



UNIVERSITI PUTRA MALAYSIA

***MODEL DEVELOPMENT OF ESSENTIAL LEAN MANUFACTURING
METHODS ON SUSTAINABLE PERFORMANCE IN MALAYSIAN
MANUFACTURING FIRMS***

MUHAMMAD HARITH BIN ZAINAL ABIDIN

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By

MUHAMMAD HARITH BIN ZAINAL ABIDIN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the Doctor of Philosophy

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June 2022

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Malaysian manufacturing production has been declining for the last decade, according to the Department of Statistics Malaysia (DoSM). 5.70 percent is expected to decrease by the end of the quarter, based on the trading economics model and analyst expectations. Manufacturing organisations in Malaysia were forced to continuously improve their performance through operational excellence and product quality enhancement in order to survive under extreme pressure. Accelerating the adoption of Lean Manufacturing (LM) will help manufacturing organisations remain competitive in the market by increasing productivity and efficiency through the process of waste elimination and non-value-added activities. The purpose of this thesis is to conduct an empirical study of the multidimensionality of essential lean manufacturing (LM) methods (i.e., total productive maintenance (TPM), continuous improvement (CI), and just-in-time (JIT)) and their association with sustainable performance (SP) as perceived by middle to upper-level managers (i.e., executives, managers, senior managers, managing directors in the manufacturing firms in Negeri Sembilan, Malaysia). The novelty of this study lies in the developed conceptual model that correlates the constructs comprises of three essential LM methods and sustainable performance. A conceptual model is developed to explore the multidimensional relationship between the four main constructs. Based on a statistical analytic approach, 12 critical success factors of essential Lean Manufacturing Methods and SP were identified. 69 of 121 respondents' usable surveys were collected from manufacturing sectors that are recognised by the Negeri Sembilan Investment Centre (NSIC). They are made up of small, medium, and large businesses. The conceptual model was validated using the Structural Equation Modelling (SEM) technique. The findings of this study suggested six hypotheses regarding the direct relationship between essential LM Methods and SP, with the JIT being the most significant determinant. Several findings, however, including the relationship between TPM and SP, the mediator role of TPM in the relationship

between CI and SP, and CI and JIT, and the mediator role of JIT in the relationship between CI and SP, were not significant due to a number of constraints, including advancement of manufacturing standards and systems, employee knowledge levels, and a lack of delegation by top management. These findings were tested and it contributes to the effectiveness and integrating theory of LM on SP knowledge paradigm. Two case studies are used to validate the developed model. According to the first case study's findings, integrating of Value Stream Mapping, Benchmarking and essential LM practices resulted in a 3.85 percent increase in the Manufacturing Performance Index (MPI), from 0.75 to 0.78. The proposed integration method in this particular case study is the significant methodological contribution in this study. Furthermore, according to the value stream map, the production lead time (PLT) reduced by nearly 6.3 percent, from 24.1 days (current VSM) to 22.6 days (future VSM). The second case study also yields favourable results. After implementing integrated essential lean methods, the company was able to achieve a defect rate reduction of approximately 50%. Additionally, the reduction increases the company's productivity by 50% after defective products are converted to good products. Theoretically, a comprehensive conceptual model relating three essential LM methods and sustainable performance was developed, serving as a valuable reference for future researchers. As a result, it can be concluded that the fundamental lean methods, namely TPM, JIT, and CI, contribute to the sustainable performance (SP) of Malaysian manufacturing firms specifically in Negeri Sembilan state.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

