INTERNATIONAL JOURNAL OF AUTOMOTIVE AND MECHANICAL ENGINEERING
ISSN: 2229-8649 e-ISSN: 2180-1606
VOL. 21, ISSUE 1, 2024, 11018 – 11035
DOI: https://doi.org/10.15282/ijame.21.1.2024.06.0852

RESEARCH ARTICLE

Sustenance Strategies for Lean Manufacturing Implementation in Malaysian Manufacturing Industries

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ABSTRACT - This study aims to investigate the relationship between sustaining factors and lean manufacturing implementation. This survey-based study was a cross-sectional study and the samples were drawn by using cluster sampling procedure from medium and large manufacturing companies based on the Federation of Manufacturers Malaysia (FMM) with the final number of 151 respondents. In total, four hypotheses were developed and tested statically using PLS-SEM through SmartPLS software. The result provided evidence that lean culture, lean leadership, and lean knowledge management have a positive relationship on lean manufacturing implementation. However, lean supplier management does not have a positive relationship on lean manufacturing implementation. The survey was responded by middle and top-level management from the discrete manufacturing industries. Although there is growing interest in empirical shreds of evidence in favor of sustaining lean, this study provides a comprehensive view of sustaining factors for lean manufacturing implementation. Hence, this study contributes to expanding the boundary of the existing literature and contributes to the body of knowledge while providing insights to practitioners in tailoring strategies to sustain lean manufacturing implementation and leverage their performance.

ARTICLE HISTORY

Received	:	15th Nov. 2023
Revised	:	08th Jan. 2024
Accepted	:	11th Feb. 2024
Published	:	20th Mar. 2024

KEYWORDS
Lean manufacturing
Sustenance strategies
Malaysia
Resource-based view
Manufacturing excellence

1.0 INTRODUCTION

Manufacturing industries have emerged with the challenges of the global market shift, which has increased the volatility and increased consumer demand, requiring manufacturers to be more adaptable than ever before [1]. Manufacturers should strive to improve and cope with the recent technological advances to maintain long-term competitiveness and adapt to the dynamic challenges [2, 3]. Manufacturers must design appropriate strategic approaches to reach a competitive advantage in order to keep improving to be competitive in this challenging market [4, 5]. Thus, lean implementation has become a strategic approach and is inevitable to survive in the market. Many firms all over the world apply the lean philosophy to develop and increase their competitive edge [6-8]. According to Shah and Ward [9], lean is a management approach that combines numerous management strategies intending to reduce waste and increase value. Lean is based on the idea that these management approaches work together to create a high-quality product at the speed of customer demand with little or no waste.

The introduction of lean manufacturing has benefited a wide range of industries, however, sustaining lean implementation is challenging, and the improvements will inevitably revert to their original state over time [10, 11]. Many firms that have tried to embrace lean have failed as they reverted to old methods of doing things. Grigg, et al. [12] indicated that following 10 years of implementing lean manufacturing, 90% of the manufacturing industries in the samples had not maintained lean production, or it was very unlikely to do so in the future. According to Vance [13], approximately 60% of lean manufacturing implementations fail after three years, and more than 92% fail within ten years. To sustain lean implementation is not an easy process, and only a few firms that adopt it will eventually succeed [14]. In addition, Flynn and Scott [15] highlighted the importance of future researchers to understand the predictors for sustainability. These predictors require different theoretical frameworks and it is also highlighted that "lean implementation did not tailor to the contexts in which it had been introduced." For that reason, this research is important to obtain a better knowledge and understanding of the factors that sustain lean manufacturing implementation.

This study will confine to Malaysia's manufacturers concerning discrete manufacturing industries in medium and large-scale industries. Small enterprises will not be selected as they are less likely to implement lean manufacturing as compared to medium and large-scale industries because of several constraints and obstacles [16]. In addition, this study will be limited to discrete manufacturing (e.g., metal works, electronics assembly, and automotive assembly) as the lean manufacturing implementation in discrete manufacturing has been applied more frequently compared to continuous process manufacturing (e.g., chemical, textile, and pharmaceutical) [17]. In summary, this study tried to fill a gap in the lack of research to favor the sustaining factors of lean manufacturing implementation by examining the extent of sustainable lean manufacturing implementation thoroughly among manufacturers in Malaysia. The theoretical and empirical data offered in this study will assist academicians and practitioners in determining the best path ahead in sustaining lean implementation to improve their lean implementation. This research is intended to aid and enhance

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knowledge and theories related to the implementation of sustainable lean manufacturing. From a practical standpoint, the findings of this study will be able to provide several recommendations to Malaysian lean practitioners to help them obtain a deeper understanding of the difficulty of sustaining lean manufacturing implementation. This study is aimed to investigate the sustaining factors for lean manufacturing in Malaysian manufacturing companies. This study comprehensively explained the theoretical and conceptual framework. Subsequently, quantitative data analysis and the discussion were discussed. Finally, research implications, limitations, and suggestions for future research were presented.

2.0 LITERATURE REVIEW

2.1 Related Theory

Research-based View Theory (RBV) explains the internal resources of the competitive advantage in a company. In general, RBV seeks out internal resources and capabilities to explain why some companies in the same field may differ in competitive advantage performance [18]. Barney [19] described firm resources as all assets, capabilities, and organizational processes, which are controlled by the firm and help the firm to increase its efficiency. Therefore, the value of a capability grows in proportion to the firm's resources. As a result, capability can indeed boost production if the necessary resources are available [20]. Amit and Schoemaker [21] claimed that resources are a stock of available factors owned and controlled by a firm. Whereas, Makadok [20] defined capability as a firm's capacity to deploy resources to achieve the desired result. This present study considers lean manufacturing bundles as a firm's resources. Lean manufacturing may have a unique bundle of resources, and the implementation may cause other companies to be superior to the other manufacturers [22, 23]. This understanding is consistent with RBV, which helps in achieving a competitive advantage by bundling resources [24]. Thus, lean manufacturing implementation must be valuable, rare, imitable, and non-substitutable for the manufacturers to have a sustained competitive advantage. Consequently, this present study regards sustaining lean manufacturing factors (i.e., lean leadership, lean culture, lean supplier management, and lean knowledge) as the capabilities underpinned by RBV theory. Following the example from Kamasak [25], sustaining factors are integrated into the most influential firm's capabilities which are human capital, networking capabilities, and business processes. The sustaining factors in this study are targeted to pursue a sustained lean implementation toward competitive advantage.

