INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
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ISSN: 2222-6990

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v13-i3/16527 DOI:10.6007/IJARBSS/v13-i3/16527

Received: *15* January 2023*,* ***Revised:*** *18* February 2023*,* ***Accepted:*** *28* February 2023

Published Online: *20* March 2023

In-Text Citation: (Hasan et al., 2023)

To Cite this Article: Hasan, M. Z., Yaacob, T. Z., Hashim, H. I. C., Asaad, M. N. M., & Iteng, R. (2023). Sustainability and Lean Manufacturing Practices: The Mediating Role of Manufacturing Performance. *International Journal of Academic Research in Business and Social Sciences*, *13*(3), 715 – 740.

Vol. 13, No. 3, 2023, Pg. 715 – 740

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ISSN: 2222-6990

Sustainability and Lean Manufacturing Practices: The Mediating Role of Manufacturing Performance

Mohd Zulfabli Hasan[1], Teh Zaharah Yaacob[2], Haini Ilyana Che Hashim[3], Mohd Norhasni Mohd Asaad[4] and Rosman Iteng[5]
[1,2] Department of Management and Technology, Faculty of Management, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia, [3]Department of Accounting and Finance, Faculty of Management, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia, [4,5]School of Technology Management & Logistics, Universiti Utara Malaysia, 06010 Kedah, Malaysia
Email: mohdzulfabli@utm.my

Abstract
Lean manufacturing practices (LMP) is considered a manufacturing philosophy that can lead to global manufacturing performance. It gives manufacturers a competitive advantage by enhancing their economic, environmental, and social positions. This study aims to examine the relationship between LMP and sustainability among Malaysia's manufacturing organisations. Specifically, it investigates the mediating role of manufacturing performance (MP) on the relationship between LMP and sustainability. Consequently, this study integrates both the Resource-Based View (RBV) and Stakeholder Theory to map and position the possible relationships between the variables in the conceptual framework. This study applies the quantitative method in which a questionnaire is developed through an extensive literature review. The population size for this study is 2368 firms, based on the Federation of Malaysian Manufacturers (FMM). In this study, the unit of analysis embodies the middle up to the top management of the selected firms. The survey questionnaires were randomly distributed to a sample of 335 manufacturing organisations in Malaysia, with a 30.4 per cent response rate. The data obtained were analysed using PLS-SEM. The results indicated i) a positive relationship between LMP and sustainability, ii) a positive relationship between LMP and MP, iii) a positive relationship between MP and sustainability, and iv) a mediating role of MP in the relationship between LMP and sustainability. Hence, LMP provides a better insight into Malaysia's manufacturing organisations by considering manufacturing performance and economical, social, and environmental sustainability. Additionally, future research also can be done through empirical study if the variables of lean manufacturing practices can be formed into multidimensionality which current study had tested lean manufacturing practices in unidimensionality. Multidimensionality perhaps could identify precise practices of lean manufacturing practices in contribution to increase the manufacturing performance towards sustainability.

Keywords: Lean Manufacturing Practices, Manufacturing Organisations, Manufacturing Performance, Sustainability

Introduction

The rapidly growing global population and the rising demand for consumer products are placing tremendous pressure on our country's manufacturing industries. According to the Department of Statistics Malaysia (2020), Malaysia's manufacturing sales in November 2019 grew by 2.3 per cent to RM73.5 billion compared to RM71.8 billion reported a year ago, as shown in Figure 1. The sales value dropped by 1.6 per cent (RM1.2 billion) in month-on-month growth, while the sales value grew by 0.5 per cent in seasonally adjusted terms.

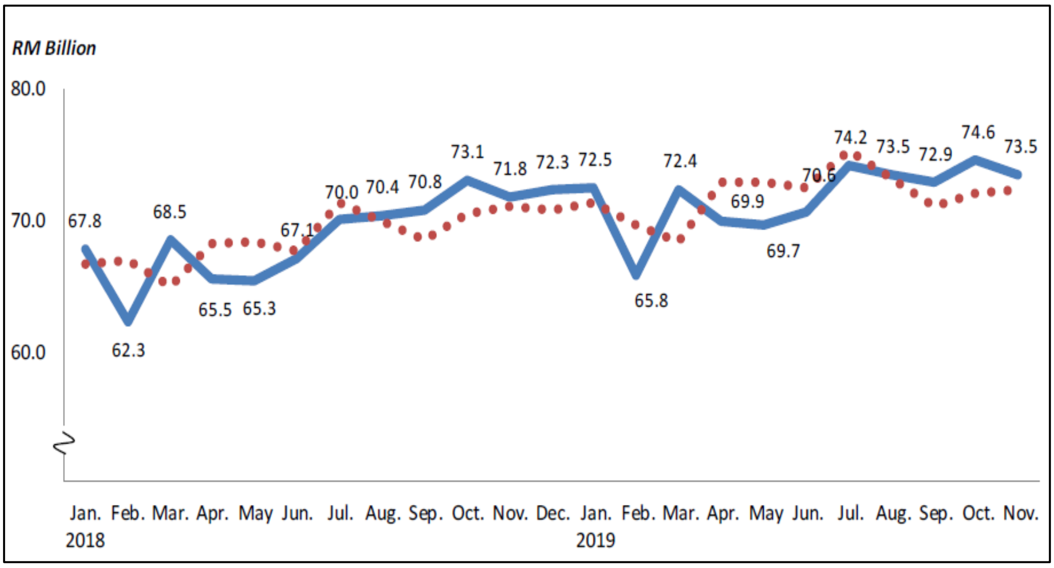

Fig. 1 Sales Value of the Manufacturing Sector (Department of Statistics Malaysia, 2020)

Consequently, new sectors have been developed, and more imported goods are added to the markets to fill the gaps. However, manufacturing operations use a massive volume of energy and natural resources and have produced more air and land pollution, thus impacting both society and the economy (Linke et al., 2013). The manufacturing operations also have a massive effect on the ecosystem and living beings (Ahmad & Wong, 2018).

