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Save It For a Rainy Day! Lean Strategies for Cost Saving: The Role of Lean Maturity

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Abstract:

Purpose: This study investigates the effect of lean implementation on production cost reduction and the moderating role of lean manufacturing maturity.

Design/methodology/approach: This study employed a cross-sectional survey, of which the samples were drawn using a cluster sampling procedure from 151 middle and top-level management of medium and large manufacturing companies gathered from the Federation of Manufacturers Malaysia (FMM). Data were analyzed using the PLS-SEM approach through SmartPLS4 software.

Findings: The result revealed that lean implementation does not leverage production cost reduction as the lean journey requires long-term orientation, which finally leads to valid cost reduction. The moderating role of lean manufacturing maturity was significant and positive in the relationship between lean manufacturing implementation and production cost reduction.

Research limitations/implications: Future research should include longitudinal settings as this study is cross-sectional, and future research might put the present model to the test in multiple industries and regions, including a cross-country comparison to improve the generalizability of the findings. Additionally, further studies could extend this study using a mixed-method approach.

Practical implications: By offering a holistic perspective, this study expands the existing literature, contributes to knowledge of integrated lean implementation and supports the management in planning their path towards cost-cutting performance.

Originality/value: This study answers the inconclusive finding between lean implementation and operational performance in terms of production cost reduction. The study contributes to the body of knowledge and, most importantly, to the practitioners in planning their lean journey.

Keywords: lean manufacturing implementation, cost reduction, lean manufacturing maturity, PLS-SEM

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1. Introduction

The manufacturing sector has expanded, necessitating more adaptability, and to remain competitive in the challenging market, the manufacturing industry must enhance productivity while maintaining quality (Besseris, 2021; Prabhu, Nambirajan & Abdullah, 2020). To compete in a highly competitive market, manufacturing companies worldwide must take a step forward to increase their production capabilities, efficiency, quality, and resilience (Meier, 2020). Lean implementation has evolved into a strategic approach for a company to achieve manufacturing excellence, and many businesses worldwide embrace the lean idea to create and strengthen their competitive edge (Adeodu, Kanakana-Katumba & Rendani, 2021). Lean is founded on the premise that multiple management methods should work together to deliver a high-quality product that adds value to the customer (Shah & Ward, 2003).

Sousa and Voss (2008) and Staedele, Ensslin and Forcellini (2019) claimed that the findings on lean manufacturing (LM) implementation on firm performance are inconclusive, arguing that various research has proven a good relationship between LM and operational performance, and numerous other studies have had divergent outcomes. This study considers LM as a tool for a journey to improve operational performance, mainly in the minimization cost, known as production cost reduction (PCR) (Shah & Ward, 2003). On the other hand, it was argued that this finding contradiction might be attributed to context-dependent variables. Similarly, Belekoukias, Garza-Reyes and Kumar (2014) and Santos and Tontini (2018) proposed integrating a more precise viewpoint on lean manufacturing maturity (LMAT) based on the length of time of LM on firm performance. This proves a gap in the moderating effect and gives a more comprehensive view of the impact of LM on firm performance with the role of LMAT as a moderator variable. Given that, it is known that LMAT would assist manufacturers in implementing lean to achieve PCR. Consequently, there are two goals for this study:

1. To investigate the relationship of lean manufacturing implementation on production cost reduction.
2. To investigate the moderating role of lean manufacturing maturity on the relationship between lean manufacturing implementation and production cost reduction.

This study is confined to discrete manufacturing since lean LM is employed more commonly in discrete manufacturing compared to continuous process manufacturing (Abdulmalek & Rajgopal, 2007). In summary, this study aims to provide a comprehensive perspective of integrated LM in the context of JIT, TQM, and TPM, supporting manufacturers in implementing and evaluating their cost-cutting performance. This decision is made by the study which produces empirical findings that satisfy the two objectives, in which lean practitioners and manufacturing management can investigate the outcomes of LM implementation to enhance overall cost performance, which in turn encourages manufacturers to continue implementing lean journey.

The structure of this article is as follows: Section 2 reviews the relevant literature, including the theoretical and conceptual framework. Section 3 follows with methodology, and Section 4 follows with an results of the empirical investigation. Section 5 presents the discussion, whereas Section 6 presents the conclusion and limitation.

2. Literature Review

2.1. RBV Theory

RBV refers to the internal resources contributing to a company's competitive advantage, and the company's management predicts future resource needs better than its competitors (Leiblein, 2003). In that situation, it will give the business an accurate estimate of its resource needs towards a competitive advantage (Kraaijenbrink, Spender & Groen, 2010). Company resources are all assets, organizational capabilities, and processes that the firm controls and uses to increase productivity. Because of this, a capacity's worth rises in direct proportion to the firm's resources (Barney, Wright & Ketchen, 2001). LM may offer a unique set of resources, and its deployment may assist other enterprises in outperforming the competing manufacturers (Inman & Green, 2018). LM must be valuable, rare, imitable, and non-substitutable for the manufacturers to have a sustained competitive advantage. If a firm executes a strategy that is not used by competitors and cannot be replicated, it is regarded as competitive (Barney et al., 2001). As a result, this study considered manufacturing excellence measured in PCR as a competitive advantage supported by RBV theory.

2.2. Contingency Theory

The topic of how different dimensions of the external environment interact with organizational features drives the contingency theory (Punnakitikashem, Somsuk, Adebanjo & Laosirihongthong, 2009). Contingency theory explains that general recommendations are not universal and must be tailored to circumstances. The structure of an organization is determined by its surroundings, and its structure and operations should match the environment to maximize performance. The contingency theory demonstrates that size impacts are relevant in many operations management methods, and existing research supports this (Taylor & Taylor, 2014). According to Donaldson (2001), the organizational fit must be achieved to improve performance.

2.3. Production Cost Reduction

Following the definition, PCR in this study is defined as a production excellence fundamental that significantly impacts cost reduction through waste reduction (Ebrahimi, Baboli & Rother, 2019). This study investigates the measurement of PCR through an in-depth review of literature through a well-established database (i.e., Scopus, Web of Science, and Google Scholar). The measurement was combined from several previous studies into a collection of common variables listed in Table 1.

Production Cost Reduction	Literature
Cost of poor quality	(Amrina & Yusof, 2011; Asif & Singh, 2017; Besseris, 2021; Digalwar & Metri, 2004; Ghalayini, Noble & Crowe, 1997; Mabunda, 2019; Mackelprang & Nair, 2010; Ojha, 2015; Santos & Tontini, 2018; Shivajee, Singh & Rastogi, 2019)
Cost of labor	(Amrina & Yusof, 2011; Digalwar & Metri, 2004; Ghalayini et al., 1997; Kamble, Gunasekaran & Dhone, 2020; Nawanir, Lim & Othman, 2016; Neely, Gregory & Platts, 2005; Santos & Tontini, 2018; Shivajee et al., 2019; Thomas, 2016).
Inventory costs	(Narain, Yadav, Sarkis & Cordeiro, 2000; Ojha, 2015; Sukarma, 2000; Thomas, 2016)

Table 1. Summary of articles in PCR

To compete in a challenging market, producers must improve product quality, significantly reduce production time, optimize productivity growth, innovate, and quickly react to changing customer demands with top priority for manufacturers is cost reduction through waste elimination (Foo, Ang, Rajamony & Lee, 2015; Ganesan & Uthayakumar, 2020; Malekinejad, Ziaeian & Hosseini Bamakan, 2022). The cost is frequently used to evaluate the performance of LM, and manufacturers usually strive for manufacturing excellence while lowering costs significantly (Nawanir et al., 2016). To attain excellence, many firms have begun on a lean journey to decrease waste throughout the value chain and eventually become cost-competitive (Afonso, Gabriel & Godina, 2022; Loh & Lau, 2019). Implementing LM eliminates all non-value-adding processes and increases customer value, and it is widely agreed that firms strive for manufacturing excellence while achieving considerable cost savings (Malekinejad et al., 2022; Womack, Jones & Roos, 2007). PCR aims to find the lowest pricing, lowest overall production cost, and maximum production capacity compared to the competitors (Santos & Tontini, 2018).

Reducing costs due to poor quality, causing either rework or scrap, will reduce overall production costs (Amrina & Yusof, 2011; Asif & Singh, 2017; Sahoo, 2019). The cost of poor quality, which is the failure cost caused by the discrepancy, is divided into internal failure costs discovered before delivery to the customer and external failure costs detected upon delivery (Ayach, Anouar & Bouzziri, 2019). Enhancing internal product quality will greatly lower production costs, directly influencing manufacturing performance (Besseris, 2021; Shivajee et al., 2019). Executing things the right way the first time lowers the cost of poor quality by minimizing the requirement for product rework or rejection (Ayach et al., 2019).

Labor cost represents production costs related to manufacturing operations and contributes an average of 12% of the cost, one of the most substantial operating costs (Foster & Gupta, 1990; Ghalayini et al., 1997; Vincent & Hu, 2010). Operating a manufacturing plant with very high labor costs will challenge the manufacturing to achieve a competitive advantage (Shivajee et al., 2019). Firms are under intense pressure to cut manufacturing costs, which may be accomplished through flexible production, contributed by a flexible workforce with a flexible attitude, various skills, and the capacity to handle various jobs with optimal resource utilization.

Inventory cost has been devoted considerable attention by many literatures to reduce overall manufacturing costs (Malekinejad et al., 2022; Nawanir, Fernando & Lim, 2021). For instance, a just-in-time production system has many benefits in eliminating waste by reducing unnecessary inventory and its costs. Manufacturers can create a precise number of items while utilizing the fewest resources and minimizing inventory by implementing LM (Mabunda, 2019; Thomas, 2016). JIT techniques based on lean concepts such as the pull system, small batch size, and heijunka might help lower inventory, and it is understood that failure in managing inventory will cause huge financial challenges (Agyabeng-Mensah, Afum, Agnikpe, Cai, Ahenkorah & Dacosta, 2020; Dutta & Mandal, 2020; Ganesan & Uthayakumar, 2020; Kamble et al., 2020; Petrillo, De Felice & Zomparelli, 2018; Valente, Sousa & Moreira, 2019).

2.4. Lean Manufacturing Implementation

This study investigates the measurement of LM through an in-depth review of literature through a well-established database (i.e., Scopus, Web of Science, and Google Scholar). The measurement was combined from several previous studies into a collection of common variables listed in Table 2.

LM Practices	Items	Literature
Just-in-time	Pull system/Kanban system	(Furlan, Vinelli & Dal Pont, 2011; Shah & Ward, 2003; Zanon, Ulhoa & Esposto, 2020; Zirar, Trusson & Choudhary, 2020)
	Small lot production	(Furlan et al., 2011; Hoque, Hasle & Maalouf, 2020; Iqbal, Jajja, Bhutta & Qureshi, 2020; Santos & Tontini, 2018; Shah & Ward, 2003; Zanon et al., 2020)
	Cellular layout	(Shah & Ward, 2003; Zirar et al., 2020)
	Quick changeover	(Afonso et al., 2022; Furlan et al., 2011; Hoque et al., 2020; Iqbal et al., 2020; Santos & Tontini, 2018; Shah & Ward, 2003)
	Heijunka	(Dave & Sohani, 2019; Santos & Tontini, 2018)
	JIT supplier	(Bose, 2020; Hoque et al., 2020; Nawanir et al., 2016; Sisson & Elshennawy, 2015)
	Value Stream Mapping	(Dave & Sohani, 2019; Mabunda, 2019)
Total Quality Management	Poka-yoke	(Furlan et al., 2011; Shah & Ward, 2003; Zanon et al., 2020)
	Standardized work	(Furlan et al., 2011; Shah & Ward, 2003)
	Quality at source	(Sancha, Wiengarten, Longoni & Pagell, 2020; Zanon et al., 2020)
	Statistical process control	(Sancha et al., 2020; Zanon et al., 2020; Zirar et al., 2020)
	Visual management	(Bose, 2020; Iqbal et al., 2020)
Total Productive Maintenance	Preventive maintenance	(Dér, Hingst, Nyhuis & Herrmann, 2022; Sancha et al., 2020; Shah & Ward, 2003)
	Predictive maintenance	(Sancha et al., 2020; Shah & Ward, 2003)

Table 2. Summary of articles in LM Implementation

The idea of lean is a wide range of management methods to create a high-quality finished products to meet consumer demand while generating minimal to no waste in order to reduce production costs (Shah & Ward, 2003). On a managerial level, LM is translated into numerous LM processes and tools, such as just-in-time (JIT), total productive maintenance (TPM), and total quality production (TQM) (Furlan et al., 2011). To illustrate different aspects of LM, various tools can be integrated into various ways, and the lean bundle concept includes JIT, TQM, TPM, and HRM, initially introduced by (Shah & Ward, 2003). This study employed an integrated model that includes three key LM bundles, JIT, TQM, and TPM, without HRM practice (Shah & Ward, 2003). The HRM bundle is not included in this analysis since it is an enabler or supplementary lean practice rather than a core practice, and the HRM component can be implemented in the early phase as an infrastructural practice for an organization (Van Assen & de Mast, 2019).

JIT focuses on decreasing manufacturing waste and response times from manufacturers to customers and delivering the appropriate components, in the right amount, at the right time while utilizing as minimal resources as possible (Mabunda, 2019; Mackelprang & Nair, 2010). This help to reduce inventories and waste along the value chain. Kanban is a popular way to build a pull system to optimize material flow within the manufacturing process and between suppliers and customers (Petrillo et al., 2018). The cellular layout is a JIT method to improve shop floor flexibility. Workstations and equipment are organized into cells to improve process flow and reduce transportation waste (Nawanir et al., 2016). JIT also uses small batch production to eliminate waste and speed up the process (Hoque et al., 2020; Sancha et al., 2020). The quick changeover is employed to accomplish JIT through small batch production. It would significantly cut manufacturing lead time by implementing technologies such as the single-minute exchange of die (Afonso et al., 2022; Mabunda, 2019). A balanced workload, or heijunka, improves operational efficiency (Dave & Sohani, 2019; Santos & Tontini, 2018). Another important JIT indicator is supplier on-time delivery, which guarantees that vendors produce things when needed (Nawanir et al., 2016; Sisson & Elshennawy, 2015). LM implementation will be exceptionally efficient when applied to the whole supply chain network, including suppliers (Sisson & Elshennawy, 2015).

TQM is a management approach aimed at increasing customer satisfaction by removing process defects and minimizing product returns (Ayach et al., 2019). It refers to the procedures related to standardized work that are used to standardize production guidelines, content, and sequencing (Furlan et al., 2011; Sukarma, 2000). It is essential to reduce variance in the production process (Dutta & Mandal, 2020; Iqbal et al., 2020). Statistical process control is at the center of process improvement that monitors a process and recognizes specific reasons for variation, alerting the user to the need for corrective action (Santos & Tontini, 2018; Sukarma, 2000; Zirar et al., 2020). Integrated visual management would increase efficiency and quality performance (Alkhaldi & Abdallah, 2019). Quality at source is connected to the culture of stopping and solving difficulties to achieve the target quality on the first attempt (Sancha et al., 2020; Santos & Tontini, 2018). Toyoda developed jidoka, a concept that employs automation to instil quality in the process and supports prudent decisions to halt operations as soon as quality issues arise (Mabunda, 2019). Poka-yoke has been established as one of the effective quality measures used in manufacturing to eliminate errors (Bose, 2020; Furlan et al., 2011).

TPM is a concept that allows production employees to take ownership and responsibility for their equipment (Holgado, Macchi & Evans, 2020; Sahoo, 2019). In the manufacturing setting, TPM aims to enhance equipment performance through a comprehensive preventative maintenance system that spans the whole life of the equipment and involves everyone in all departments and levels (Dér, et al., 2022). It promotes plant maintenance through small-group and volunteer activities. TPM ultimate goal is to achieve zero operational downtime and zero defects by preventing, rather than addressing, unexpected failures, speed losses, and quality concerns (Rajput & Jayaswal, 2012; Sahoo, 2020). Preventive maintenance is important to keep equipment in order (Dér et al., 2022; Tortorella, Vergara & Ferreira, 2017). TPM comprises preventative and predictive maintenance, a full maintenance system for the equipment life cycle (Nakajima, 1988; Sancha et al., 2020). Maintenance technicians outsource equipment maintenance duties to operators as part of preventative maintenance, such as lubrication, adjustments, and small repairs, referred to as autonomous maintenance. The objective is not only to transfer tasks to manufacturing workers. Instead, the goal is to provide the operators with equipment ownership, basic care, and maintenance (Kovács, Kő & Demeter, 2020). Based on the discussion, H1 stated as follows:

H1: Lean manufacturing implementation has a positive effect on production cost reduction.

2.5. Lean Manufacturing Maturity

The organization is formed by contingencies since it must be suitable to avoid performance deterioration. The moderating impact of LMAT on the relationship between LM and PCR is explained using contingency theory. The role of LMAT is anticipated to positively affect manufacturing cost reduction. Understanding the maturity level of an organization's processes will aid in setting goals for process change (Santos & Tontini, 2018). The organization would identify viable methods to reach the desired aim based on its understanding of maturity level. As described by Paulk, Curtis, Chrissis and Weber (1993), maturity occurs when the process is launched, repeated, specified, managed, and optimized. Measuring maturity enables an organization to evaluate its performance concerning specified criteria. Measuring maturity level identifies the organization's strengths and limitations to develop excellence (Santos & Tontini, 2018). LMAT is used to assess maturity level measured in terms of fidelity, extensiveness, and experience, adapted from Myers and Powers (2017).

Previous research has found that LMAT improves performance (Galeazzo, 2019; Santos & Tontini, 2018; Zanon et al., 2020). Manufacturers with a low degree of LMAT do not regularly employ lean tools and lack the habits to sustain a lean journey (Santos & Tontini, 2018). On the other hand, manufacturers with a higher level of LMAT have a more consistent quality culture, problem-solving approach, and waste reduction activities, all of which lead to PCR (Santos & Tontini, 2018). The most frequently mentioned goal of implementing LM is to reduce production costs which that is the core concept of LM to eliminate waste and increase customer value Bhasin and Burcher (2006); Olson, Olson, Czaplewski and Key, 2021). LM might increase productivity and waste reduction, contributing to the main goal of lowering costs and remaining competitive in the market (Chiarini & Brunetti, 2019). LMAT is crucial in transforming lean production into a viable system with reduced production costs (Galeazzo, 2019). In particular, a company's expertise with LM directly impacts its capacity to achieve profitable growth and applying lean tools to lower production costs in their everyday work operations favoured the status of LMAT (Jorgensen, Matthiesen, Nielsen & Johansen, 2007). Previous studies have proven that LMAT positively and statistically significantly impacts PCR. Based on the discussion, the hypothesis is stated as follows:

H2: Lean manufacturing maturity moderates the relationship between lean manufacturing implementation and production cost reduction.

Considering the above literature review, the study framework in Figure 1 is proposed.

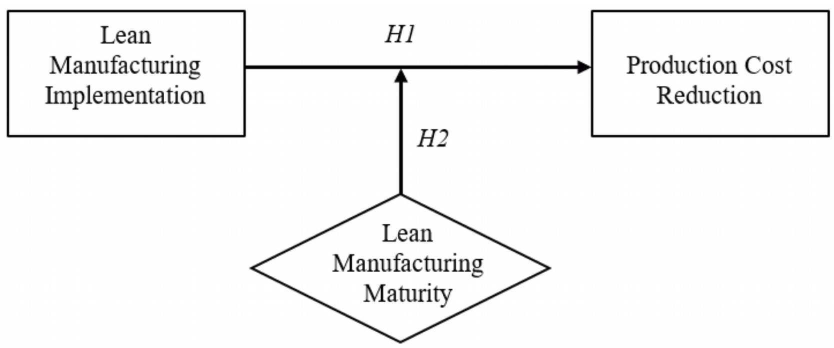

Figure 1. Theoretical Framework

3. Methodology

To achieve the research objectives, the researcher employed a quantitative approach, which was used to assess whether or not the variables were related. Based on previous research, a measurement instrument was created to assess specific aspects through adoption, adaptability, and self-development. