THE ROLE OF OVERALL EQUIPMENT EFFECTIVENESS IN THE RELATIONSHIP BETWEEN FIT MANUFACTURING STRATEGIES AND BUSINESS PERFORMANCE

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task could be accomplished if it is done one step at a time.

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I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my PhD study. My fellow postgraduate students should also be recognized for their support. My sincere appreciation extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips proved to indeed be useful. Unfortunately, it is not possible to list all of them in this limited space. Furthermore, I am indebted to all my family members for their unwavering support.

ABSTRACT

In the current era, manufacturing companies operate in a less secure and more complex environment. Stakeholders' pressure on manufacturers to reduce waste and manage operations and their negative impact on the environment and society is growing. This has lead companies and researchers to highlight methods to apply viable strategies and processes in order to minimize negative impacts of industry traditional manufacturing strategies and improve business performance. On top of that, manufacturing companies need to adapt fit manufacturing (FM) strategies such as lean manufacturing (LM), agile manufacturing (AM) and sustainability manufacturing (SM) to enhance business performance (BP). Similarly, the overall equipment effectiveness (OEE) has become a major concern for modern manufacturing technology systems. This study aims to investigate the mediating role of overall equipment effectiveness (OEE) on the relationship between fit manufacturing (FM) strategies i.e. lean manufacturing (LM), agile manufacturing (AM) and sustainability manufacturing (SM) with business performance (BP). This study employed a quantitative approach to address the research objectives. The response rate was 75%. The clean data of 252 respondents were collected through questionnaires. Data were analyzed through structural equation modelling (SEM) using AMOS 22. Direct and indirect effects were calculated to test the endogenous and exogenous variables. The findings confirmed that there is a positive relationship among FM strategies i.e. LM, AM, SM and BP of Malaysian manufacturing firms. In addition, these study findings also confirmed that OEE mediated the relationship between FM strategies i.e. LM, AM, SM and BP of Malaysian manufacturing firms. This study makes a novel academic and practical contributions to the field of sustainability along with fit manufacturing strategies in addition to significant contribution to the body of knowledge. Finally, this research provides meaningful insight to manufacturing organizations, manufactures, policymakers, and government institutions related to Malaysian manufacturing industry.

ABSTRAK

Dalam era masa kini, syarikat-syarikat pembuatan beroperasi di dalam persekitaran yang kurang selamat dan lebih rumit. Tekanan daripada pihak berkepentingan terhadap pengeluar untuk mengurangkan sisa, menguruskan operasi dan mengawal kesan negatif ke atas alam sekitar dan masyarakat adalah semakin meningkat. Hal ini telah menyebabkan syarikat dan para penyelidik berusaha untuk menekankan kaedah yang mengguna pakai strategi dan proses yang berdaya maju bagi meminimumkan kesan negatif strategi pembuatan tradisional industri dan meningkatkan prestasi perniagaan. Di samping itu, syarikat-syarikat pembuatan perlu mengadaptasi strategi-strategi pembuatan 'fit' (FM) seperti pembuatan 'lean' (LM), pembuatan tangkas (AM), dan pembuatan mampan (SM) untuk meningkatkan prestasi perniagaan (BP). Selain itu, keberkesanan peralatan keseluruhan (OEE) telah menjadi perhatian utama dalam sistem teknologi pembuatan moden. Kajian ini bertujuan untuk mengkaji peranan pengantara keberkesanan peralatan keseluruhan (OEE) ke atas hubungan di antara strategi pembuatan 'fit' (FM) iaitu pembuatan 'lean' (LM), pembuatan tangkas (AM), dan pembuatan mampan (SM) dengan prestasi perniagaan (BP). Kajian ini menggunakan pendekatan kuantitatif untuk mencapai objektif penyelidikan. Kadar maklum balas kajian ini adalah 75 peratus. Data bersih daripada 252 orang responden telah dikumpulkan melalui soal selidik. Data telah dianalisis menerusi pemodelan persamaan berstruktur (SEM) dengan menggunakan AMOS 22. Kesan langsung dan tidak langsung telah dikira untuk menguji pembolehubah endogen dan eksogen. Penemuan kajian ini mengesahkan bahawa terdapatnya hubungan positif di antara strategi FM iaitu LM, AM, SM, dan BP dalam kalangan syarikat pembuatan di Malaysia. Tambahan pula, kajian ini mendapati OEE menjadi pengantara hubungan strategi FM iaitu LM, AM, SM, dan BP dalam kalangan syarikat pembuatan di Malaysia. Kajian ini memberi sumbangan besar kepada bidang akademik dan praktikal yang berkaitan dengan kemampanan dan strategi pembuatan yang sesuai, selain daripada sumbangan penting ke atas ilmu pengetahuan. Akhirnya, kajian ini menyediakan fahaman yang bermakna kepada organisasi pembuatan, pembuat dasar bidang pembuatan, dan institusi kerajaan yang berkaitan dengan industri pembuatan di Malaysia.

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LIST OF ABBREVIATIONS

AM	-	Agile Manufacturing
BP	-	Business Performance
CFA	-	Confirmatory Factor Analysis
CIM	-	Computer-Integrated Manufacturing
DSM	-	Department of Statistics Malaysia
FM	-	Fit Manufacturing
FMC	-	Flexible Manufacturing Cells
FMM	-	Federation of Malaysian Manufacturers
FMS	-	Flexible Manufacturing System
GDP	-	Gross Domestic Product
LM	-	Lean Manufacturing
MRP	-	Material Requirements Planning
OEE	-	Overall Equipment Effectiveness
OMP	-	Overall Manufacturing Performance
OP	-	Operational Performance
PMS	-	Performance Measurement Systems
RBV	-	Resource Based View
RMS	-	Reconfigurable Manufacturing System
SEM	-	Structural Equation Modelling
TPM	-	Total Productive Maintenance

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A growing number of stakeholders are pressuring manufacturers to reduce waste and manage operations to reduce the negative impact on the environment and society. This has lead companies and researchers to highlight the methods and viable strategies and processes to achieve the desired reduction (León and Calvo-Amodio, 2017). However, efforts to become more eco-friendly and minimise the social impacts of traditional manufacturing strategies have been viewed as obstructions to economic viability and business performance (Florida, 1996, Found and Rich, 2006, Hines et al., 2006, Found, 2009, Khor, 2011, Wilson, 2010, Wong and Wong, 2014, Cherrafi et al., 2016, Chiarini, 2014, Garza-Reyes, 2015c). The high-performance manufacturing process can be accomplished through high-quality products, speedy processes, cost efficiency, flexibility and reliability, intending to empower the company to achieve higher performance, increased market share and accelerated sales growth. However, these are not always in line with green strategies (Pham et al., 2008; Pham and Thomas, 2010; Alfalla-Luque and Medina-Lopez, 2009, Laureano Paiva et al., 2012, Lucato et al., 2012, Al-Tahat and Jalham, 2015, Ebrahim, 2011a; Singh and Mahmood, 2014).

Over the years, several manufacturing strategies and techniques have enhanced the productivity and business performance (BP) of manufacturing firms such as total quality management (Martínez-Lorente et al., 1998) business process re-engineering (Burke and Peppard, 1995), Just-In-Time (Sakakibara et al., 1993) Six Sigma (Harry, 1998) and lean thinking (Hines et al., 2004), among others. Despite these initiatives, a significant number of companies struggle to achieve long-term sustainability (Wilson, 2010, Chiarini, 2017, Garza-Reyes, 2015c, Wong and Wong, 2014, Cherrafi et al., 2016). In response to this, researchers believe that the application of fit manufacturing (FM) enables production firms to become viable and function well in a globally

competitive market through enhanced business performance (Womack et al., 1990b, Kidd, 1996, Thomas and Pham, 2004, Pham et al., 2011, Cherrafi et al., 2016). Fit manufacturing (FM) integrates the lean manufacturing (LM), agile manufacturing (AM) and sustainability manufacturing (SM)(Williams, 2013, Pham et al., 2008c, Pham et al., 2011, Johansson and Sundin, 2014, Garza-Reyes, 2015b, Gort, 2008, Martínez-Jurado and Moyano-Fuentes, 2014). The implementation of lean and agile manufacturing strategies help firms to achieve operational efficiencies and improve business performance and overall sustainability (Singh and Singh Ahuja, 2014, Pham et al., 2008a, Pham et al., 2011).

Similarly, Malaysian manufacturing firms require FM strategies to enhance business performance and overcome manufacturing challenges (Zubaidah et al., 2007). Total production maintenance (TPM) shares high operating costs, and is considered one of the important factors for explaining business performance (Soltan and Mostafa, 2015). Manufacturing firms look for competitive advantage through integrating LM and AM strategies with maintenance activities to ensure seamless operations. Overall equipment effectiveness (OEE) infrastructure is a measurement indicator developed by Seiichi Nakajima (1988) useful to evaluate and demonstrate the effectiveness of manufacturing operations equipment studied by various researchers (Dal et al., 2000, Pomorski, 1997, Gibbons and Burgess, 2010, Garza-Reyes et al., 2015, Andersson and Bellgran, 2011, Binti Aminuddin et al., 2016, Dadashnejad and Valmohammadi, 2017, Haming et al., 2017).

OEE infrastructure is used to measure the performance of the system maintenance based on several parameters including (1) the availability of equipment, (2) production efficiency, and (3) quality output of equipment (Borris, 2006). OEE infrastructure provides a foundation for these manufacturing strategies controlling and minimising underlying losses that impede equipment efficiency and overall business performance (Binti Aminuddin et al., 2016). The current study investigates the impact of FM strategies, i.e. LM, AM and SM on BP of Malaysian manufacturing firms. It also examines the role of OEE infrastructure in the relationship between FM strategies, i.e. LM, AM and SM and BP of Malaysian manufacturing firms.

1.2 Overview of the Malaysian Manufacturing Industry

Malaysia is an emerging economy looking to emerge as a high-income nation by 2020. The economy developed at more than 4% every year from 2016-17. Financial and monetary arrangements help to support economic development (Economic Planning Unit, 2015).

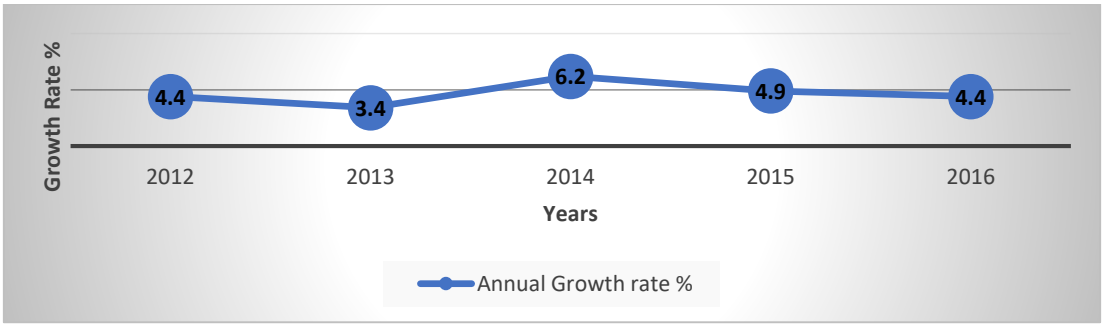

Figure 1.1 GDP Performance of the Manufacturing Sector Department of Statistics (2016)

Figure 1.1 depicts the inconsistent trends in the average annual growth rate from 2012-2016. The growth rate was 4.4% in 2011 and reduced to 3.40% in 2013. However, it regained momentum in 2014 and increased to 6.2%. The percentage then reduced from 4.9% in 2015 and 4.4% in the year 2016 (Department of Statistics, 2016).

The Malaysian economy needs consistent and sustainable growth to meet the target of achieving high-earning country status by 2020. To this end, the manufacturing sector plays a significant role.

1.3 Annual Labour Productivity Growth

Malaysia wants to become a high-earning country by 2020. For this purpose, Malaysia's manufacturing companies can help to increase productivity growth. According to the eleventh Malaysia plan (EMP), improving productivity requires an exhaustive arrangement of strategies encompassing the growing pace of human capital

progression, an increase in development, adjustments in the governmental system, and regional connection through exchange and investment opportunities(Malaysia Productivity Corporation, 2016). But the problem with Malaysia's manufacturing companies is the decreasing rate in the human Annual Labour Productivity Growth". Figure 1.2 shows the labour output development among the OECD nations during the period from 2011-2015.

Figure 1.2 Research Goal Labour productivity growth. Source: Productivity Statistics OECD (2016)

1.4 Malaysian Manufacturing Industry Propelling Malaysia Towards Industry 4 and Future Outlook

Industry 4.0 has already been used in practice, and has been an active area of research for almost a decade. Scholars (Ghobakhloo, 2018; Culot, Nassimbeni, Orzes & Sartor, 2020) believe that Industry 4.0 is an upcoming phenomenon, whether it is wanted or not. Industry 4.0 is a potential hit rather than hype. Thus, all manufacturers need to ready themselves to embrace this potential industrial revolution to remain competitive in the turbulent and hyper-competitive market. Technological innovations and changes in business environments affect both firms' short-term performance and long-term sustainability. When future directions and options in technology are obscure and uncertain, firms need to formulate an appropriate technology strategy to support their planning for interacting with upcoming future technological developments such as Industry 4.0 (Ivanov et al., 2016; Lee et al., 2013).

The manufacturing sector is essential to accelerating the economic growth of the country. Recent advancements in globalisation and technology affect manufacturing systems. To stay competitive, companies must use manufacturing systems that not only produce their goods with high productivity but also allow for rapid response to market pressures and changing consumer needs. Traditional manufacturing refers to manufacturing principles focused on producing a certain set number of products each period and holding a reserve in case of unexpected demand or shortages. This strategy still works well for many types of manufacturing. Nevertheless, in some industries, it is being replaced by lean manufacturing, which seeks to save money by matching production flow with changing demand and focusing on efficiency instead of reserves. By applying manufacturing strategies, the manufacturing sector is strategising to enhance their business performance. Thus the integration of manufacturing strategies is vital to survive in the current market competitive environment. To gain excellence in manufacturing activities, firms must implement Fit Manufacturing with Lean and Agile systems tend to achieve sustainable benefits. Overall, Fit Manufacturing, which is known as a competitive paradigm, empowers manufacturing organisations to support universal competitiveness.

Malaysia means to boost output in manufacturing by accelerating automation and enhancing skilled labour under the EMP. To nourish an effective environment, the government shall vigorously participate in the prevalent growth in exports with a concentration on productivity and innovation in the manufacturing sector. Manufacturing is essential and evident by its share in the GDP, international trade, and creating employment opportunities (Economic Planning Unit, 2015).

Globally, manufacturing firms have embarked on the revolution of the fourth surge or Industry 4. Industry 4 concentrates on “smart factories”, which are related to robotics, modern sensors for information input, prescient analytics, and internet of things (IoT). As per an investigation on Malaysia’s computerisation venture, 30% of our producers have begun to contribute and use current technologies regardless of being responsive to the idea of Industry 4.0. Several elements have impacted their relative hesitance to put resources into present-day technology. They incorporate the absence of skilled labour, higher creation price, and a powerless economic atmosphere.

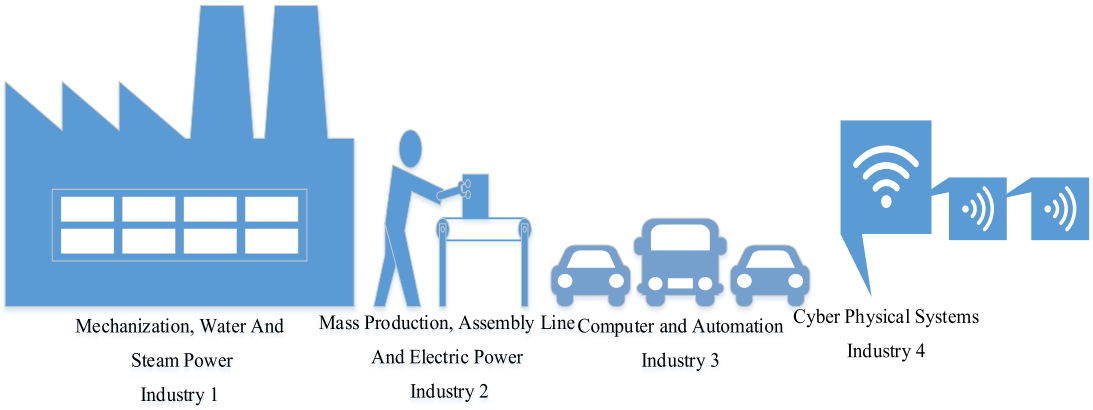

Figure 1.3 Stages of the evolution of the manufacturing industry. Source: Schlaepfer et al. (2015)

Figure 1.3 shows how the manufacturing industry evolved through various stages, i.e. (1) mechanisation, water, and steam power (2) mass production, assembly line, and electric power (3) computer and automation (4) cyber-physical systems (Schlaepfer et al., 2015).

Manufacturing segment in Malaysia asks for more noteworthy computerisation before stakeholders can set out on Industry 4. Industry 4 requires producers to become adaptable because it requires them to automate their \ operations in e light of a typical IoT communication component. To meet the Eleventh Malaysian Plan (EMP) towards Industry 4.0 requires integrating Fit Manufacturing (FM) strategies, Agile Manufacturing (AM), Lean Manufacturing (LM), and Sustainable Manufacturing (SM) to improve Business Performance (BP). Strategies of fit manufacturing, i.e., AM, LM, and SM, are more environmentally friendly than traditional manufacturing. But the problem with some Malaysian manufacturing companies is that they are unable to transform traditional manufacturing to fit manufacturing due to which these companies fail to achieve long-run business improvement.

Based on estimated data in Malaysia, IoT will support the economy to encounter substantial development even post 2020 and achieve RM42.5 billion by 2025 as output. To increase industrial usage of IoT, the government needs to protect information that is mandatory to be upgraded to develop dependable ecosystems for producers, providers, and customers to share private and legitimate data. Thus, for

example, the Penang Skills Development Centre (PSDC) and Malaysian Industry-Government Group for High Technology (MIGHT) will drive the production sector towards Industry 4.0. Malaysia will take a substantial leap into the new time of digitalization once it puts resources into upscaling and upskilling the foundation of the production sector by investing in R&D (Malaysia Productivity Corporation, 2016).

1.5 Manufacturing Sector's Skills Landscape and Future Challenges

The Malaysian government under EMP means to expand efficiency in manufacturing through cutting edge technology and automation by upgrading workforce abilities. To sustain a proficient environment, the government will be effectively engaged with the prevailing advancement of export-related efforts with a concentration on efficiency, output, and creative development in the manufacturing sector (Economic Planning Unit, 2015). Globalisation brings both opportunities and challenges for manufacturing industries worldwide. However, developing countries like Malaysia needs a workforce with equipped scientific and technological advanced skills. Lean manufacturing systems and expanding automation are motivating upskilling necessities for nonspecific and specialised skills crosswise over virtually all professions. A report published by FORFÁS (2013) highlighted key significant challenges and skills required for manufacturing industry by 2020. This includes the (1) need to implement sustainable operations such as (2) lean manufacturing strategies (3) cost competitiveness (4) to overcome skill deficiencies (5) advanced automation and technology application (6) environmental regulations and compliance (7) and environmental concerns and usage of energy resources.

Figure 1.4 Future Skills Requirements and challenges for the Manufacturing Sector

To meet the Eleventh Malaysian Plan (EMP) targets, the pathway towards industry 4 Malaysian manufacturing industry needs to integrate Fit manufacturing strategies, including Lean, Agility, and sustainability, to improve productivity and business performance.

1.6 Problem Statement

In the present global scenario, the manufacturing industry is facing environmental problems such as climate change, population growth, pollution, and the increasing cost of energy and resources. Manufacturing industries face significant challenges to remain economically competitive without ignoring environmental and social considerations (Abdullah et al., 2017). Researchers believe that traditional manufacturing strategies and processes had been viewed as barriers to business performance and overall economic sustainability. For many traditional manufacturers, there are three strategies, although some firms will do more than one: 1) Offsetting labour cost disadvantages in the existing product line by significantly improving productivity. 2) Changing the nature of the product made to a more original, sophisticated, specialised, high-quality 'niche' or 'boutique' product, that possibly cannot be made with a low-skilled workforce, and looking to export. 3) Moving the assembly line aspects of the production of relatively simple manufactures to cheaper centres overseas. For some companies, this may mean they retain only the high-value elements such as design and marketing domestically. For some companies, this could involve specialising in making one component as part of a global supply chain. Both lean and sustainability manufacturing are environmentally friendly (Florida, 1996; Found, 2009; Khor, 2011; Wilson, 2010; Ahmad et al., 2017).

Similarly, Malaysian manufacturing firms adopt LM and AM (Wahab et al., 2013, Habidin et al., 2018) to gain benefits like increased market share and customer satisfaction, increase sustainability and business performance through high-quality products with lower cost (Wong et al., 2009, Agus and Shukri Hajinoor, 2012, AlManei et al., 2017) concerning customers' demand with minimum waste policy (Nordin et al., 2010). However, many companies are not able to transform traditional manufacturing processes to lean manufacturing companies due to formidable challenges and barriers (Nordin et al., 2010). The barriers in the implementation of lean manufacturing, such as cultural challenges, cost investment, technological and managerial issues, lack of resources efficiency, and workers' resistance to change (AlManei et al., 2017; Khusaini et al., 2016).

Malaysian manufacturing firms need to identify their manufacturing capabilities to improve firm performance. Due to unexpected changes and threats of the business environment, manufacturing firms need to be agile enough (Malay Mail Online, 2017) to beat environmental uncertainties (Dubey and Gunasekaran, 2015b). Firms use agile manufacturing as an operational strategy in perceiving and anticipating changes in the business environment. Changing competitive conditions and increasing levels of environmental complexity have caused companies to consider agile manufacturing (Mirghafoori et al., 2017). An agile manufacturer possesses a handful of capabilities and abilities and manages situational turbulence effectively as compared to traditional manufacturing systems (Amlus et al., 2018).

The Malaysian manufacturing industry depicts inconsistent trends in growth rate from period 2012-2016 in contributing to GDP (Economic Planning Unit, 2015). Manufacturing firms need consistent and sustainable growth to play a significant role in the Malaysian economy in achieving high-income nation status by 2020. Labour productivity growth in the past five years has declined in Malaysia, with 2.3% among ASEAN members (OCDE, 2016). According to productivity report 2016-17, only 30% of Malaysian manufacturers have started to invest in automation and modern technology in a march towards the concept of Industry 4. Manufacturing firms need a workforce with equipped scientific and technological advanced skills, investment, sustainable production mechanisms, and delivery to customers. Lean manufacturing techniques and increasing automation are driving requirements for operations in ensuring competitiveness and sustainability in many key industrial sectors (Malaysia Productivity Report, 2016).

Likewise, manufacturing firms are adopting automation using advanced technology with a common strategy to minimise production costs and enhance their productivity and product quality. However, increasing the level of automation in operations (Alsyouf et al., 2007; Ahmed et al., 2005) Automation will have a fewer number of employees, but due to the complex machinery, the work of maintenance department becomes very important (Ahuja and Khamba, 2008, Garg and Deshmukh, 2006, Hansson et al., 2003). Manufacturing firms are facing issues in maintenance management (Singh et al., 2016) and finding ways for effective techniques to improve

overall productivity and business performance. Therefore, it has become crucial for firms to focus on effective maintenance systems. Automation will have fewer employees, but due to the complex machinery, the work of the maintenance department becomes very important (Ahuja and Khamba, 2008; Garg and Deshmukh, 2006; Hansson et al., 2003). To overcome this problem, the application of overall equipment effectiveness (OEE) is considered among the most important performance metrics used by manufacturing organisations for monitoring not only the productivity and quality of product performance but also as an indicator and driver of performance improvements (Garza-Reyes, 2015a, Andersson and Bellgran, 2011, Sohal et al., 2010). Therefore, to overcome the mentioned challenges, Malaysian manufacturing firms need to integrate fit manufacturing strategies, i.e. LM, AM and SM, to improve productivity and business performance.

Ebrahim et al. (2011) found a positive correlation between Fit Manufacturing and Business Performance. The Leanness measure has always been associated with the performance of profit-oriented strategies. On the other hand, Agility and Sustainability measures can be associated with the performance of cost-oriented strategies. Moreover, Yang, Hong (2011) found the relationship between Lean Manufacturing practices, environmental management (environmental management practices along with environmental performance) and Business Performance outcomes (market together with financial performance). Yang, Hong (2011) there is a relationship between Lean Manufacturing and Business Performance both direct and indirect. Chen (2015) found a positive and direct effect of Sustainability with Business Performance in terms of improvement methods. Agility, a direct positive correlation was revealed between Lean Manufacturing and operational performance by Inman, Sale (2011) in their model called Agile Manufacturing Model. Pham and Thomas (2004) demonstrated that there is a relationship between Fit Manufacturing and Overall Equipment Effectiveness (OEE). Raja (2015) illustrated a positive correlation between OEE and Performance. Bititci, McLeod (2011) stated that OEE is a platform for Business Performance improvement. The Overall Equipment Effectiveness infrastructure has been chosen as a mediator because the literature supports that there is a positive relationship between Fit Manufacturing and Overall Equipment Effectiveness and also between Overall Equipment Effectiveness and Business Performance.