2.2 Lean Manufacturing Implementation

Lean is a management philosophy that incorporates a variety of management strategies. The core of lean is that these management practices work together to create a high-quality product at the speed of customer demand while creating little or no waste [9, 26]. Since the publication of the best-selling book "The Machine that Changed the World" by Womack, et al. [27] which popularized the lean idea. Samuel, et al. [28] investigated how lean has been stimulated through literature and recognized that lean is a trademark for the Toyota Production System (TPS), which originated in Japan. It is also known as a process improvement approach that an organist may use to enhance its manufacturing performance [29, 30]. As a result of its popularity and widespread implementation in the manufacturing setting, lean has been later named "lean manufacturing" [31]. In the last two decades, with excellent examples like TPS, more interest has been paid to lean manufacturing [27]. It has become a basic and common manufacturing philosophy, and numerous factories throughout the world have embraced it to replicate Toyota's outstanding successes [32]. While lean manufacturing originated in the automotive industry, it has been documented to be used in other industries such as services, construction, and agriculture [33].

On a managerial level, lean manufacturing is translated into various lean manufacturing practices and tools such as just-in-time, total productive maintenance, and total quality production [34]. The primary objective of lean manufacturing implementation is to create a simplified process flow that delivers exactly what the customer wants at the right time and in the right quantity [9, 35]. There are many ways to combine individual lean manufacturing practices to represent multiple dimensions of lean manufacturing practices. Shah and Ward [9] were the first to introduce the four lean bundles model consisting of JIT, TQM, TPM, and HRM. The term "bundles" was used to capture the depth of a multidimensional concept. Lean bundle in this study is defined as a set of interrelated and internally consistent practices in lean implementation [9, 26]. Adapting the lean manufacturing bundles from Shah and Ward [9], this present study will apply an integrated model combining three core lean manufacturing bundles, namely JIT, TQM, and TPM, without the HRM bundles. HRM bundle is not integrated into this study as this bundle is an enabler or complementary lean bundle, and it is not a core practice of lean manufacturing bundles [34]. Moreover, according to Van Assen and de Mast [36], the HRM element is proposed as an infrastructural practice for an organization to be deployed at an early stage of lean implementation.

2.3 Just-In-Time (JIT)

JIT stands for just-in-time, which focuses on eliminating waste in the manufacturing chain as well as reaction times from manufacturers to consumers [37]. This concept aims to create and supply the appropriate parts, in the right number, at the right time, using the least number of resources [38]. JIT has been generally attributed for improving quality, productivity, and efficiency, as well as improving communication and lowering costs and waste [39]. JIT is the second pillar of TPS and a critical component of lean manufacturing [38]. Abu-Khalifa and Al-Okdeh [40] emphasized the necessity of organizations producing desired products at the correct time. It will help to reduce inventories and possible waste along the value chain by manufacturing accurately. The JIT idea differs from the traditional production approach, which is based on the push system. In manufacturing, the push system occurs when the output is pushed to the next process regardless of the time and resources required for the following step [41], whereas the pull system is produced when the next process pulls it through various signals [39]. Kanban is a popular way to implement a pull system. It is used to optimize the flow of materials inside the manufacturing process as well as the flow between suppliers and customers [42, 43].

Furthermore, the cellular layout is a JIT strategy that will help in increasing shop floor flexibility. Workstations and equipment are set up in a cellular layout to enhance smooth process flow by decreasing transportation waste [44]. JIT uses small-batch production to eliminate waste and streamline the manufacturing process [45]. According to Dieste, et al. [46], JIT aims to shift away from batch manufacturing toward small-lot production. In addition, the quick changeover was used to achieve JIT through small lot production, and it will considerably reduce manufacturing lead time using an approach such as a single-minute exchange of die (SMED) [38]. Dieste, et al. [46] mentioned that quick changeover is enabled with the SMED application using quick fastening devices and shortening setup times. Furthermore, achieving a consistent workload, or *heijunka*, will increase operational efficiency. Dieste, et al. [46] mentioned value stream mapping as one of the practices in the JIT bundle among others. Another essential JIT measure is supplier on-time delivery, often known as JIT suppliers, which ensures that items are delivered by the suppliers when they are needed [44, 47]. Sisson and Elshennawy [48] mentioned that lean implementation activities are highly efficient with the entire supply chain network implementation condition, including suppliers.

2.4 Total Quality Management (TQM)

Since the Industrial Revolution in Britain in the seventeenth century, TQM has progressed quickly and many businesses are attempting to manage the deliveries and output to meet customer satisfaction [49]. According to Al-Hyari [50], TQM is defined as a management viewpoint aimed at achieving customer satisfaction by minimizing process defects and lowering the return of supplied items by taking advantage of management, staff, suppliers, and consumers [49]. To enhance customer satisfaction, manufacturing embraced TQM principles to improve the firm's products, processes, and resources leading to better performance [51]. TQM improves and maintains product quality by guaranteeing process stability to fulfill customers' requirements. In lean settings, TQM has been developed by various lean practices to reduce the variation of the production process [34].

TQM covers the practices related to standardized work. It is required to reduce variation in the production process. The implementation of standardized work is aimed to standardize the production guidelines, content, sequence, timing, and outcome of the workers' actions. On top of that, statistical process control (SPC) is another critical TQM measurement as it is the core of process improvement [49]. As TQM is an approach towards customer focus by reducing the defects and returning products, SPC influences these accomplishments of the target. It refers to a system for monitoring a process and detecting specific reasons for variation, as well as alerting the need for corrective action when problems arise [35, 52]. Moreover, Abdallah and Alkhaldi [53] included visual management in TQM bundles and believed with the implementation of TQM, improved efficiency and quality performance will be obtained. Quality at source is related to the culture of stopping and solving problems to get the desired quality right at the first attempt [52]. Jidoka is a concept developed by Toyoda to build quality in the process by using automation automatically. By all means, it supports a wise decision to immediately stop the procedure once quality issues occur [54]. Furthermore, poka-yoke has been proposed and developed as one of the efficient quality strategies used in manufacturing for mistake-proofing [55, 56]. The quality at the source and poka-yoke approaches will have a direct influence on manufacturing performance by avoiding errors and, indirectly, lowering operating costs and enhancing quality [35].

2.5 Total Productive Maintenance (TPM)

TPM is a concept that allows production employees to take ownership of and become more responsible for the equipment's reliability [57, 58]. From the manufacturing context, according to Imai [59] TPM aims at *"maximizing equipment effectiveness with a total system of preventive maintenance covering the entire life of the equipment involving everyone in all departments and at all levels. It motivates people for plant maintenance through small-group and voluntary activities."* The ultimate goal of TPM is to achieve zero operational downtime and zero defects by eliminating equipment errors and preventing rather than fixing unanticipated failures, speed losses, and quality problems [60, 61].

One of the main elements of TPM is preventive maintenance, and it is vital in maintaining equipment in top condition [62]. TPM includes both preventive and predictive maintenance, and it is a total system of maintenance for the entire life cycle of the equipment [63]. As part of preventative maintenance, technicians hand over equipment maintenance responsibilities to operators, such as lubrication, adjustments, and minor repairs. This is known as autonomous maintenance. The goal is not to simply handover the responsibility to production operators, but this step is aimed to provide the ownership of the equipment to the operators and upkeep and basic maintenance [64]. In addition, As attested by Shah and Ward [9] and Sancha, et al. [45], TPM is a collection of techniques that are primarily concerned with increasing equipment effectiveness through planned predictive and preventive maintenance.

2.6 Sustaining Factors for Lean Manufacturing Implementation

Despite the evidence that widely demonstrates a positive correlation between lean manufacturing implementation and manufacturing excellence, many manufacturers are still struggling to sustain the implementation [65, 66]. Sustaining the implementation of lean manufacturing is crucial in any change. It plays a critical role in taking advantage of improvement over the long term, emphasizing achieving operational excellence [67]. Previous literature showed several issues in sustaining the lean implementation, Grigg, et al. [12] conducted a case study involving 20 manufacturers in New Zealand, participating in the government's effort to implement a lean program. This study aimed to measure the effectiveness and sustainability of the program within ten years of implementation. Based on the investigation, only two companies are still sustaining the lean implementation, and two companies are in the stage of re-implementing. This has shown that sustaining the initial success of such programs is usually considered a major challenge, with 90% of the samples failing to maintain implementation. This percentage is considered high compared to the efforts made by the government to support the competitive advantage from the implementation of lean. Sohal and Egglestone [68] performed a survey of 72 companies in Australia, including 50 top organizations and 22 SMEs. The survey was conducted in various industries, including metal processing, food and beverages, tobacco, chemical, automotive, and building products. This study shows that lean production methods have been or are being introduced in the vast majority of companies. However, based on the indicators used to determine the level of commitment to the lean manufacturing system, the results revealed that only 10% of the companies have adequately implemented and sustained their lean implementation. This showed the poor performance of the organization in sustaining the lean implementation.

2.7 Lean Leadership

The essence of leadership is the ability to inspire and influence the collective efforts of subordinates to adapt to new transformative changes required towards the organization's goal and objective [13, 61]. Lean leadership, postulated by Antony, et al. [69] is beliefs, behaviors, and competencies that display respect for individuals, inspire individuals, reduce organizational politics, ensure effective use of resources, and eliminate mistakes. Leaders will have a big impact on the effectiveness of lean implementation by supporting employees, inspiring, coaching, and exchanging ideas with their coworkers, which will be critical sustaining factors for lean manufacturing implementation [47]. Leadership engagement is critical to the long-term success of lean manufacturing implementation. One of the best methods for leaders to demonstrate their commitment is to participate actively in the implementation of any lean improvement initiatives [48]. To inspire workers to engage proactively in this journey, the best conditions for lean manufacturing diffusion must be set, and management is responsible for fostering physical and emotional commitment.

Furthermore, involving top management in lean activities will ensure that improvements are achieved and the actions are aligned with the business vision and objective [70]. Leadership requires vision and forward-thinking, as lean implementation is long-term [71]. Lean implementation will lead to success, and it will assist manufacturers in achieving manufacturing excellence [13]. However, if it is not sustained over a period, it will backfire on the organization. Thus, lean manufacturing implementation is nothing without visionary leadership thinking behind it [58]. Another lean leadership attribute identified by Antony, et al. [69] is coaching to inspire and motivate subordinates. One of the most direct ways to coach is during gemba genchi genbutsu, where two-way communication happens, and leaders communicate to workers and coach as needed. Coaching helps managers to see the problem in actuality, inspires staff, and indirectly raises morale and levels of motivation [72]. In addition, Vance [13] claimed that top management must have an effective communication channel to ensure that the lean implementation is sustained throughout time. A variety of communication strategies, such as town hall meetings, newsletters, individual meetings, and video displays, can be used as successful communication tools. Therefore, the below hypothesis is formulated:

H1: Lean leadership positively affects lean manufacturing implementation

2.8 Lean Culture

There is general agreement on the definition of culture, which is described as something that exists and has a significant impact on human behavior [73]. Schein [74] elaborated on his perspective on culture, describing culture as a property of those people who share common behaviors and attitudes. Organizational culture has an impact on organizational performance since it is influenced by individual behavior [75]. Lean culture is defined in this study as a shared behavior and attitude that exists and plays a major role in influencing lean implementation. The challenge to implement and sustain lean manufacturing lies in defining the organizational culture [76]. To sustain lean implementation, continuous improvement is a culture used to drive changes and lead to operational excellence [77]. In creating a continuous improvement culture, gemba walk practice is crucial to sustain any lean improvement [10]. Lean is not only about tools and methods, it is about people and improving the attitude of the employees [78].

Hoque, et al. [79] mentioned that Long-term lean implementation is dependent on management and employee commitment to achieving long-term benefits. Employee involvement and awareness of the rationale for lean implementation are critical to the success of lean implementation and its processes [58, 80, 81]. According to Sisson and Elshennawy [48], employee involvement is a critical component in a successful lean implementation. Deep engagement and employee involvement in driving the changing culture through continuous improvement are essential to achieving long-term lean manufacturing implementation [65]. The culture of continuous improvement should become the behavior of employees. It should not require management initiatives to embed the improvement culture, and it should come from the will of the people within the organization [82]. In creating the step towards continuous improvement culture, the practice of gemba genchi genbutsu is suggested. This practice aims to find the improvement ideas where the operation is conducted and the value is created [83]. Genchi genbutsu is an important activity to identify problems and find continuous improvement ideas. This activity will empower the employees to share their ideas and indirectly enhance their motivation [72]. Hence, this study proposed the following hypothesis:

H2: Lean culture positively affects lean manufacturing implementation

2.9 Lean Supplier Management

Suppliers are important concerns for the performance of buyers or users, as they contribute to product efficiency, stability, and cost towards manufacturing excellence [47, 79, 84-86]. To leverage the capacity of suppliers completely, the buyers must manage their suppliers [87]. Lean supplier management in this present study is defined as the practice of selecting the supplier, collaborative supplier partnership, and supplier development program towards lean manufacturing implementation. The trend toward collaborative partnerships with suppliers is expanding, particularly among large and international manufacturers seeking to improve on aspects such as delivery, quality, and cost [88].