**PENELITIAN KESAN KAEDAH-KAEDAH PENTING PEMBUATAN
KEJAT
TERHADAP PRESTASI LESTARI DI
PERUSAHAAN PEMBUATAN MALAYSIA**

Oleh

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Pengeluaran pembuatan Malaysia menurun sejak sedekad lalu, berdasarkan model ekonomi perdagangan dan jangkaan penganalisis daripada Jabatan Perangkaan Malaysia (DoSM), 5.70 peratus pengeluaran pembuatan dijangka akan menurun pada akhir suku tahun. Organisasi pembuatan di Malaysia terpaksa berterusan meningkatkan prestasi mereka melalui operasi yang jitu dan peningkatan kualiti produk agar dapat bertahan di bawah tekanan yang melampau. Mempercepat penerapan pembuatan *kejat* (LM) akan membantu organisasi pembuatan terus berdaya saing di pasaran dengan meningkatkan produktiviti dan kecekapan melalui proses penyingkiran aktiviti boros dan tiada nilai tambah. Tujuan tesis ini adalah untuk mengendalikan kajian empirikal mengenai multidimensi kaedah penting pembuatan Kejat (LM) (iaitu penyelenggaraan produktif menyeluruh (TPM), peningkatan berterusan (CI), dan tepat waktu (JIT)) dan kaitannya dengan prestasi lestari (SP) seperti yang diamalkan oleh pengurus peringkat pertengahan hingga ke atas (iaitu eksekutif, pengurus, pengurus kanan, pengarah urusan di syarikat pembuatan di Negeri Sembilan, Malaysia). Model konsep telah dihasilkan untuk mengkaji hubungan multidimensi antara empat konstruk utama. Berdasarkan pendekatan analitik statistik, faktor kritikal yang berkesan bagi pembuatan kejat dan SP telah dikenal pasti. 69 daripada 121 tinjauan responden yang digunakan adalah daripada sektor pembuatan yang diiktiraf oleh Pusat Pelaburan Negeri Sembilan (NSIC). Mereka terdiri daripada perusahaan kecil, sederhana, dan besar. Pembaharuan kajian ini berdasarkan model konsep yang menghubungkan konstruk-konstruk daripada tiga kaedah utama LM dan prestasi lestari. Model konsep kajian ini disahkan dengan menggunakan teknik Pembinaan Model Berstruktur (SEM). Penemuan kajian ini mencadangkan enam hipotesis mengenai hubungan langsung antara Kaedah-kaedah penting LM dan SP, dengan JIT adalah penentu yang paling signifikan. Namun, beberapa penemuan kajian seperti hubungan antara TPM dan SP,

peranan mediator TPM dalam hubungan antara CI dan SP, dan CI dan JIT, dan peranan mediator JIT dalam hubungan antara CI dan SP adalah tidak signifikan kerana sejumlah kekangan, termasuk kemajuan standard dan sistem pembuatan, tahap pengetahuan pekerja, dan kurangnya pemantauan oleh pengurusan atasan. Dapatan kajian ini diuji dan ia menyumbang kepada keberkesanan dan integrasi teori pembuatan Kejut kepada paradigma prestasi lestari. Dua kajian kes digunakan untuk mengesahkan model yang dikembangkan. Menurut penemuan kajian kes pertama, mengintegrasikan kaedah-kaedah penting LM menghasilkan kenaikan 3.85 peratus dalam Indeks Prestasi Pembuatan (MPI), dari 0.75 hingga 0.78. Kaedah integrasi yang dicadangkan dalam kajian lapangan ini merupakan salah satu sumbangan metodologi yang signifikan dalam kajian ini. Selanjutnya, menurut peta aliran nilai, masa petunjuk pengeluaran (PLT) dapat dikurangkan hampir 6.3 peratus, dari 24.1 hari hingga 22.6 hari. Kajian kes kedua juga memberikan hasil yang baik. Setelah melaksanakan kaedah penting tanpa lemak bersepadu, syarikat dapat mencapai penurunan kadar kecacatan sekitar 50%. Selain itu, pengurangan itu meningkatkan produktiviti syarikat sebanyak 50% setelah produk yang rosak ditukar menjadi produk yang baik. Hasilnya, dapat disimpulkan bahawa kaedah-kaedah penting LM, iaitu TPM, JIT, dan CI, menyumbang kepada prestasi lestari (SP) firma pembuatan Malaysia khususnya di Negeri Sembilan.

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I certify that a Thesis Examination Committee has met on 13 May 2022 to conduct the final examination of Muhammad Harith Bin Zainal Abidin on his thesis entitled “Model Development of Essential Lean Manufacturing Methods on Sustainable Performance In Malaysian Manufacturing Firms” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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LIST OF ABBREVIATIONS

CFA	Confirmatory Factor Analysis
CI	Continuous Improvement
DPM	Defect Per Million
EFA	Exploratory Factor Analysis
FDA	U.S. Food and Drug Administration
FMM	Federation of Malaysian Manufacturers
IBS	Industrialized Building System
JIT	Just-In-Time
LM	Lean Manufacturing
MPI	Manufacturing Plant Performance Index
MPP	Manufacturing Plant Productivity
NSIC	Negeri Sembilan Investment Center
PLT	Production Lead Time
PM	Preventive Maintenance
SEM	Structural Equation Modelling
SP	Sustainable Performance
TPM	Total Productive Maintenance
VSM	Value Stream Mapping

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Most manufacturing companies today face increased competitiveness as a result of unavoidable globalization, which presents both possibilities and difficulties for all sectors of those companies involved. There are two key drivers of manufacturing competitiveness that remain critical: cost containment and productivity growth. Deloitte Touch Tohmatsu Limited and The Competitiveness Council performed research on the Global Manufacturing Competitiveness Index 2016 (Deloitte, 2016). A company's existence and long-term development are dependent on its ability to compete in the marketplace (Arya et al., 2015). The market for organization endurance and development and growth sustainability values positive aggressiveness, therefore it is important (Arya et al. 2015). Based on recent data from the Department of Statistics Malaysia, industrial output in Malaysia has decreased during the last decade (Trading Economics, 2020). According to the trade economics model and analysts' estimates, the rate of 5.70 percent decline will occur by the end of the quarter (Figure 1.1 and 1.2). The operational efficiency and product quality of Malaysian manufacturing companies have to be constantly improved in order for them to remain viable in the face of extreme competition Through waste reduction and non-value-added operations, accelerating the implementation of Lean Manufacturing (LM) can help manufacturing companies stay competitive in the market.

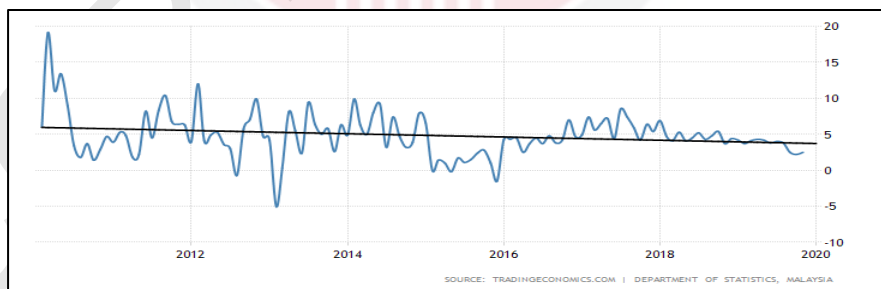


Figure 1.1 : Downtrend manufacturing production Malaysia (million/MYR) over the last ten years 2010-2020

(Sources: Trading Economics 2020 and Department of Statistic 2020)

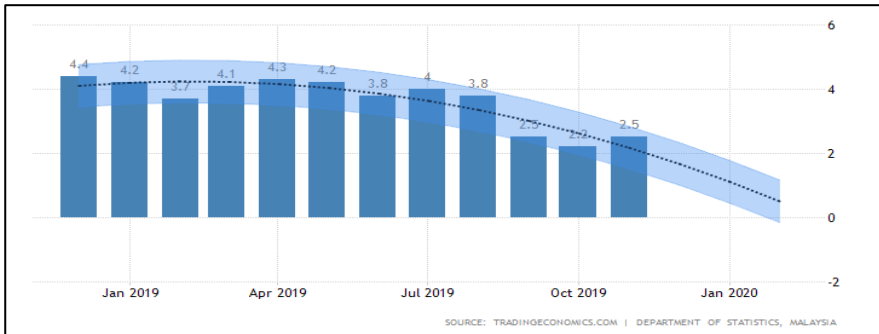


Figure 1.2 : Historical diagram of the current trend and forecast on Malaysian manufacturing production (million/MYR)
 (Sources: Trading Economics 2020 and Department of Statistic 2020)