Advanced manufacturing systems have replaced traditional manufacturing system due to technological development. The manufacturing industry requires a "total" manufacturing initiative that is pro-active to market changes and capable of delivering both short-term operational goals and long-term suitability benefits. This integrated manufacturing strategy, called fit manufacturing (FM), is defined as the integration of three major strategies lean, agility, and sustainability manufacturing was introduced by Pham and Thomas, 2005. Under the fit manufacturing framework, a manufacturing firm is said to be fit if its operational strategy can be described as lean, agile and sustainable. Each of the three core elements brings a different perspective to the world of manufacturing fitness (Pham et al., 2011). Malaysian manufacturing companies must look beyond improving manufacturing processes as a solution to remain in business need an integrated manufacturing strategy that combines the strengths of leanness and agility with sustainability to deliver long-term fitness. For long-run successful business performance (BP), some Malaysian manufacturing companies failed to implement FM strategies as they do not know the effectiveness of the equipment for their modern manufacturing system. To evaluate the effectiveness of manufacturing operations, Seiichi Nakajima (1988) introduced overall equipment effectiveness (OEE). However, there is a lack of study on the impact of OEE infrastructure on BP. This research studies the role of FM strategies on BP through the mediating role of OEE.

From the literature review, several conclusions can be drawn, leading to the identification of gaps that this study intends to address. Firstly, a comprehensive review of the literature reveals that there are inconsistent findings on business performance. Some researchers considered business performance as one-dimensional and some as multidimensional. This inconsistency in the findings and conclusions in the literature has led to calls for additional research to identify the underlying factors of business performance. So, there is a theoretical gap in the literature on business performance that needs to be addressed. Secondly, the literature indicates that most of the research on business performance is dependent on robust manufacturing strategies. Few studies examined the relationship between LM, AM and sustainability with performance individually. However, previous research overlooked analysing the relationship between LM, AM and SM collectively known as fit manufacturing strategies with business performance.

The literature reveals that business performance is mostly related to overall equipment effectiveness. Therefore, there is a theoretical gap in the literature to find the relationship between OEE infrastructure and business performance. Chen (2015) also gave a future call for researchers to investigate the indirect relationship between FM strategies and business performance. There is growing stakeholder pressures on manufacturers to reduce waste and manage operations and their negative impact on the environment and society. For this, FM strategies are necessary to improve business performance. There is also a need to check machine equipment efficiency for this OEE infrastructure.

A further review of the literature, however, indicated that, to date, there is yet to be a study, which has empirically investigated the possible mediating effect of OEE infrastructure on the relationship between FM strategies and business performance. This shows the existence of a contextual gap in the literature, and there have been calls for researches to address the phenomenon. Additionally, the literature indicates that despite the proliferation of research on business performance, most of the studies have concentrated on the developed economies, especially of America, Europe and Australia (Othman and Ameer, 2014; Inman, 2011; Yang, Hong, 2011; Chen, 2015; Ebrahim, 2011; Pham and Thomas, 2004; Raja, 2015).

To date, very few studies have examined the concept of business performance with FM strategies and mediating role of OEE infrastructure in the developing countries (Karunasena, 2012; Van der Wal and Yang, 2015). Further, regarding the limited research focus in the developing countries, the literature review indicates explicitly a dearth of systematic research on business performance with FM strategies and the mediating role of OEE infrastructure in Malaysia. To address these gaps, this study aims to understand the relationship of FM strategies (AM, LM, SM) and business performance with the mediating effect of OEE infrastructure in Malaysia. Thus, the study aims to address some theoretical, contextual and empirical gaps existing in the literature.

1.7 Research Significance

This study makes significant contributions to knowledge and practice. First of all, this research contributes to the body of knowledge by investigating the relationship between FM strategies (AM, LM and SM), OEE infrastructure and Business Performance (BP). This study develops its own framework. A holistic framework of FM assuming that a firm can be qualified fit if it incorporates the three integral strategies such as leanness, agility together with long-term economic sustainability. This study individually investigates the relationship between AM, LM and SM with BP. The current study examines LM strategy along with two others, i.e. AM and SM core components of fit manufacturing and business performance within Malaysian manufacturing firms.

Secondly, the researcher focuses on OEE infrastructure and its impact on business performance. In previous studies, OEE infrastructure was significantly overlooked. This research focuses on the antecedents of business performance within Malaysian manufacturing firms. OEE performs corrective measures to decrease negative factors affecting production and then extends corrective measures to other units of the factory. As a result, many firms lose their market share to the larger multinational firms (Khanna et al., 2011). So, firms must emphasise effective maintenance systems. This study gives a vision to government and manufacturers that they should provide relevant policy and institutional fit framework for the sustainable business performance of the manufacturing industry.