Collaborative partnerships have been found to improve relationships of both parties in terms of cost and reward sharing as well as shared product growth [79]. Another key factor in sustaining the lean manufacturing implementation is to have it implemented holistically, as a corporate-wide effort, and one reason for failure in sustaining is when the lean implementation is not extended widely to the rest of the organization [48]. Once the organization has implemented lean successfully, suppliers should participate in the next sequence to be extended [47]. Toyota has established a long-term, mutually supportive supplier relationship, supplier development plan, and synchronized the production schedule with its delivery schedule [44, 89, 90]. In addition, as part of supplier management, supplier selection based on the capability that leads to operational excellence plays an important role [91, 92]. Several studies have analyzed the positive relationship between supplier selection activities and the performance of manufacturers [93, 94].

H3: Lean supplier management positively affects lean manufacturing implementation

2.10 Lean Knowledge Management

Knowledge is the key source of competitive advantage [95, 96]. Referring to Dombrowski, et al. [97], knowledge is the information that is interpreted out of the experiences and expectations, and it belongs to a person or the organization. Consequently, it is necessary to incorporate knowledge management to arrange and coordinate the knowledge within the organization. Jorgensen, et al. [66] explained that manufacturing failed to sustain lean manufacturing implementation due to a lack of attention within the organization to develop lean manufacturing capabilities. By improving lean skills, employees can continually obtain a better understanding while implementing it and at the same time create a learning environment that supports lean culture. The knowledge and experience of lean manufacturing could be obtained from external consulting companies specializing in lean manufacturing and providing expertise in the principles and tools. According to Vance [13], external lean experts' utilization has given many firms the correct knowledge and experience to implement and sustain their lean implementation.

Many researchers have highlighted inadequate training as one of the major problems affecting the long-term viability of lean implementation, such as Burawat [47], Chiarini and Brunetti [84], Costa, et al. [65], Sahoo [61], and Tiwari, et al. [70]. Trained employees are a vital part of sustaining lean manufacturing implementation as they speed up the improvement process and analyze the improvement ideas accurately [70, 80, 83]. Sisson and Elshennawy [48] reported that manufacturing companies with the highest lean implementation level had spent a high level of lean training. In line with a study from Sisson and Elshennawy [48], Flynn and Scott [15] claimed that lean efforts are sustained in the context where the employees are well trained with the practices of lean and able to materialize the theoretical knowledge. As part of lean knowledge management, Sisson and Elshennawy [48] suggested the importance of providing staff with opportunities to engage in lean events that strengthen the training concepts. Kaizen events, which are workshops, are useful for practitioners as an excellent tool for driving continuous improvement to transfer lean know-how rapidly [13, 65, 83]. Based on the facts and figures, the following hypothesis is formulated.

H4: Lean knowledge management positively affects lean manufacturing implementation

3.0 METHODOLOGY

In accomplishing the objectives of this study, the researcher adopted a quantitative method. This method was adopted to explore whether there is any correlation between the variables. A measurement instrument was developed to measure specific variables through adoption, adaptation, and self-development by referring to previous studies as explained in Table 1. Different scale properties (i.e., 5-point for sustaining factors for lean manufacturing implementation and 6-point for lean manufacturing implementation) were used as a way to avoid common method bias in the measurement scales [98]. During the development stage, three academicians and two industrial practitioners were invited to evaluate the content validity, clarity, brevity, and importance of the developed measurement.

Table 1. Development of measurement items

Construct	Item Code	Measurement Item	Reference
Lean Leadership	LL1	Our management prioritizes lean initiatives (e.g., *Gemba*, 5S, kaizen) as one of their routine activities.	Henrique, et al. [99]; Sisson and Elshennawy [48]
	LL2	Our management monitors the KPIs' achievement of lean implementation.	Hoque, et al. [79]; Netland [100]
	LL3	Our management actively involves in lean implementation.	Henrique, et al. [99]
	LL4	Our management has clear vision and mission of how the lean is implemented.	Shehadeh, et al. [101]; Vance [13]; Laureani and Antony [71]
	LL5	Our management has clear understanding on lean implementation.	Santos and Tontini [102]; Udod, et al. [83]
	LL6	Our management provides clear guidance on lean implementation.	Santos and Tontini [102]; Balzer, et al. [103]
	LL7	Our management regularly communicates lean-related matters (e.g., vision, strategies, tools and techniques) with employees.	Osman, et al. [104]; Balzer, et al. [103]; Vance [13]
Lean Culture	LC1	Our employees are committed to eliminate all types of waste (non-value-added activities) in our operations.	Hoque, et al. [79]; Sisson and Elshennawy [48]
	LC2	Our employees actively involved in lean activities.	Fullerton and Wempe [105]; Flynn and Scott [15]
	LC3	Our employees actively involved in continuous improvement programs.	Fullerton and Wempe [105]; Mathaisel [77]; Hines [82];
	LC4	Kaizen (i.e., every day, everywhere, and every time continuous improvement) is our culture.	Hines [82]; Costa, et al. [65]
	LC5	We believe that there is no best way of doing things but there is always the better ways.	Byrne and Byrne [106]; Nawanir, et al. [44]
	LC6	Our employees perform *gemba* walk as a routine activity (*Gemba* walk refers to walkabout activity performed by employees to understand the actual shop floor conditions).	Henrique, et al. [99]; Udod, et al. [83]; Loh and Lau [72]
Lean Supplier Management	LSM1	We establish long-term partnership with our suppliers.	Kamble, et al. [35]; Nawanir, et al. [44]
	LSM2	We involve suppliers in lean and problem-solving activities.	Fullerton and Wempe [105]; Chavez, et al. [107]
	LSM3	We provide development programs (e.g., quality and engineering supports) to suppliers.	Fullerton and Wempe [105]; Nawanir, et al. [44]
	LSM4	We consider performance (e.g., quality, cost, flexibility, efficiency, etc.) as one of the supplier's selection criteria.	Kamble, et al. [35]; Vij, et al. [92]
	LSM5	We rely on few high-performance suppliers.	Nawanir, et al. [44]
Lean Knowledge Management	LKM1	We create an active learning environment to support lean culture and improve lean knowledge, skills, and capabilities.	Jorgensen, et al. [66]; Goodyer and Grigg [108]
	LKM2	We emphasize internal capability development (e.g., training, workshop, competition, etc.) to sustain lean implementation.	Jorgensen, et al. [66]; Grigg, et al. [12]
	LKM3	We habitually share best practices between workstations, departments, or companies.	Christensen [109]; Goodyer and Grigg [108]
	LKM4	We incorporate an effective knowledge sharing culture.	Goodyer and Grigg [108];
	LKM5	We consistently train our employees on lean-related activities.	Sisson and Elshennawy [48]
	LKM6	We facilitate our employees to engage in lean events (e.g., training, exhibitions, competitions, etc.).	Sisson and Elshennawy [48]; Costa, et al. [65]

Table 1. (cont.)

Construct	Item Code	Measurement Item	Reference
JIT	JIT1	We use *kanban* to authorize production or material movement (*Kanban* is a work signaling system such as cards, verbal signals, light flashing, electronic messages, empty containers, etc).	Petrillo, et al. [42]; Cimorelli [39]
	JIT2	We produce a product based on the current demand from its users.	Petrillo, et al. [42]; Bento and Tontini [110].
	JIT3	We produce in the smallest possible quantity per batch (batch is the quantity of goods produced at one time).	Nawanir, et al. [44]; Sancha, et al. [45]
	JIT4	We perform machines' setup quickly if there is a change in process requirements.	Dieste, et al. [46]; Nawanir, et al. [44]
	JIT5	Our production processes are located close together to support the smooth flow of materials.	Sancha, et al. [45];Nawanir, et al. [44]
	JIT6	We group dissimilar machines together to process a family of parts with similar shapes or processing requirements.	Fullerton and Wempe [105]; Nawanir, et al. [44]
	JIT7	We level our production, in which production volume is distributed equally to have the same daily quantity of outputs.	Santos and Tontini [102];
	JIT8	We produce different models of products daily based on the composition of monthly demand.	Bento and Tontini [110]
	JIT9	Our suppliers deliver materials to us just as it is needed (in just-in-time basis).	Nawanir, et al. [44]; Bento and Tontini [110]
	JIT10	We use value stream map to visualize all activities (both value-added, and non-value added) required to transform customer requests into goods or services.	Kamble, et al. [35]; Burawat [47]
TQM	TQM1	We have standardized work documents (e.g., SOP, work instruction, etc.) to guide workers in performing activities in the production system.	Santos and Tontini [102]; Bento and Tontini [110]
	TQM2	We standardize the works in our production line to reduce processes variation.	Dutta and Mandal [112]; Bento and Tontini [110]
	TQM3	Production processes on shop floors are monitored with statistical quality control techniques to control the process variance.	Kamble, et al. [35]; Camuffo and Gerli [113]
	TQM4	We apply a human error prevention mechanism with error-proof devices (*pokayoke*) in our production line.	Santos and Tontini [102]; Dave and Sohani [114]
	TQM5	We implement an automated stopping mechanism, in which when an abnormality/irregularity happens, the process will automatically stop.	Bento and Tontini [110]; Galeazzo [115]
	TQM6	We use visual control systems (e.g., *andon*/line-stop alarm light, level indicator, warning signal, signboard, etc.) as a mechanism to make problems visible.	Santos and Tontini [102]; Kamble, et al. [35]
TPM	TPM1	We implement preventive maintenance (i.e., planned maintenance of equipment to prevent failure) for all equipment in the production line.	Kamble, et al. [35]; Dave and Sohani [114]; Nakajima [63]
	TPM2	We ensure that machines are in a high state of readiness for production at all the times.	Kamble, et al. [35]; Nawanir, et al. [44]
	TPM3	We scrupulously clean workspaces (including machines and equipment) to make unusual occurrences noticeable.	McKone and Weiss [116]; Nakajima [63]
	TPM4	Our operators continuously monitor and perform minor adjustments/maintenance on their equipment.	Nawanir, et al. [44]; Kamble, et al. [35]
	TPM5	We implement predictive maintenance (i.e., a proactive measure by foreseeing the breakdown of the equipment to be maintained with early sign of failure) for all equipment in the production line.	Hashemian [117]

Discrete manufacturing in medium and large-scale industries listed in the Federation of Malaysian Manufacturers (FMM) involved in this study. Kotrlik and Higgins [118] reported that the sampling frame is represented by the accessible population after taking out all individuals of the target population who will or may not participate or who cannot be accessed during the study period. In this regard, the sampling frame will be the accessible discrete manufacturing industries in medium and large-scale industries in Malaysia. The unit of analysis proposed for this study was organization, and the elements of the unit of analysis were the middle management (i.e., Managers) and top management (i.e., Vice President, Chief Executive Officer, Chief Operation Officer, General Manager, and Senior Manager). This element was selected with the understanding that the knowledge and what is assumed to be valid knowledge [119]. Thus, these positions could reasonably be expected to have expert knowledge of lean manufacturing and its sustaining factors. Cluster random sampling based on industry types was applied to draw the sample from the population.

Data was collected online by using Google Forms. This approach is suitable for the respondents in the wide geographical area which is not possible for the researcher to personally reach them. Another advantage of this approach is that respondents could take their time to fill up the questionnaire at their convenience and considerably low cost. To find the best solution for sample size, this study used G-power statistical software version 3.1.9.7 to calculate the minimum sample size required in this study [120, 121]. Using the F-test, with an effect size of 0.15, an alpha value of 0.05, a statistical power of 95%, and numbers of predictors of 4, the result of a minimum 129 sample size is required for this study with an actual statistical power of 95.05%. In order to have a good response rate, 1,000 questionnaires were sent to the selected companies. A total of 172 completed surveys were used in the analysis, with a response rate of 17.2%. However, 21 responses are not included in subsequent data analyses due to unrelated manufacturing sectors (i.e., process or continuous manufacturing) and the survey was completed by ineligible respondents. Finally, 151 data sets were usable resulting in a 15.1% effective response rate, higher than the minimum required sample of 129. Based on the total number of 151 respondents, the background and demographic represent types of industry, years of operations, plant location, respondent's positions, year of services, and years of experience in the company are shown in Table 2. Based on the table, all the respondents are eligible to participate in the survey.

Table 2. Respondent demographics from the questionnaire

Demographics	Sample	
	n	%
Types of Industry		
Transport equipment & other manufacturers	75	49.67
Electrical and electronics	54	35.76
Non-metallic mineral and fabricated metal products	19	12.58
Wood, furniture, paper, and printing	3	1.99
Years of operation		
More than 5 years	129	85.43
Between 2 and 5 years	12	7.95
Less than 2 years	10	6.62
Manufacturing plant location		
Central (Kuala Lumpur, Selangor, Negeri Sembilan)	72	47.68
East coast (Pahang, Terengganu, Kelantan)	30	19.87
Northen (Kedah, Penang, Perak)	29	19.21
Southern (Johor, Malacca)	19	12.58
West Malaysia (Sarawak)	1	0.66
Position in the company		
Manager (Lean, Operation, Inventory, Quality, Supply Chain)	114	77.48
Senior/General Manager (Operation, Inventory, Quality, Supply Chain)	27	17.88
Chief Operations/Manufacturing Officer	7	4.64
Year of service in the current position		
More than 3 years	82	54.30
Between 1 and 3 years	46	30.46
Less than 1 year	23	15.23
Year of experience in the company		
More than 5 years	65	43.05
Between 3 and 5 years	49	32.45
Less than 3 years	37	24.50

In summary, Figure 1 shows the research flow chart proposed in this study. Based on the research methodology, the next section will explain the quantitative data analysis using the SEM-PLS approach to analyze the collected quantitative data and derive meaningful findings.