Womack and Jones (2010) mentioned the improvement continuity leads to excellent lean concept sustenance where the fundamental elements such as cultural, technical, management and other manufacturing aspects in controlled systematically and consistently. On top of that, an accurate and acceptable lean manufacturing methods implement in the organization is critical to establish a sustainable manufacturing performance. Multiple tools and methods comprise a collection of lean manufacturing methods used to enhance the sustainable performance of manufacturing firms, with all of these performances falling under the triple bottom line (TBL) pillars and the lean strategy's umbrella (Bhasin, 2012; Henao et al., 2019). Operational Performance (OP) is one of the TBL's pillars that focusing on economic perspective throughout the manufacturing firms, and with the current unpredictable economic context has made the issue of OP more crucial across all its sectors. Considering the significance of lean manufacturing, it is essential to comprehend its impact on sustainability. Various approaches, including Continuous Improvement (CI), also known as Kaizen, Total Productive Maintenance (TPM), and Just-in-Time (JIT), were deemed to be the most critical components of the lean business approach (Rocha, 2018).

1.2 Problem Statement

To begin, governments, non-governmental organisations, and customers all put pressure on manufacturing firms to operate sustainably. While lean practises may benefit businesses on an environmental, social, and financial level, their impact on long-term performance is ambiguous. (Iranmanesh et al., 2019). Malaysian manufacturers require a successful Lean model as a reference for effective LM adoption, but according to Ng and Ghobakhloo (2018), Malaysia continues to lack verified statistical lean models. Apart from that, the primary impediments to LM adoption include a lack of experience and awareness of LM among practitioners at the operational level (Rose, 2017). Additionally, due to budgetary restrictions, SMEs are hesitant to implement LM until the benefits of lean are realized (Yusoff and Said,

2018). In light of the discussion above, the author identified the following issues and gaps in the fundamental lean approaches used by Malaysian manufacturing firms in the following table:

Table 1.1 : The problem statement of research study

Categories	The Problem/Gaps	References
LM implementation within Malaysian Manufacturing Firms	<p>There is a scarcity of proven statistically verified lean models based on Malaysia's existing LM trend that can be utilized to guide existing and future lean enterprises toward a successful lean conclusion.</p> <p>Insufficient expertise of LM at operational level</p> <p>Financial constraints and small capital to implement LM</p> <p>There is a dearth of research on the relationships between each of the fundamental lean tools, between all of the field of research and development and performance outcomes, and between each of the field of research and development and the seven wastes.</p> <p>No accessible standard practices for Malaysian SMEs.</p>	<p>(Ng and Ghobakhloo, 2018)</p> <p>(Rose, 2017)</p> <p>(Yusoff and Said, 2018)</p> <p>(Rose et al., 2017)</p>
Relationship between Lean Methods	<p>No clear framework accessible on JIT and CI applied together.</p> <p>Lack of empirical study between JIT and TPM</p>	<p>(Dinsdale and Bennett, 2015)</p> <p>(Durakovic et al., 2018).</p>
LM and Sustainable Performance	<p>Lack of focus on impact of TPM on sustainable area specifically operational performance.</p>	<p>(Henao et al., 2019)</p>

Table 1.1 : Continued

<p>Few empirical studies have been done yet of LM practices on Sustainable Performance.</p> <p>No empirical study has been done of CI on SP in large and multinational 2 companies.</p> <p>Lack of social issues arise from implementation of LM.</p>	<p>(Ishak et al., 2017; Nujoom et al., 2017; Baril et al., 2016)</p> <p>(Nguyen ,2019)</p> <p>(Thomas et al.,2016; Sajan et al., 2017)</p>
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1.3 Research Questions and Research Hypotheses

This study purposes to investigate the impact of three essential lean practices (i.e., CI, JIT, TPM) on sustainable performance in Malaysian manufacturing firms specifically in Negeri Sembilan state. In accordance to the current issues being discussed, this research study claims to respond and fulfil the following research question (RQ) and research objective (RO). The articulated following questions are designed to answer the objectives of this study:

Question 1: What are the critical success factors of essential Lean practices namely Total Productive Maintenance (TPM), Continuous Improvement (CI) and Just-In-Time (JIT) and Sustainable Performance in Malaysian manufacturing firms?