Lean and agile manufacturing strategies are based on productivity and business performance improvement (Hallgren and Olhager, 2009;Sindhwani and Malhotra, 2015;Ghobakhloo and Azar, 2018). These manufacturing strategies have received significant attention from academia, policymakers, business managers and practitioners in advanced economies especially in the UK and U.S. For instance, according to the 2007 IW/MPI Census of Manufacturers, nearly 70% of all plants have adopted lean manufacturing as an improvement methodology in a census of U.S (Blanchard, 2007). In the UK, the report shows that while lean manufacturing concept continues to engage the attention of UK manufacturers, they do not pursue it with the

same intensity and depth compared to U.S. firms (Engineering Employers' Federation, 2001). Contrary to this, in some cases, firms that have tried to implement a lean strategy, only a few succeed (James, 2006). For instance, the implementation of lean and agile manufacturing has not shielded some of Japanese, European and US automobile manufacturers from the global economic downturn of 2008–2009 (Pham et al., 2011). However, in general, global implementations of lean and agile manufacturing strategies have helped firms to achieve operational efficiencies (Pay, 2008).

However, alongside sustainability was remain a key concern beside operational excellence of lean and agile improvement programmes for managers in manufacturing firms to meet the challenges of a sustainable future (Pham et al., 2011). The issue for many organisations is that these proposed solutions, although they deliver economic benefits in the short-term, failed as long-term business improvement strategies since they rarely become the explicit or even implicit focus of change initiatives in companies(Bateman, 2001). However, the performance of these manufacturing strategies has not yet been measured through integrated fit manufacturing approach (Pham et al., 2011).

It is clear that the manufacturing industry requires a "total" manufacturing initiative that is pro-active to market changes and capable of delivering both short-term operational goals and long-term suitability benefits. This integrated manufacturing strategy, called fit manufacturing (FM), is defined as the integration of three major strategies, i.e. lean, agility, and sustainability manufacturing (Pham and Thomas, 2005, Thomas and Pham, 2004). Under the fit manufacturing framework, a manufacturing firm is said to be fit, if its operational strategy can be described as lean, agile and sustainable. Each of the three core elements brings a different perspective to the world of manufacturing fitness (Pham et al., 2011).

However, the fit manufacturing (FM) paradigm enables the manufacturing industries to become sustainable and operate effectively in a globally competitive market. The proposed fit paradigm is aimed at providing a new manufacturing management perspective to both academics and industrialists (Pham et al., 2008b).

This study is based on a model of fit manufacturing strategies, mainly leanness, agility and sustainability (Pham and Thomas, 2005). Malaysian manufacturing companies must look beyond improving manufacturing processes as a solution to remain in business. This requires an integrated manufacturing strategy that combines the strengths of leanness and agility with sustainability to deliver long-term fitness. The main difference between local and foreign manufacturing practices is one of culture, which affects both the negotiation process and the price negotiation. Failing to negotiate correctly because of cultural issues, the company does not consider as important, can lead to an overall failure in doing business. Along with culture, process focus, pull production, equipment productivity and environmental compatibility is also makes a difference in local and foreign manufacturing practices.

An OEE measurement indicator developed by Seiichi Nakajima (1988) is useful to evaluate and demonstrate the effectiveness of manufacturing operations equipment. OEE is used as a measurement of the performance of the system maintenance. This method ascertains the availability of equipment, production efficiency, and quality output of equipment (Borris, 2006). The success of manufacturing strategies is based on OEE to tackle the underlying losses that impede equipment efficiency and overall business performance. OEE is a quantitative metric that endeavours to identify indirect and hidden productivity and quality costs, in the form of production losses(Binti Aminuddin et al., 2016). Overall Equipment Effectiveness (OEE) is a key research area studied by many researchers (Dal et al., 2000, Pomorski, 1997, Gibbons and Burgess, 2010, Garza-Reyes et al., 2015, Andersson and Bellgran, 2011, Binti Aminuddin et al., 2016, Dadashnejad and Valmohammadi, 2017, Haming et al., 2017).

Manufacturing firms are adopting automation models using advanced technology to minimise production costs and enhance their productivity and product quality. However, growing levels of automation in operations (Alsyouf, 2007; Ahmed et al., 2005) increased the role and responsibility of maintenance department (Ahuja and Khamba, 2008, Garg and Deshmukh, 2006, Hansson et al., 2003). Manufacturing firms are facing issues in maintenance management(Singh et al., 2016) and finding ways for effective techniques to improve overall productivity and business

performance. Therefore, it has become crucial for firms to focus on effective maintenance systems. To overcome this problem application, OEE is considered as one of the most important performance metrics being used by manufacturing organisations not only for monitoring the productivity and quality of product performance but also as an indicator and driver of performance improvements (Andersson and Bellgran, 2011, Sohal et al., 2010, Garza-Reyes et al., 2015). Based on a comprehensive review of literature, the current study introduces a new framework that expands the original of fit manufacturing (FM) strategies, namely LM, AM and SM, by integrating overall equipment effectiveness (OEE) measures to predict the business performance (BP) of Malaysian manufacturing firms.

1.8 Scope of the Study

To make this research more effective and manageable, the scope of this study focuses on three main areas.

a. This research focuses on fit manufacturing strategies, namely lean manufacturing (LM), agile manufacturing (AM) and sustainability manufacturing (SM) and business performance within Malaysian manufacturing firms.

b. The population and sample of survey respondents targeted in this research is manufacturing firms registered with the Federation of Malaysian Manufacturers (FMM). The study proposes a model and investigates the relationship between fit manufacturing (LM, AM and SM) strategies and business performance through overall equipment effectiveness (OEE) within Malaysian manufacturing firms. Therefore, this study will be conducted in the manufacturing firms listed on the FMM directory (2016). The results of this study will be generalised to the Malaysian manufacturing industry initially and could later be applied to similar industries.

1.9 Research Questions

A research question is viewed as a crucial early step that provides a point of orientation for an investigation. It helps the researcher to investigate the problem and formulate study objectives based on literature and design methods (Bryman, 2007). Designing research questions is one of the most critical steps in research processes. Therefore, the current study has formulated four research questions.

i. What is the relationship between fit manufacturing strategies, i.e. LM, AM and SM, with business performance (BP) of Malaysian manufacturing firms?

ii. What is the relationship between fit manufacturing strategies, namely LM, AM and SM and overall equipment effectiveness (OEE) of Malaysian manufacturing firms?

iii. What is the relationship between overall equipment effectiveness (OEE) and business performance (BP) of Malaysian manufacturing firms?

iv. Does overall equipment effectiveness (OEE) mediate the relationship between fit manufacturing strategies, namely LM, AM and SM and business performance (BP) of Malaysian manufacturing firms?

1.10 Research Objectives

Establishing research questions makes it possible to select research objectives and methods at later stages. Research objectives provide an accurate description of the research questions that need to be answered (Bryman, 2007).

i. To investigate the relationship between fit manufacturing strategies, namely: LM, AM and SM and business performance (BP) of Malaysian manufacturing firms.

ii. To investigate the relationship between fit manufacturing strategies, namely LM, AM and SM and overall equipment effectiveness (OEE) of Malaysian manufacturing firms.

iii. To investigate the relationship between overall equipment effectiveness (OEE) and the business performance of Malaysian manufacturing firms.

iv. To test the indirect effects of overall equipment effectiveness (OEE) on the relationship between fit manufacturing strategies, namely LM, AM and SM and business performance (BP) of Malaysian manufacturing firms.

1.11 Operational Definitions

An operational definition primarily refers to how a researcher operationalises study variables based on valid dimensions or items. The purpose of operational definitions is not about creating new concepts but focuses on the processes of operationalisation and validation of specific concepts based on its dimension and items (Flannelly et al., 2014).

Table 1.1 Operational Definitions

Terms	Definitions	Name of Researcher
Fit Manufacturing	A competitive manufacturing model is comprised of lean manufacturing, agile manufacturing strategies and sustainability.	Pham and Thomas (2011)
Agile Manufacturing	A Manufacturing strategy to exhibit capabilities of responsiveness, flexibility, and quickness in responding to changes in customer demand. The AM	Inman et al. (2011)

Terms	Definitions	Name of Researcher
	will be operationalised through ten various capabilities, e.g. processes flexibility, use of technology and overall strategic vision.	
Lean Manufacturing	A production strategy used in organisational efficiency which focuses on the waste decrease and progressing productivity throughout by the application of various elements. The LM will be measured through various manufacturing tools such as manufacturing cells, reduced setup times, kanban system, one-piece flow, reduced lot sizes, reduced buffer inventories, 5S, and Kaizen.	(Fullerton et al., 2014)
Sustainability Manufacturing	Sustainability refers to the integration of economic, environmental, and social components. A company's efforts to go beyond focusing not only on profitability, but also to manage its environmental, social, and broader economic impact on the marketplace and society.	(Svensson et al., 2016)
Overall Equipment Effectiveness (OEE)	Overall equipment effectiveness (OEE) infrastructure is a measure of how well a manufacturing operation is utilised (facilities, time and material) compared to its full potential, during the periods when it is scheduled to run. It identifies the percentage of manufacturing time that is truly productive. An OEE of 100% means that only good parts are produced (100% quality), at the maximum speed (100% performance), and without interruption (100% availability).	Binti Aminuddin et al. (2016)
Business Performance	The degree to which a focal firm has superior performance relative to its competition. BP is a multidimensional construct that will be operationalised through operational excellence, customer relationship and revenue growth.	Rai et al. (2006)

1.12 Thesis Organisation

This thesis includes three chapters. Chapter one presented the thesis background and the problem statement and contained its objectives, questioning the researcher concerning studies in the areas of fit manufacturing, overall equipment effectiveness and business performance. The scope and significance of the study were explained. Chapter two contains the literature review about Malaysian manufacturing

firms, fit manufacturing, OEE and business performance. Chapter three analyses the development of fit manufacturing, explaining its concepts and the measurement of OEE as well as business performance management concepts.

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