Up till now, sustainability has become the most crucial strategy of the new millennium in manufacturing organisations. Most business strategies are gradually emphasising the importance of sustainability. Nonetheless, previous studies have received less attention in the literature (Iranmanesh et al., 2019). Elkington (1997) addressed sustainability as a "triple bottom line" consisting of social, environmental, and economical. Similarly, Aminpour et al (2020) stated that sustainability is a comprehensive and evolving notion, emphasising the common interpretation interconnection of social, environmental, and economic components of the notion.

Globally, organisations are under pressure from stakeholders to manage and support the triple bottom line (TBL) of social, environmental, and economic well-being as societal and environmental concerns deteriorate (Juettner et al., 2020). Governments, non-governmental organisations, and consumers are currently pressuring manufacturers to perform sustainably (Iranmanesh et al., 2019). Subsequently, a great deal of attention has been given to the notion of sustainability due to some controversial issues, such as increasing scarcity of natural resources, rapid global environmental degradation, and human beings pursuing higher life quality (Hami, Muhamad, & Ebrahim, 2016). However, according to Abdul-Rashid et al (2017), manufacturers must be proactive in their approach to sustainability by integrating it into their strategy and practices. Sustainability has been divisive due to its rising importance in most business plans; yet, the development and implementation of sustainability-focused operational strategies remain an issue (Longoni & Cagliano, 2015).

The relationship between lean manufacturing and sustainability, according to several researchers, including King and Lenox (2001); Hasle et al (2012); Longoni et al (2013), is still being debated and requires additional research. The understanding of lean manufacturing deployment among the companies adopting such practices and tools is crucial in pursuing sustainability (Nawanir et al., 2020). Besides, the companies need to comprehend the way to align these efforts to evade contradictory impacts.

Literature Review

In their report, Hallgren and Olhager (2009) noted the just-in-time (JIT) or Toyota Production System (TPS), the antecedent to lean production with Taiichi Ohno, Shigeo Shingo, and Yasuhiro Monden's effort and mixing attempts as a great sign of an increase in JIT/TPS/lean in the 1980s, before lean manufacturing is introduced. Hallgren and Olhager (2009) and Schonberger (2007) also indicated that the concepts and procedures associated with lean were identical to those associated with JIT before it. Womack and Jones (1996) defined lean as the following five critical lean principles:

i. Determine what does and does not provide value to the customer.
ii. Emphasise non-value-added waste throughout the value stream process.
iii. Carry out activities that uninterruptedly create value.
iv. Provide services that are triggered solely by the customer.
v. Pursue excellence by removing sequential layers of waste as they become visible.

These principles are known as waste removal guidelines. On the basis of these principles, lean practices have various instruments at their disposal. Lean implementation is based on two primary pillars: JIT and *jidoka* (Jekiel, 2011). JIT is a method of delivering the appropriate quantity at the appropriate time and location. On the other hand, *jidoka* is the Japanese term for autonomation, which generally means quality at the source. It occurs when a human intervenes in an automated process to prevent substandard quality output. When quality at the source thinking has become ingrained in the organisation's environment, the *jidoka* production approach can be extended to the maintenance function (Aikens, 2011). Furthermore, lean manufacturing practices result in increased industry performance (Melton, 2005).

Besides, lean manufacturing consists of a large number of tools, techniques, and practices. Although past scholars and practitioners sought to identify the primary lean manufacturing practices, they could not agree on their relative relevance (Nawanir et al., 2013; Ahmad et al., 2003). The author's background typically corresponds to the sort of practice. Nevertheless, while the practices differ, the underlying concept remains the same. Shah and Ward (2003) recognised twenty-two lean manufacturing practices regularly pointed out in literature and considered them into four bundles associated with JIT.

Cellular Manufacturing

Cellular manufacturing is a manufacturing process minimising transportation delays or other conveyance issues by structuring workspaces and tools in a layout, promoting the movement of materials and components through the process (Suzaki, 1985). Conversely, Zahraee (2016) described cellular manufacturing as the process of grouping all the essential equipment, machines, and workers for a certain product or a group of related items into a set or cell. Cellular manufacturing, in reality, has the potential to eliminate waste associated with transportation and superfluous motion; the '3M' stands for men, machinery, and material. Stemhanou and Spiegl (1992) characterised cellular manufacturing as adapting while keeping a competitive pricing structure. Meanwhile, Fullerton et al (2003) referred to cellular manufacturing as the collecting and creating common concepts, principles, challenges, and tasks.

Pull system/Kanban

Kanban is a visual indicator promoting flow by 'pulling' products through the process as defined by the customer. It is a marking system for rising JIT manufacturing. Ohno (1988) indicated that the Toyota production system employs the *kanban* method of operation. *Kanban* performs various functions, including tracking delivery or pick-up or information, providing production information, discouraging excessive production and extreme conveyance, acting as a work order for goods, avoiding defective products by identifying the process that results in them, revealing existing problems, and maintaining inventory tracking. Additionally, Nawanir et al (2020) stated that implementing a pull system, producing when customers request only, can lead to less work and more efficient machine utilisation. Furthermore, the real benefit of the pull system is that it results in reduced inventory; thus, reducing the corresponding inventory cost (Herzog & Tonchia, 2014).

Quick Changeover

Shah and Ward (2007) defined short changeover or set-up time as the time between the end of the current run and the start of the next run while running at the ideal rate. Shah and Ward also mentioned that reducing the set-up time can help to reduce the time between product changeovers. Furthermore, Monden (1983) stated that lowering set-up time will help promote greater flexibility, especially for multiple products in the same production line. These reductions ensure that a company can respond rapidly to customers' needs by reducing lead times, such as the time required to set up, move, process, wait, and queue.

Total Quality Management

According to Zahraee (2016), total quality management (TQM) is a strategy of continuous improvement employing organisational commitment to fulfil the fundamental needs of consumers. It is predicated on the premise that systems and not the people generate incompetence. Participation and preparation, problem-solving, mathematical approaches, long-term goals, and detection serve as crucial elements. TQM is one of the lean practices applied widely in the manufacturing industry (Krishnan & Parveen, 2013).

Total Productive Maintenance (TPM)

Total productive maintenance, abbreviated TPM, was described by Shah and Ward (2003) as the employment of maintenance practices to maximise equipment effectiveness through scheduled and preventative maintenance. TPM enables waste reduction by reducing idle downtime during operation because it is one of the lean manufacturing pillars. Furthermore, TPM is a maintenance system administering the equipment entire life in every section, such as planning, manufacturing, maintenance, and others, to increase the equipment's overall performance. According to Zahraee (2016), TPM aims to enable detection, modification and rectification of glitches to prevent failures. Consequently, employees conduct coordinated tool protection to detect any anomalies. In this situation, since operators are positioned near the machines, they were included in the protection and control operations to avoid and alert malfunctions.

Small Lot of Production

According to Chen and Tan (2011), the JIT system is characterised by small lot sizes. The key to Ford's mass production system is making large lots of single parts that are punching out a large number of parts without a die change (Ohno, 1988). Furthermore, batches are made as small as possible compared to traditional mass production, in which a bigger volume is considered better in production levelling. Smaller lot size facilitates the use of JIT systems, allowing the systems to function more efficiently, resulting in lower work-in-process (WIP) inventories, reduced space requirements, and more flexibility.

Further, Nawanir et al (2020) discovered that small lot production has the added benefit of increasing quality because quality issues are detected quickly, minimising the risk of defects being passed, and inventory levels are, therefore, lower because batch quantities are entirely dependent on the quantities produced. Consequently, it conserves energy and resources associated with inventory management and the handling of defective products.

Sustainability

In the present volatile industrial climate marked by severe resource shortages, players in the industry are motivated to adopt strategies for sustaining their businesses, simultaneously pursuing market advantage (Nawanir et al., 2020). Sustainability was first described as a theoretical term in 1987, with the publication of the Brundtland Report titled "Our Common Future" by the World Commission on Environmental and Development (WCED) (Shokouhyar, Seddigh, & Panahifar, 2020). The commission defined sustainable development in this report as development that serves current demands without jeopardising future generations' ability to meet their own (WCED, 1987).

Elkington (1994) transformed the three dimensions years later, described them as "People, Planet, and Profits". Elkington (1994) developed the original notion of "sustainability", taking into account environmental, social, and economic dimensions (Abdul-Rashid et al., 2017). Sustainability is thought to be a long-term goal that should be established in nature. Numerous businesses consider sustainable business strategies solely to increase their short-term value. As the emphasis on sustainability continues to increase, more consideration should be given to sustainability as a long-term perspective (Ferro et al., 2017). Meanwhile, Nawanir et al (2020) assert that rising resource utilisation, climate change, biodiversity loss, water shortages, and population changes and volatility have prompted society to examine sustainability challenges through the triple bottom line lens. As a result, researchers found that sustainability is vital in determining an organisation's stability. According to past studies, nowadays, most organisations consider sustainability to strengthen placement and be competitive.

Manufacturing Performance
It is critical for manufacturing companies to determine, assess, and enhance their production and operational performance (Tan & Wong, 2015). Nevertheless, manufacturing performance measurement remains an unstable subject due to its diverse and multi-dimensional manufacturing properties (Hon, 2005). Although global competition is rising, companies competing in the modern market should innovate and provide superior products and services and refine their manufacturing processes (Taj & Morosan, 2011).

Subsequently, manufacturing performance becomes an essential measure of the companies' success (Adebanjo et al., 2016). The achievement in manufacturing performance enhances companies' manufacturing competitive capabilities (Jabbour et al., 2014; Wickramasinghe & Wickramasinghe, 2017). Nevertheless, Hasan et al (2017) indicated that manufacturing performance is frequently analysed in a multifaceted manner pertaining to particular research. Besides, a complete manufacturing performance measurement system needs to be comprehensive and cover the most critical performance dimensions of the organisation (El Mola & Parsaei, 2010). Furthermore, according to Randhawa and Ahuja (2018), manufacturing performance and organisational sustainability can be improved by deploying lean manufacturing. Therefore, the researcher believes that manufacturing performance has various measures in measuring it; thus, they need to be incorporated.

Methodology
This study employed the simple random technique since the technique is the purest form of probability sampling and easy to implement (Cooper & Schindler, 2014). Moreover, Sekaran and Bougie (2016) has the least bias and offers the most generalisability compared to other probability sampling techniques. Nevertheless, the participants will have an equal chance of being selected when using random sampling, as stated by Saunders et al (2016); thus, all the manufacturing organisations in Malaysia will have an equal chance to be selected.

Subsequently, the target sample frame was selected from the Malaysia Federation of Malaysian Manufacturers, Malaysia's premier economic organisation that gathers all manufacturers registered in Malaysia. The population size for this study was 2368. However, the sample size required is 335, based on the table produced by (Krejcie and Morgan, 1970). Thus, 335 respondents were randomly selected from the list to participate in this study. Research randomiser software available at web application http://randomiser.org was performed to generate random numbers of this study. This software has randomised 335 the total sample size out of 2368 manufacturing organisations in Malaysia.

These 355 manufacturing organisations, including from Sabah and Sarawak, were from 11 different industries, namely; i) Electrical and Electronics (E&E), ii) Machinery, Appliances, and Parts, iii) Transport Equipment, iv) Food, Beverages, and Tobacco, v) Other Manufacturing Goods, vi) Chemical and Plastics, vii) Rubber, viii) Iron, Steel, and Metal, ix) Wood-based, x) Non-Metallic Mineral, and xi) Petroleum-based.

In this study, the organisation was chosen as the unit of analysis based on the research questions. The unit of analysis's element was decided based on the individual's function within the organisation and his/her familiarity with lean manufacturing practices and manufacturing performance.. Hence, the unit of analysis in this study will be the organisations involved with lean manufacturing practices, starting from the middle management up to the top management.

In response to this study, descriptive analysis was performed to evaluate the basic statistical description of constructs used. Statistical values, such as means and standard deviation, were calculated for all constructs, comprising independent, mediating, moderating, and dependent variables. Meanwhile, for the inferential statistic, this study employed SmartPLS due to its capability in handling problematic modelling issues. Besides, there are three fundamental reasons: small sample sizes, non-normal data, and formatively measured constructs. On the other hand, other reasons for using PLS approach have been justified by Roy et al (2012) in their study, which are formative latent variable can be tested by scholars independently; sample size can be compromising, expectations about the normality of the data or residual distributions.

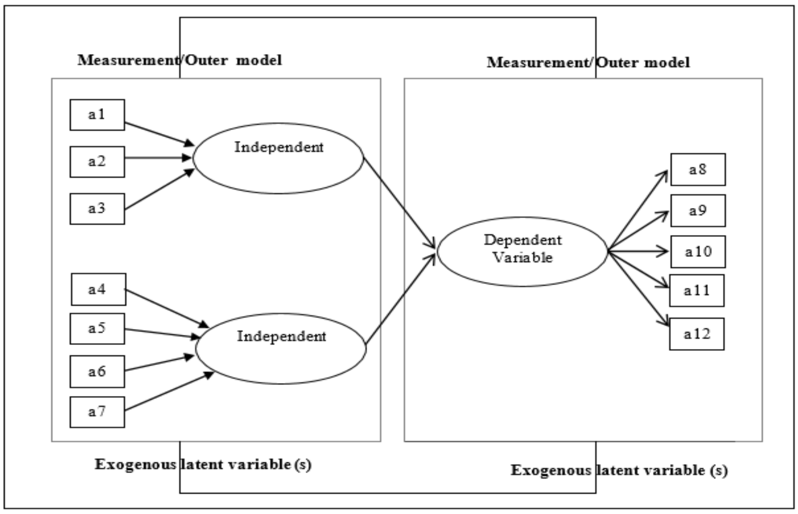

Fig. 2 A Simple Path Model (Source: Hair et al., 2017)

Theoretical Framework

A theoretical framework refers to a network of associations among variables in a research study that is logically developed, described, explained and expounded on the relationship between the variables examined in this study (Sekaran & Bougie, 2016). This framework was developed upon conducting the literature review, comprising lean manufacturing practices as an independent variable, sustainability as a dependent variable, and manufacturing performance as a mediating variable.

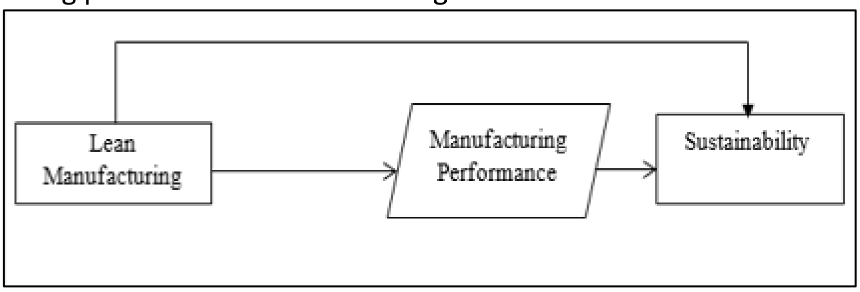

Fig. 3 Theoretical Framework

Two theories underpin the theoretical framework, as illustrated in Figure 3 Resource-Based View Theory and Stakeholder Theory. Based on the theoretical framework, hypotheses will be developed in order to show the relationship among variables. Previous literature shows the relationship between the variables. This study uses an alternative hypothesis (h_a), a statistically significant relationship between two variables.

Lean is a critical business practice. It is a powerful motivator for environmental conservation and long-term sustainability (Ho, 2010). Furthermore, King and Lenox (2001); Rothenberg et al (2001) defined lean practices as managerial measures decreasing or eliminating wastes in all its manifestations. As a result, lean practices enable a particular organisation to avoid pollutant and harmful emissions by reducing logistical costs and minimising non-value-added activities.

Additionally, lean practices contribute to the sustainability of environmental performance (King & Lenox, 2001; Shah & Ward, 2003). It contributes to the notion that lean leads to sustainability activities, consistent with (Langenwalter, 2006). Any form of challenges, even environmental ones, can benefit from lean manufacturing practices. It applies to environmental and social sustainability strategies as well (Longoni & Cagliano, 2015). Furthermore, sustainability is more than just about maintaining existing operational levels and accessing new markets to replace lost ones; it is also concerned with achieving progress to expand healthily. As a result, the organisation should be able to manage manufacturing operations through lean adoption. Therefore, the following Hypothesis 1 (H_1) is formulated:

H_1: There is a relationship between lean manufacturing practices and sustainability in the manufacturing organisation.

Fullerton and Wempe (2009) discovered that employing manufacturing performance measures mediates lean manufacturing and financial performance. A noteworthy conclusion from a study conducted by Taj and Morosan (2011) is that lean manufacturing practices have a notable impact on manufacturing performance. They measured manufacturing performance through three components: flow, flexibility, and quality.

However, quality is not indicated a positive relationship with lean practice. It means that improving the quality of products needs to consider supply management and labour factor. In addition, Chong et al (2001) found that the lean practices implemented can help companies increase manufacturing performance. Implementing lean manufacturing practices can reduce variability, enhance productivity, minimise cost, and improve delivery. As a result, it can improve manufacturing performance (Cua et al., 2001). Likewise, research by Shah and Ward (2003) provided explicit evidence that lean practices influence manufacturing performance to be improved. Therefore, the following Hypothesis 2 (H2) is formulated:

H_2: There is a relationship between lean manufacturing practices and manufacturing performance.

Implementing manufacturing practices comprises lean operational and business practices associated with sustainability (Piercy & Rich, 2015). Furthermore, a study conducted by Stubblefield Loucks et al (2010) found that the particular company does certainly need thoughtfulness when it comes to business strategies to achieve sustainability and, in fact, the tools that are developed to support sustainability need to be recognised. In addition, their study also indicated that lean operations meet a wide range of sustainability outcomes.

Furthermore, experts recommended that the organisation implement a multi-strategy approach to achieve a limited manufacturing performance increase and operational sustainability. Thomas et al (2016) asserted a correlation between the sustainability technique and the application of tools, models, and manufacturing performance levels.

Additionally, sustainable companies are better positioned to favour stricter environmental and social standards, allowing them to compete more efficiently. For example, the manufacturing performance leads to financial stability at Oki Semiconductor Manufacturing in Portland, Baxter International, and The Collins Companies. In total, it generated an estimated $1 million in savings within the first year of implementation. Other than that, according to Langenwalter (2006), a company embracing sustainability needs not to worry about strict regulations because, over time, sustainability might make the difference between obtaining and not obtaining building permits. Therefore, the following Hypothesis 3 (H3) is formulated:

H_3: There is a relationship between manufacturing performance and sustainability.

When hypothesising the effect of one variable on another variable dependant on a third variable, it is usual to use a third variable, such as a moderator or mediator viewpoint (Xu et al., 2006). Nawanir et al (2013) discovered that operational performance and business performance positively correlate with lean practices in a manufacturing organisation. Similarly, it was found that the relationship between lean practices and business performance was partially mediated by operational performance.

Furthermore, Fullerton and Wempe (2009) conducted a study establishing that manufacturing performance measures act as a mediator between lean manufacturing and financial performance. Furthermore, the mediation results may provide light on the consistent findings of previous studies investigating the relationships between financial performance and lean practices. As a result, manufacturing executives prefer to deepen the relationship between the established business model, the desired competitive strategy, and the manufacturing performance required to maintain a competitive market position (Gomes et al., 2011). Therefore, to maintain manufacturing strength, organisations need to be aware of the highest importance of manufacturing practices. Therefore, the following Hypothesis 4 (H_4) is formulated:

H_4: Manufacturing performance is a mediating variable influencing lean manufacturing practices on sustainability.

Results

A total of 2,368 manufacturing companies in Malaysia, including Sabah and Sarawak, were included in the study's population. This study has achieved a 30.5% response rate, hence meeting the acceptable requirement. The data examination stage is crucial in all types of research but is particularly important when a researcher intends to use Structural Equation

Modelling (SEM) (Hair Jr et al., 2010; Hair et al., 2014). Meanwhile, Hair et al (2017) denoted the primary dataset issues that need to be examined, including; i) missing data, ii) suspicious response patterns (e.g., straight-line responses, inconsistent responses, etc.), iii) outliers, and iv) data distribution normality.

This study utilised 101 valid samples representing 101 manufacturing companies in Malaysia for data analysis. The companies included in this study were selected using research randomiser software. Every selected company was represented by personnel with the most suitable position to fill up the survey form. The respondents were required to furnish the following information in the demographic section of the survey form: designated positions, assigned department, lean implementation duration, enterprise's size, enterprise's ownership, and categories of product produced.

Measurement Model

Measurement model analysis includes the assessment of i) Cronbach's alpha (α) and composite reliability (ρ_c) to indicate internal consistency, ii) outer loadings to specify individual indicator reliability, iii) average variance extracted (AVE) to accomplish convergent validity, and iv) discriminant validity through cross-loadings, Fornell-Larcker criterion, and Hetereotrait-Monotrait (HTMT) ratio.

This study applied a second-order measurement model since the constructs understudied (i.e. lean manufacturing practices, manufacturing performance, and sustainability) were regarded as multi-dimensional variables, consistent with previous studies (Habidin, 2012; Iteng, 2013; Nawanir, 2015; Todorova, 2013). Conventionally, the second-order measurement model assessment in PLS-SEM is conducted through the "repeated indicator" approach (Becker et al., 2012). However, the correct AVE will not appear in the resulting output; hence researchers need to do the appropriate calculation manually (Sarstedt et al., 2019). Due to this limitation, this study employed another technique called the "two-stage approach", as suggested by (Ringle et al., 2012). This technique is called the "two-stage approach" because:

i) Stage One: Researchers need to apply the repeated indicator approach (Becker et al., 2012) to obtain latent variable scores of the first-order constructs.

ii) Stage Two: Previously obtained latent variable scores were used as the manifest variables to establish the second-order constructs.

Figure 4 illustrated Stage One of the measurement model assessment, while Figure 5 illustrated Stage Two of the measurement model assessment.

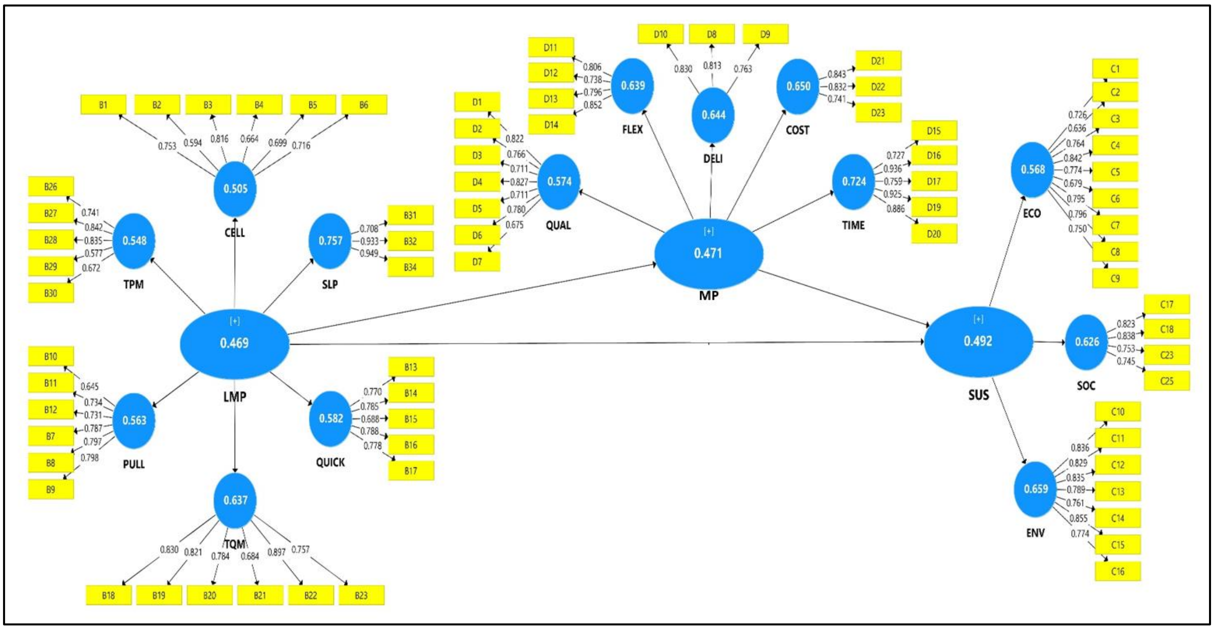

Fig. 4 Measurement model (stage one)

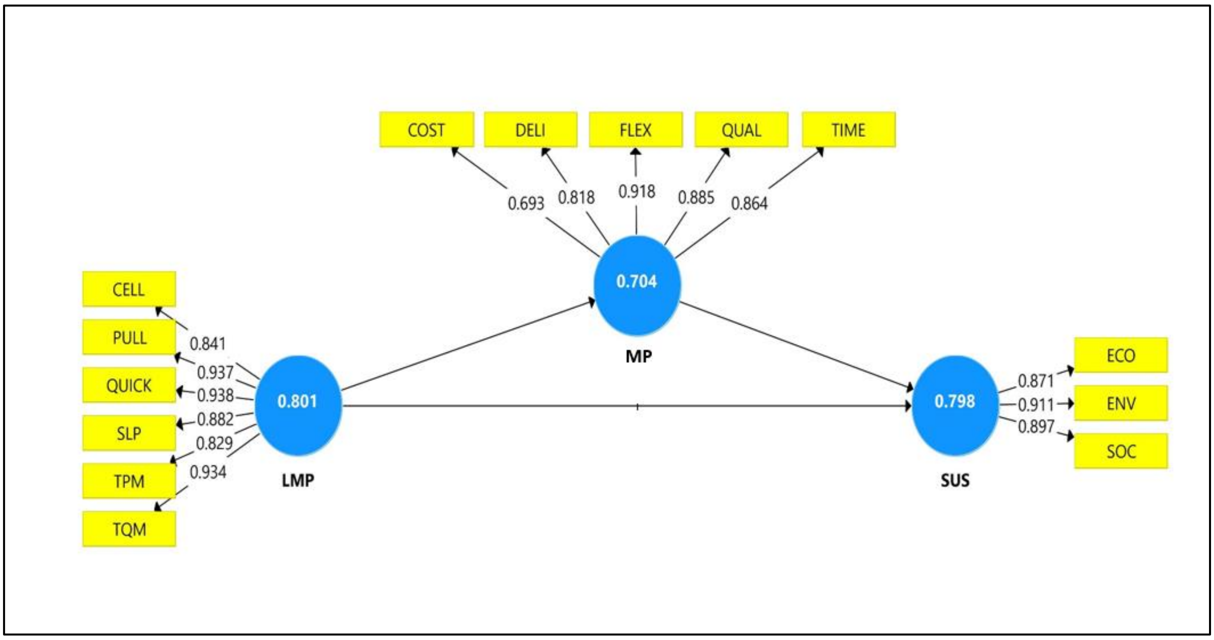

Fig. 5 Measurement model (stage two)

Structural Model

Structural model analysis, also known as significance testing, tests whether a certain result likely has occurred by chance. It involves testing whether a path coefficient is truly different from zero in the population. The null hypothesis of no effect (i.e., the path coefficient is zero in the population) is rejected if the empirical *t*-value (as provided by the data) is larger than the critical *t*-value, assuming a specified significance level. Empirical *t*-value is the test statistic value obtained from the data set at hand, while critical *t*-value is the cut-off or criterion on which the significance of a coefficient is determined (Hair et al., 2017).

In this study, structural model analysis was performed to answer the main research objectives. Using bootstrapping procedures with 5000 resamples (Hair Jr et al., 2014, 2017) in SmartPLS 3.2.8 software (Ringle et al., 2015), the empirical *t*-values (*t*-statistics) were computed to indicate the significance of the hypothesised relationships. The structural model for this study is illustrated in Figure 6.

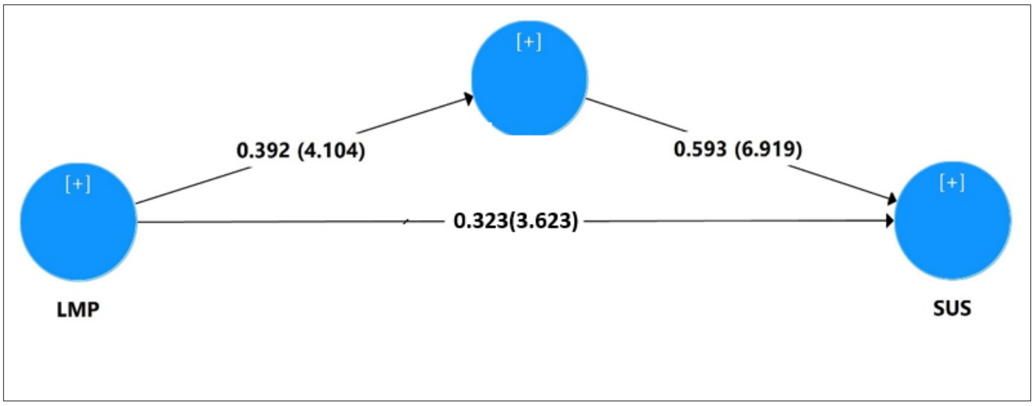

Fig. 6 Structural model

Direct Relationships of LMP and MP on SUS

Table 2

Results of of LMP and MP on SUS

Hypotheses	β	Std. Dev	T Stats	P values	Decisions
H1: LMP->SUS	.323	.089	3.623***	0.000***	Accepted
H3: MP->SUS	.593	.086	6.919***	0.000***	Accepted

Note. Two-tailed test. Significant at $p < .05$*, $p < .01$**, $p < .001$***

Table 2 demonstrates that *t*-statistics of H_1 and H_3 are above 1.96 and *p*-values are less than .01, meaning there is a significant and positive relationship between LMP and SUS and between MP and SUS. Thus, H_1 and H_3 are supported. These findings are consistent with the study of Iranmanesh et al. (2019), in which it was found that there is a positive impact of lean manufacturing practices towards sustainable performance. Furthermore, a study by Piercy and Rich (2015) also reported that lean operations meet a wide range of sustainability. Meanwhile, Hong, Yang, and Dobrzykowski (2014) and Lacy, Haines, and Hayward (2012) also proved that manufacturing performance contributes to sustainability in the organisation.