Figure 1. Research flow chart

4.0 RESEARCH FINDINGS

The adopted technique for estimating the hypothesized model includes using the PLS-SEM and the statistical software SmartPLS3 (Ringle et al., 2015). PLS-SEM is a multivariate, non-parametric method utilized to estimate latent variable path models [122]. PLS-SEM was used in this study due to the exploratory nature of the research and PLS-SEM can process complex research models [122]. PLS-SEM through Smart-PLS software was used to analyze the causal relationships between constructs as it is capable of producing sensible results even with the existence of little outliers and the data would not be distorted [123]. Additionally, SmartPLS is capable when the subject has a limited number of samples while the build of the model is complex [124].

As data were gathered from a single source, a full collinearity assessment was run to test whether common method bias is a concern in our study. The results shown in Table 3 indicate that VIF for all constructs ranged from 2.074 to 3.226, confirming again that common method bias did not pose a validity threat as the VIFs were all below the threshold of 3.3 [125].

Table 3. Full collinearity testing

Constructs	VIF
Lean Leadership	2.715
Lean Culture	2.309
Lean Supplier Management	2.074
Lean Knowledge Management	2.958
Just-In-Time	2.536
Total Quality Management	2.840
Total Productive Maintenance	3.226

The hypotheses were tested using a two-step approach [122]. First, the measurement model was examined to test the validity and reliability of the instruments. Then, the structural model was run to test the hypothesis developed. For the measurement model, the loadings, average variance extracted (AVE), and composite reliability (CR) were assessed. Following the suggestion from Hair, et al. [122], the values of loadings should be > 0.4, the AVE should be >0.5, and the CR should be >0.7. From the first run of the PLS algorithm, the value of AVE for JIT (i.e., 0.471) and LMI (i.e., 0.486) was below the threshold value. Thus, three items (i.e., JIT1, JIT3, and JIT10) with low loading were deleted. With the deletion of the items, AVE was above the recommended threshold of 0.50, the loading exceeded the ideal level of greater than 0.40, and the CR was all higher than 0.70 indicating that all the measurements are valid and reliable [122]. Details of the convergent validity result are depicted in Figure 2 and Table 4.

Table 4. Convergent validity

Outer Loading	Outer Loading	CR	AVE
Lean Leadership	0.681 - 0.846	0.921	0.625
Lean Culture	0.692 - 0.775	0.884	0.561
Lean Supplier Management	0.540 - 0.866	0.888	0.618
Lean Knowledge Management	0.758 - 0.828	0.914	0.640
JIT	0.518 - 0.826	0.899	0.529
TPM	0.773 - 0.888	0.925	0.712

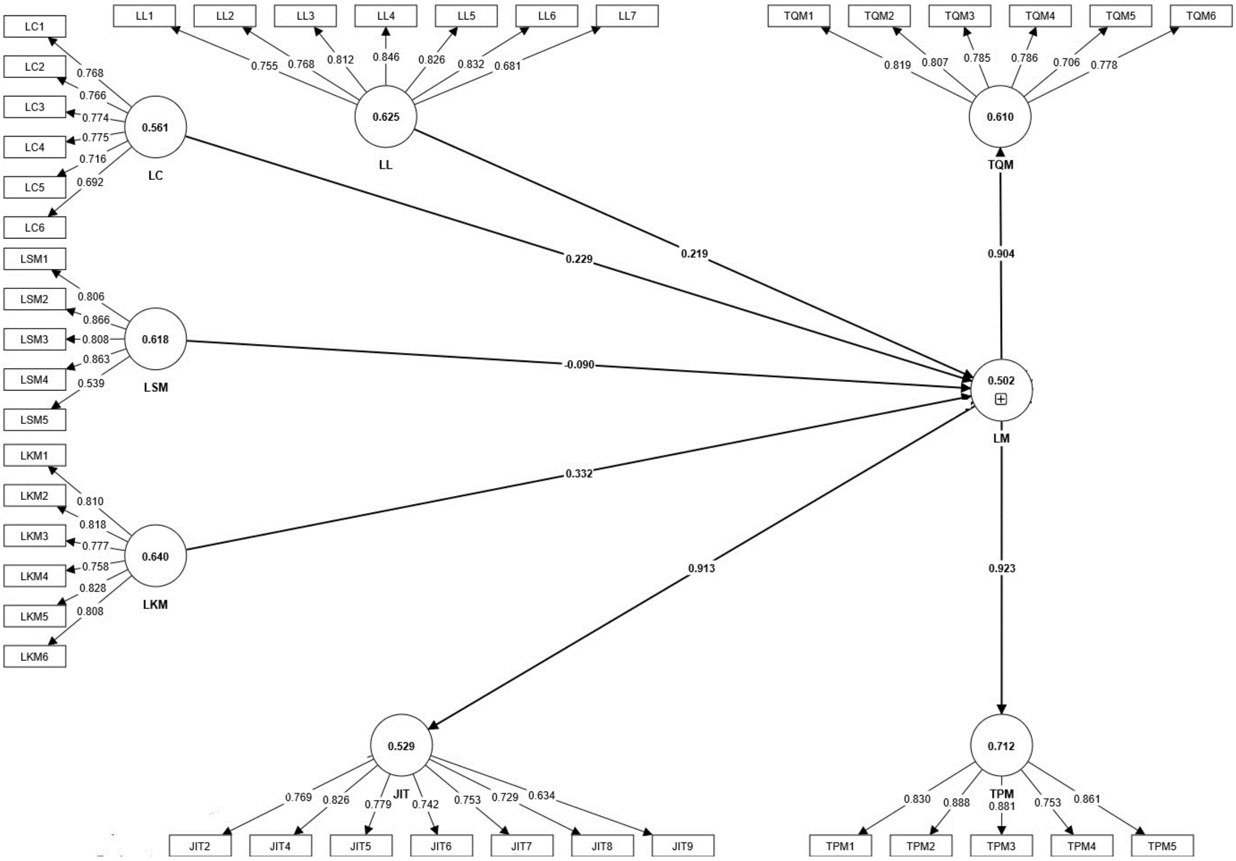

Figure 2. Evaluation of structural model through PLS bootstrapping

Discriminant validity is used to check the dissimilarity in the measurement tools of different constructs. To assess discriminant validity, this study follows the heterotrait-monotrait ratio of correlations (HTMT) procedure prescribed by Henseler, et al. [126]. The HTMT value above 0.900 suggests a lack of discriminant validity [122]. In contrast, a value of more than 0.900 is considered as lack of discriminant validity. Table 5 shows that the values for discriminant validity through the HTMT test were lower than 0.900. This proved that all construct questions were different and not interchangeable in their meaning. The highest value was 0.878, and the lowest value was 0.438. Therefore, it reflects satisfactory discriminant validity.

