be assembled in the production line. *Jundate* is a method of delivery in which suppliers do not deliver parts directly to main assembly line. The parts must be prepared in sub line to combine a number of parts into a set form. It is frequently applied for large-volume parts that cannot be delivered in its original packaging to the main line, or parts containing a lot of components.
Purpose	To establish mutually supportive nature of relationship between manufacturer and its suppliers.
Related practices	It is supported by PS, SLP, and UPL. It supports PS, SLP, UPL, and QC.

9.1	**Long term and mutual relationship with suppliers** [1, 2, 4]
9.1.1	Implementation of lean manufacturing must be supported by good suppliers.
9.1.2	Manufacturer and its suppliers must be bound in a long-term relationship.
9.1.3	Manufacturer should… • Emphasize to work together with suppliers for mutual benefits. • Regularly solve problems jointly with suppliers. • Visit and observe problems of suppliers, and the problems should be resolved together.
9.2	**Suppliers' development programs** [1, 4]
9.2.1	To support production process, suppliers should be well developed. Development programs should be provided for all suppliers.

9.2.2	Suppliers must be developed in several aspects, ranging from production systems, internal production processes, logistics, and performance aspects (such as safety, quality, productivity, delivery, and so on).
9.2.3	Suppliers are encouraged to improve their performance.
9.2.4	To undertake supplier development, routine assessment on suppliers' performance should be performed.
9.2.5	The routine assessment should be undertaken by special divisions and should be supported by other divisions that deal directly with suppliers.
9.2.6	Development programs should be undertaken not only for new suppliers, but also for existing suppliers.
9.2.7	Suppliers are encouraged to implement the lean manufacturing system in their own companies.
9.2.8	Suppliers should be trained to implement the lean manufacturing system, and to follow rules of the game set by the manufacturer.
9.2.9	The implementation of the lean manufacturing system by suppliers should be evaluated and improved.
9.2.10	Competition among suppliers should be encouraged.
9.2.11	Suppliers' performance should be annually assessed. Annually, outstanding suppliers should be awarded.
9.2.12	To enhance suppliers' performance, orders are allocated based on their performance.
9.3	**JIT delivery from suppliers** [1, 4]
9.3.1	This activity is aimed to ensure that suppliers are able to deliver their products in the JIT basis (as promised, just as it is needed, in the right quantity, at the right time, and at the right place).
9.3.2	It can be realized through synchronization between manufacturer's production schedule and delivery schedule of parts and materials from suppliers.
9.3.3	Manufacturer should arrange the schedule of shipment to customers, as well as schedule for internal production process, and ordering to suppliers. All are scheduled down to the detail of time. This schedule is then communicated to suppliers. Suppliers will arrange their own schedule.
9.3.4	Meetings with suppliers should be held regularly to notify manufacturers' production schedule. Based on the schedule, suppliers arrange their production and delivery schedule, matching with the manufacturer's requirement.
9.3.5	The suppliers should be able to adapt to the demand change.
9.3.6	Milk run delivery system should be applied, to ensure that delivery from suppliers follows the JIT principles. Goods from suppliers should be received in small lot size with frequent deliveries. • Suppliers' addresses were geographically mapped. • The goods form suppliers who are located nearby to each other are picked by one truck provided by logistics partner. Hence, one truck collects goods from a number of suppliers. • The logistics partner delivers the goods to the manufacturer.
9.3.7	Suppliers must deliver their products to the point where it is required.
9.3.8	Besides milk run delivery; in an assembly line, *jumbiki* and *jundate* delivery system should be applied.
9.3.9	*Jumbiki* delivery system [4] • By applying *jumbiki*, suppliers deliver parts and materials based on production sequence at where they are going to be used. • Arrivals of parts and materials should be in line with sequence of the main body processed in the production line.

	• It can work well when delivery lead time from suppliers is shorter or at least equal to the speed of production along the assembly line. Hence, suppliers and manufacturer should be close proximity. • *Jumbiki* delivery system could be applied for large-size parts, unique items (uncommon parts), and parts with low delivery costs.
9.3.10	*Jundate* delivery system • In the *jundate* system, parts are prepared in a sub line by combining multiple components into a set form before its installation to the main part of the product.

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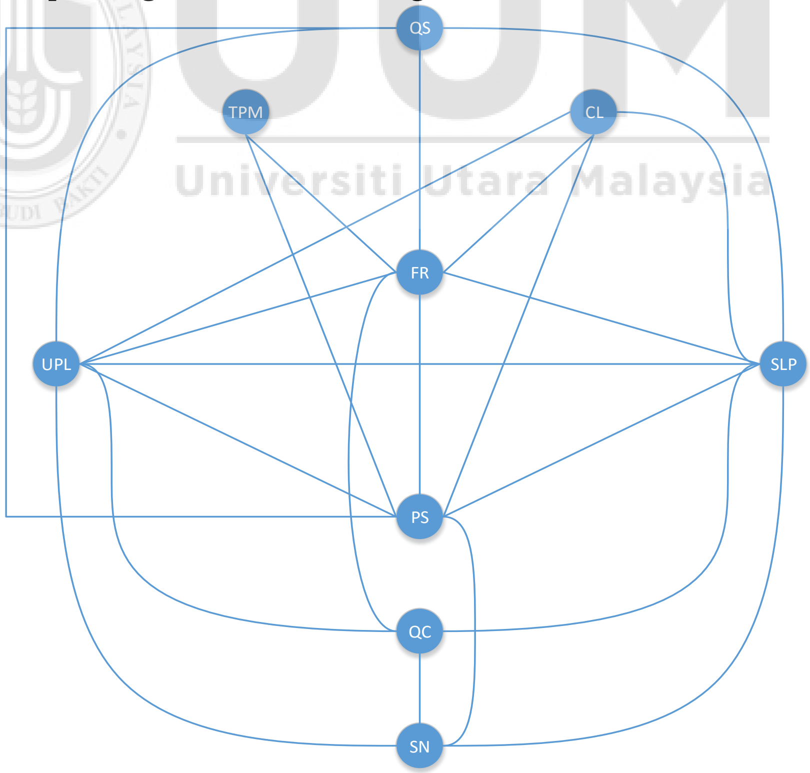
2. Feld, W. M. (2001). *Lean manufacturing: Tools, techniques, and how to use them*. Florida: St. Lucie Press.
3. Hirano, H. (2009). *JIT implementation manual: The complete guide to just-in-time manufacturing*. Boca Raton, FL: CRC Press, Taylor & Francis Group.
4. Monden, Y. (2012). *Toyota production system: An integrated approach to just-in-time* (4th ed.). Boca Raton, FL: CRC Press, Taylor & Francis Group.

Appendix 1
Inter-relationship among Lean Manufacturing Practices



Appendix 2
Forms/Records

Form #	Record/Form/Activity Name	Satisfies Clause
Required by Standard		
Other Forms/Records		

Appendix 3
Revision History

Revision	Date	Description of changes	Requested By