Direct Relationship of LMP and EC on MP

Table 3

Results of LMP on MP

Hypotheses	β	Std. Dev	T Stats	P values	Decisions
H2: LMP->MP	.392	.095	4.104***	0.000***	Accepted

Note. Two-tailed test. Significant at $p < .05$*, $p < .01$**, $p < .001$***

Further, the *t*-statistics for H_2 is greater than 1.96 (i.e., $t = 4.014$), with the *p*-value less than .01, indicating a significant relationship between LMP and MP, as illustrated in Table 3. Hence, H_2 is supported. In the same vein, H_4 is also supported at $t = 3.719$ and $p < .001$. These findings corroborate Shurrab and Hussain's (2018) study, which established a significant relationship between lean manufacturing practices and manufacturing performance. Academics and practitioners alike have hailed lean as a source of competitive advantage in both developing and developed economies. Similarly, Hashmi, Khan, and Haq (2015) discovered a positive relationship between manufacturing performance and lean manufacturing practices.

Indirect Relationship between LMP and SUS through MP

Table 4

Results of Indirect Relationship between LMP and SUS through MP (Mediating)

Hypotheses	β	Std. Dev	T Stats	P values	Decisions
H4: LMP->MP->SUS	.232	.065	3.589***	0.000***	Accepted

Note. Two-tailed test. Significant at $p < .05$*, $p < .01$**, $p < .001$***

Table 4 exhibits that H_4 representing the indirect relationship between LMP and SUS is significant at *t*-value equals 3.589 and *p*-value is less than .01, meaning MP does mediate the relationship between LMP and SUS; hence, H_5 is supported. A similar finding was also evident, reflecting the result of manufacturing performance by several respective scholars, such as Nawanir, Lim, and Othman (2016), Nawanir et al. (2013), and Fullerton and Wempe (2009) supporting manufacturing performance as a mediator in examining the relationship between lean and other performances, such as business performance and financial performance. Meanwhile, to obtain the VAF value, the calculation is as follows:

$$VAF = \frac{a * b}{(a * b) + c}$$

$$VAF = \frac{0.232}{(0.232) + 0.323}$$

$$VAF = 0.418$$

Based on the calculated VAF, the value indicated a 41.8% variance and can be characterised as a typical partial mediation. On the other hand, a VAF value of 80% or above indicates full mediation, while VAF below 20% is assumed as no mediation (Hair Jr et al., 2017).

Predictive Relevance of the Model

Table 5

Results of Predictive Relevance of the Model Q^2

Hypotheses	Effect Size (q^2)	Predictive Relevance (Q^2)
H1: LMP->SUS	.113	.502
H3: MP->SUS	.300	
H2: LMP->MP	.171	.353

Furthermore, the model's predictive relevance (Q2) was evaluated to determine whether a model precisely predicts data that was not utilised to estimate model parameters. This study employed the blindfolding process to determine the Q2 value in PLS-SEM. Blindfolding is a strategy for sample reuse in which a portion of the data matrix is removed, and the model estimates are used to anticipate the removed portion. It conveyed information on a model's out-of-sample predicting ability (Chin, 1998; Hair Jr et al., 2017; Henseler et al., 2009). A Q2 value greater than 0 implies that the model has predictive relevance for a certain endogenous construct, whereas a Q2 value less than 0 suggests that the model does not (Fornell & Cha, 1994; Hair Jr et al., 2014). From Table 5 it can be seen that the Q2 values for SUS and MP are .502 and .353, respectively, which are more than 0. These values suggest that this model has sufficient predictive relevance; hence, this result concludes the finding section.

Discussion

Lean Manufacturing Practices and Sustainability

Research Objective 1: To examine the relationship between lean manufacturing practices and sustainability in the manufacturing organisation.

Hypothesis 1 was tested, and the result indicated a positive relationship between lean manufacturing practices and sustainability, demonstrating that a variable was significantly important in manufacturing organisations. This result was also consistent with the study of Iranmanesh et al (2019), in which it was found that lean manufacturing practices positively impact sustainable performance The researcher believes that a significant relationship between lean manufacturing practices and sustainability is due to the important role of lean manufacturing practices in enhancing companies' performance, not only carried out at the operational level but also at the business level, subsequently leading to sustainability in the organisation (Nawanir et al., 2018).

Meanwhile, Shrafat and Ismail (2019) found that lean manufacturing practices have grown in importance as a manufacturing development component. Companies begin to assess and evaluate their current operational status to adopt lean manufacturing practices. Besides, lean manufacturing has drawn the interest of businesses seeking market advantage through strengthened management practices (Shrafat & Ismail, 2019).

Despite the fact that lean manufacturing practices have been around for a while, the findings clearly show that the practices significantly impact sustainability in Malaysian manufacturing organisations. Manufacturing organisations with fully manufacturing lean practices attain greater sustainability, to put it in a nutshell.

Lean Manufacturing Practices and Manufacturing Performance

Research Objective 2: To examine the relationship between lean manufacturing practices and manufacturing performance.

Hypothesis 2 was tested, and the result indicated that a positive relationship was found between lean manufacturing practices and manufacturing performance, demonstrating that a variable was significantly important in manufacturing organisations. This result was also consistent with the study of Shurrab and Hussain (2018), in which it was found that there is a significant relationship between lean manufacturing practices and performance in their research. They believed that academics and practitioners alike have recognised lean as a source of competitive advantage in both developing and developed countries.

Lean manufacturing practices are a crucial component of many manufacturing organisations' strategies to preserve their competitive positions in the market. This statement was supported by Shrafat and Ismail (2019), agreeing that lean manufacturing practices can enhance manufacturing performance. A study conducted by Yadav, Jain, Mittal, Panwa, and

Lyons (2019) discovered that SMEs primarily employ eight practices: customer involvement, employee involvement, pull system, 5S, TPM, statistical process control, SMED, and production levelling. These practices have a positive effect on manufacturing performance. As a result, it demonstrates that lean implementation in SMEs is likely to impact manufacturing performance significantly. The findings imply that, even with a small number of applied practices, lean manufacturing can assist improve manufacturing performance in SMEs.