Table 5. Discriminant validity: Heterotrait-Monotrait ratio statistics

Construct	JIT	LC	LKM	LL	LSM	TPM
JIT						
LC	0.671					
LKM	0.649	0.836				
LL	0.649	0.803	0.767			
LSM	0.482	0.723	0.790	0.616		
TPM	0.849	0.664	0.680	0.611	0.438	
TQM	0.817	0.554	0.584	0.514	0.367	0.878

After evaluating the measurement model with satisfactory validity and reliability, the hypothesis testing in the structural model by running the bootstrapping was conducted. When running the bootstrapping procedure, Hair, et al. [122] recommended that the minimum number of bootstrap samples used in the bootstrapping technique should be at least as high as the number of valid observations in the original data set, and the recommendation is 5,000 bootstrap samples. According to Hair, et al. [122], in most settings, the 95% confidence level is used and it implies that the p-value must be smaller than 0.05 to render the relationship under consideration significant. To determine the significance level, a one-tailed test was used as the hypotheses generated in this study are the directional hypotheses [127]. Due to this justification, such predictions in directional hypotheses were tested with a one-tailed test with critical values of 2.33 (significance level = 1%), 1.645 (significance level = 5%), and 1.28 (significance level = 10%). Table 6 exhibits the results of the hypothesis testing from the bootstrapping analysis.

Table 6. Summary of hypotheses testing

Path	Std. Beta	Std. Error	t-value	p-value	Bias	Confidence Interval		Decision
						5.00%	95.00%	
H1: LL-LMI	0.225	0.120	2.220	0.043	0.015	0.016	0.365	Supported
H2: LC-LMI	0.221	0.112	2.060	0.010	-0.008	0.085	0.432	Supported
H3: LSM-LMI	-0.098	0.107	0.099	0.197	-0.008	-0.247	0.082	Not Supported
H4: LKM-LMI	0.377	0.133	3.269	0.003	0.029	0.138	0.508	Supported

Note: p-value≤0.05 (1-tailed test); Note: LL [Lean leadership], LC [Lean culture], LSM [Lean supplier management], LKM [Lean knowledge management], LMI [Lean manufacturing implementation].

To verify the statistical significance of the path coefficients bootstrapping techniques together with SmartPLS 3 that were embedded in this study through the bootstrapping processes and the successively created p-values, the verification of the t-values, as well as each path coefficient, was carried out. Hair et al. (2019) suggested observing the confidence interval to provide additional facts about the degree to which the population parameter dropped at a certain level of confidence. As shown in Table 5, H1 presents a positive effect of lean leadership on lean manufacturing implementation at 5% significant level with the outcome of standardized β=0.225, t-value=2.220, p-value=0.043, and confidence interval ranges between 0.016 and 0.365. The result of H2 shows a standardized β of 0.221, a t-value of 2.060, a p-value of 0.010, and a confidence interval ranging between 0.085 and 0.432. This result showed that the hypothesis lean culture positively affects the implementation of lean manufacturing is supported. H3 predicts the relationship between lean supplier management and lean manufacturing implementation and findings showed that H3 is not supported at a 5% significant level (i.e., standardized β of -0.098, t-value of 0.099, p-value of 0.197, and confidence interval between -0.247 and 0.082). H4 predicts the relationship between lean knowledge management and lean manufacturing implementation and findings showed that H4 is supported at a 5% significant level (i.e., standardized β =0.377, t-value=3.269, p-value=0.003, and confidence interval between 0.138 and 0.508).

The R2 is to assess the proportion of the variance in the endogenous constructs that can be accounted by the exogenous constructs. Because the R2 is the squared correlation of actual and predicted values, as such it includes all the data that have been used for model estimation to judge the model's predictive power. It represents a measure of in-sample predictive power [122]. R2 values of 0.26, 0.13, and 0.02 are described as substantial, moderate, or weak respectively [128]. The values of R2 for LMI are 0.457, and the R2 value for JIT, TQM, and TPM is 0.821, 0.822, and 0.856 respectively. As the R2 values are higher than 0.26, it is considered all the variables have substantial determination. The evaluation of f^2 indicates how greatly the contribution of an exogenous variable to an endogenous variable is [128]. Hair, et al. [122] reported that the f^2 with values 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively. The f^2 of lean culture, lean leadership, and lean knowledge management are 0.033, 0.040, and 0.088 respectively, which indicates a small effect size. Meanwhile, there was no effect size (i.e., 0.008) on the relationship between lean supplier management and lean manufacturing implementation. The predictive relevance value or Q^2 value determines whether the data points of indicators in the endogenous variable in the reflective measurement model can be predicted precisely (Wong, 2013). According to Hair, et al. [122], the relative measurements for Q^2 are 0.02, 0.15, and 0.35, representing the constructs that have a small, medium, or large predictive relevance, respectively. The value of predictive relevance lower than 0.02 should be ignored as it has insufficient predictive relevance. The value of Q^2 for LMI is 0.223 indicates medium predictive relevance. Meanwhile, Q^2 for JIT, TQM, and TPM is 0.456, 0.492, and 0.600 respectively indicating a large predictive relevance.

5.0 DISCUSSIONS

To identify the sustaining factors for lean manufacturing implementation, the researcher combined the measurements from several previous studies into a collection of common variables which are lean leadership, lean culture, lean supplier management, and lean knowledge management. Thus, the current study developed four direct hypotheses to empirically test a framework encompassing the sustaining factors for lean manufacturing implementation. Based on the findings, it was determined that three factors (H1, H2, and H4) have a positive relationship with lean implementation, whereas one hypothesis (H3) has a negative relationship with lean implementation. Three sustaining factors which are lean leadership, lean culture, and lean knowledge management positively affect lean manufacturing implementation. Based on this finding, large and medium discrete manufacturers in Malaysia need to embrace these three sustaining factors to ensure the implemented lean is sustained over time.

This positive relationship between lean leadership on lean manufacturing implementation is consistent with previous research by Burawat [47], Loh and Lau [72], and Udod, et al. [83]. Lean leaders encourage, motivate, and coach employees to ensure the effective use of resources and eliminate waste. Burawat [47] mentioned that management leadership in the plant is important in reaching success in lean implementation through TQM activities. This is particularly important in maintaining the entire organization's contribution to lean implementation practices, employee involvement in lean training, and continuous improvement activities. Loh and Lau [72] reported that empirical evidence shows that leadership is one of the most important factors in sustaining lean implementation. Silva, et al. [129] noted that committing all employees to sustain the lean journey is challenging. Organizations must engage in leadership development for managers, fostering transformational leadership. Silva, et al. [129] suggest that this form of leadership is preferred for a successful lean journey because it focuses on team member growth and employee motivation. Holmemo, et al. [130] concluded that leadership is the most important success factor for lean transformations and explored the importance of lean leadership from soft and hard leadership. In summary, with regard to lean leadership, it should be highlighted that lean leaders must be fluent in the language of lean and adequately trained to coach and guide employees in accordance with the company's mission and vision.

The finding endorses Costa, et al. [65], Henrique, et al. [10], and Pakdil and Leonard [76] viewpoint that lean culture positively affects lean manufacturing implementation. Henrique, et al. [10] proposed a step-by-step guide and routine approach to ensure the culture of lean is cultivated in the organization. Tools and strategies for process improvement are essential, but their ultimate value is determined by the culture that supports improvement. There would be no operational excellence or organizational efficiency if individuals did not grasp the lean culture. In addition, DeSanctis, et al. [78] reported that implementing lean is not only about the tools and techniques, but the culture of people is equally important. The factor contributing to the failure to sustain the lean implementation is when the changes backslide to the old ways. In conclusion, findings on lean culture indicate that lean culture improves lean manufacturing implementation. Based on the qualitative findings, it should be emphasized that cultivating a lean culture is the top priority for sustaining lean manufacturing implementation. This is because a company with the correct culture has the employees committed to putting up their best efforts in all lean activities, including training, gemba walks, coaching, kaizen events, and other activities that necessitate a strong lean culture.

A positive relationship between lean knowledge management and lean manufacturing implementation is aligned with previous research by Burawat [47], Sahoo [61], and Flynn and Scott [15]. Inadequate training is one of the major problems affecting the long-term viability of lean implementation. In, addition, Flynn and Scott [15] claimed that lean efforts are sustained in the context where the employees are well trained with the practices of lean and able to materialize the theoretical knowledge, as well as able to see the beneficial outcomes from the implementation. On the other hand, the hypothesis on the relationship between lean supplier management and lean manufacturing implementation is not consistent with the previous study from Hoque, et al. [79] and Powell and Coughlan [86]. For lean implementation to take root and spread, values and attitudes must be combined and transformed into a new cultural norm. Additionally, it is easier to share knowledge when the culture encourages a friendly environment. Lean will only be a success story if the right mentality exists. According to the framework of this study, these findings show that lean knowledge must be the priority in order for Malaysia manufacturers to sustain their lean manufacturing implementation

The finding in this study posited that lean supplier management is not a significant factor for large and medium discrete manufacturers in Malaysia to keep the lean implementation sustained. This finding is consistent with Vallejo, et al. [131] who claimed that lean supplier management is not a consideration factor during the sustaining stage of lean implementation, but it should be considered for an expansion factor after it is well sustained. In summary, conclusions about lean resource management can be drawn in several ways. To begin with, a dedicated organization does not promote the long-term sustainability of lean implementation since the roles and responsibilities to advise, coach, and inspire the organization should be undertaken by management instead of a dedicated organization. Furthermore, the organization paid higher costs due to having a dedicated organization. Financial resources are not a significant factor in sustaining lean implementation because the fundamental of lean is defined as making small, continuous adjustments rather than large, abrupt ones. However, financial planning is essential if the business intends to integrate technology into its production line. Additionally, the company must be able to sustain the lean implementation for them to extend the initiative to the suppliers. Hence, these findings are believed to provide important theoretical and managerial implications.

6.0 CONCLUSIONS

This study offers several significant contributions to researchers and practitioners. This research is hoped to widen the knowledge and help the body of knowledge to significantly explore the effects of lean manufacturing implementation from resource-based view (RBV) theory. This theory aims to gain a competitive advantage with valuable, rare, inimitable, and non-substitute resources and capabilities [132]. Contextually, this study also adds contributions. According to the best knowledge of researchers, this was the first study conducted in the medium and large-scale discrete manufacturing of Malaysia to provide a comprehensive analysis on identifying the sustaining factors of lean manufacturing implementation. This study provided a comprehensive view of sustaining factors for lean manufacturing implementation. Previous studies have investigated the determinants that influence lean implementation sustainability in a particular setting (e.g., single case study, lack of generalization, and small survey size). It does not include a comprehensive view of sustaining the lean manufacturing implementation [12]. It gives a shred of evidence that comprehensive research on the sustainable lean scope is limited.

Moreover, the research offers fruitful managerial implications. From the practical perspective, this present study will be able to draw several suggestions to the lean practitioners to gain more profound knowledge, and better equip them to address the problem of sustaining lean manufacturing implementation. In addition, employing the RBV will assist the manufacturers in gaining better performance as a strategy to achieve a competitive advantage. Despite all these arguments and all hypotheses supported in this study, the main critical point is the confirmation of the factors to sustain lean implementation in the manufacturing industries. Lean leadership, lean culture, and lean knowledge management are important factors to reap the maximum benefit of lean implementation. In detail, as demonstrated by the results generated by the IPMA, the findings prove that lean knowledge management provided the highest important factor to sustain lean manufacturing implementation, followed by lean leadership and lean culture. In addition, lean implementation is widely believed and has become inevitable for the manufacturers to survive in the current market situation [133]. This is because lean offers a systematic approach to increase production efficiency by increasing the activities that value-adding for the customer by reducing the waste in the operations [134, 135]. As a result, this study will aid lean practitioners in identifying the factors to sustain lean manufacturing implementation.

However, this study has several limitations that were discovered during the research process. For a more comprehensive study, these constraints should be addressed in the future. To begin with, this study setting was cross-sectional. Thus, future studies should include longitudinal settings. Moreover, future studies could test the current model in other industries, countries and make a cross-country comparison to enhance the generalizability of the results. In addition, further study could extend this study using a mixed-method approach. Applying both methods will contribute significantly in providing a holistic view and it provides a breadth and depth to the understanding of phenomena that neither qualitative nor quantitative research approaches alone could support to answer the research questions [136, 137]. Only 46.7% of the sustaining factors of lean manufacturing are explained by the shared effects of lean leadership, lead culture, lean supplier management, and lean knowledge management. Hence, future researchers are suggested to investigate the other sustaining factors, for instance, lean resources as suggested by Henrique, et al. [10] and Knol, et al. [138].

7.0 ACKNOWLEDGEMENT

We would like to acknowledge the Universiti Malaysia Pahang for providing financial support for this research through the University Grant No. RDU210327.

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