Question 2: What is the conceptual model that connects CI, JIT, TPM and SP in the Malaysian manufacturing firms?

Question 3: What is the impact three essential lean methods (i.e., CI, JIT, TPM) on Sustainable Performance and mediating effects of the construct in the conceptual model?

Question 4: How to validate the significance of the developed conceptual model?

The researcher derived hypotheses for this study from contemporary Lean Manufacturing and Sustainable Performance literature and existing findings in order to address research questions:

Hypothesis 1: TPM practices have positive impact on SP aspects

Hypothesis 2: TPM practices have positive impact on JIT aspects

Hypothesis 3: CI practices have positive impact on TPM aspects

Hypothesis 4: JIT practices have positive impact on SP aspects

Hypothesis 5: CI practices have positive impact on JIT aspects

Hypothesis 6: CI practices have positive impact on SP aspects

Hypothesis 7: TPM practices mediates the relationship between CI and SP aspects

Hypothesis 8: JIT practices mediates the relationship between CI and SP aspects

Hypothesis 9: TPM practices mediates the relationship between CI and JIT aspects

1.4 Research Aim and Objectives

The purpose of this research is to empirically investigate the multidimensional effects of three critical lean methods (CI, JIT, and TPM) on sustainable performance (SP) and to develop a conceptual model for Malaysian manufacturing firms operating in the Negeri Sembilan state. According to the research questions, the following specific objectives have been proposed for this study:

- i. To identify the critical success factors of essential lean methods specifically (i.e., CI, JIT, TPM) and Sustainable Performance implemented in Malaysian manufacturing firms.
- ii. To develop the conceptual model which links between essential lean methods namely CI, JIT, TPM with Sustainable Performance (SP).
- iii. To examine the impact of three essential lean methods (i.e., CI, JIT, TPM) on Sustainable Performance and mediating effects of the constructs in the conceptual model.
- iv. To validate the applicability of the developed model through case studies in two manufacturing firms (SMEs and medium-large company).

1.5 Scope and Limitations

Due to time constraints and a lack of resources, the findings of this study revealed several limitations and shortcomings that must be identified and addressed in the near future. To begin, because this study focused exclusively on Malaysian firms, it may lack the necessary information to avoid bias. Another study limitation is the use of a cross-sectional data collection procedure. As such, concluding the relationship between time series variables is quite challenging. As a result, no causal relationship should be inferred from the findings of this study. Indeed, the study's target sample of middle- to upper-level managers was another weakness, as their perspectives on the research topic may differ from those of average employees, resulting in bias. Finally, it is possible to identify potential research areas in order to expand on this subject. The scope of this study's LM methods is constrained by the examination of only three LM practises. Clearly, there are numerous additional LM practises that

may have an impact on SP (e.g., operation, environment and social). They may have a significant influence on how employees feel about SP.

1.6 Thesis outline

This thesis is divided into five chapters. The first chapter provided an overview of the research. In other words, it summarized the research's origins and context, the statement of the problem, research questions, thesis objectives, and thesis outline. The second chapter conducts an extensive review of contemporary literature on the variables of interest, namely TPM, CI, JIT, and SP, as well as the relationships between these four practices. It also discusses the underlying theories; the conceptual model connecting the constructs was introduced, as well as the four set of hypotheses that established. Chapter three will discuss research methodology. The strategies used in this study were extensively discussed. This chapter discusses the research design, target population, and sample, as well as data collection issues, such as developing a structured questionnaire and conducting and evaluating the questionnaire using validity and reliability tests. The chapter concludes with an explanation of the statistical techniques, which include both descriptive and inferential statistics, that were used to infer the results of this study. Chapter four summarizes the study's findings. This includes thematic analysis of the semi-structured interview, exploratory factor analysis of the pilot study, and primary data analysis using SPSS 22 and AMOS 22 techniques. This chapter discusses the results of the hypotheses testing. Chapter five contains the discussion, a summary of the entire study, as well as the study's implications and conclusion. A concise review and summary of the research objectives, as well as the major accomplishments and conclusions regarding the new knowledge gained through this research, will be provided. The limitations, implications, and recommendations for future research were discussed in greater detail.

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