On the contrary, a case study by Iwao and Marinov (2018) explicitly mentioned that the implementation of lean, especially continuous improvement in Toyota Motor Plant and Matsuo Construction company, could lead to manufacturing performance enhancement. The outcomes of each case are significantly different. While Toyota's improvement activities considerably contribute to performance improvement, Matsuo Construction has encountered an unusual situation in which a considerable percentage of improvement activities and ideas fail to result in performance improvement. This study seeks to provide insight on the management style that effectively links improvement activities to a performance by comparing these two situations.

On the other hand, a study conducted by Saleh, Sweis, and Saleh (2018) found that continuous improvement and statistical process control (SPC) have a significant influence in attaining the intended manufacturing performance. Additionally, it was demonstrated that TQM practices in the manufacturing sector, such as continuous improvement, SPC, process management, and quality tools and techniques, significantly impact manufacturing performance, including quality and inventory management performance. Furthermore, the data indicated that achieving the targeted operational performance results is significantly reliant on continuous improvement and SPC practices.

Hence, unquestionably the result indicates that lean manufacturing practices have a relationship with manufacturing performance in the Malaysian manufacturing organisations. Thus, the initial finding was justified to establish a positive correlation between lean manufacturing practices and manufacturing performance in Malaysian manufacturing organisations. In other words, the effect of manufacturing practices has resulted in increased manufacturing performance.

Manufacturing Performance and Sustainability
Research Objective 3: To examine the relationship between manufacturing performance and sustainability.

The testing of Hypothesis 3 revealed a positive correlation between manufacturing performance in Malaysian manufacturing organisations and sustainability. Based on previous studies examining manufacturing performance inversely to assure sustainability, it was projected that manufacturing performance would promote sustainability. For example, Galpin et al (2015); Hong et al (2014); Lacy et al (2012) have established that manufacturing performance leads to an organisation's sustainability. Nonetheless, sustainability in the manufacturing sector is centred on financial and environmental performance but not on social performance.

Meanwhile, Thomas et al (2016) discovered in their study that there is a relationship between the sustainability technique and the use of tools, models, and manufacturing performance levels. Similarly, Iranmanesh et al (2019) found that lean manufacturing practices significantly positively impact sustainability through process and equipment design, product design, supplier relationships, and customer relationships.

According to Ruben et al (2019), an integrated lean sustainable manufacturing system creates value for customers by consistently eliminating waste and implementing eco-friendly, economically viable, and safe processes to produce green products, improving social performance. Meanwhile, organisations can no longer justify opting out of strategic sustainability by substituting narrow incremental sustainability techniques for a business strategy incorporating sustainability considerations, such as new product development, closed-loop manufacturing, and continuous innovation into a whole cohesive system (Cavaleri & Shabana, 2018).

This hypothesis result indicated that the manufacturing organisations had taken the initiative to improve the organisation's efficiency and save indispensable costs to sustain. This study has also measured manufacturing performance in quality, delivery, flexibility, time, and cost. Most of the respondents have scaled reasonably agree and strongly agree for all indicators.As a result, the current study's findings confirm the positive correlation between manufacturing performance and sustainability, previously demonstrated to be strongly influenced by lean manufacturing practices.

Mediating Role of Manufacturing Performance

Research Objective 4: To examine the mediating effect of manufacturing performance between lean manufacturing practices and sustainability.

Manufacturing performance has been measured differently depending on the study's purpose and suitability. In this study's context, the manufacturing performance variable has been identified as the same variable of operational performance due to the dimensions and items used by the researcher. According to Voss et al (1997); Tan and Wong (2015); Hon (2005), the same metrics have been employed to monitor and measure the performance and efficiency in the particular organisation for operational performance and manufacturing performance. As a result, since operational performance is the same variable as manufacturing performance, it is also used to reference this study.

The current study hypothesises that manufacturing performance mediates the relationship between lean manufacturing practices and sustainability. This study's findings revealed that manufacturing performance indeed acted as a partial mediator between lean manufacturing practices and sustainability in Malaysian manufacturing organisations, as predicted. According to Nawanir et al (2013), manufacturing performance partially mediates the relationship between lean practices and business performance in the manufacturing sector. Profitability, sales, and customer satisfaction were used to assess business performance. In terms of the financial aspects of this study, profitability and sales growth were thus go hand in hand with the sustainability indicators. Inversely, this study measured the manufacturing performance by quality, delivery, flexibility, time, and cost.

Limitations of the Study

Since this is the first time examining the relationship between lean manufacturing practices and manufacturing performance towards sustainability with the mediating effect of manufacturing performance in Malaysian manufacturing organisations, some limitations or boundaries exist in conducting this research, as follows:

1) Lack of cooperation from the representatives of manufacturing organisations in Malaysia due to time constraints and confidentiality of information.
2) The evidence to support the study's findings is quite limited since previous studies have shown that most of the studies have been conducted in different settings and with different variables. Studies pertaining to the moderating effect of ethical climate in manufacturing industries are also minimal.
3) Generally, most manufacturing organisations have a policy in revealing any relevant information about their organisations. Thus, due to the organisations' policy, certain respondents are unable to participate directly to give any information or data.

Conclusion

Lean manufacturing practices are critical and should be implemented throughout the organisation. It was the most critical term for any organisation in the modern world, as earlier scholars claimed. Furthermore, lean manufacturing practices have enabled manufacturing organisations to achieve more with less. However, the extent to which lean can contribute to sustainability is something that this study proposes investigating the relationship between lean manufacturing practices, manufacturing performance, and their impact on sustainability in manufacturing organisations. The awareness for this investigation came about due to discovering the fragmented and inconsistent results of previous studies. As a result, it has commanded the researcher to conduct this study to link the gap strategically.

The literature review was accessible comprehensively to direct the study in developing the conceptual framework, hypotheses, and research instruments. Additionally, the conceptual framework for this study incorporated theoretical gaps in sustainability (endogenous variable) that were clarified by lean manufacturing practices (exogenous variable) based on their manufacturing performance (mediator). This study has been underpinned by the Stakeholder Theory and Resource-Based View Theory as the foundation to support the study. Six hypotheses were formulated to test the relationship between variables.

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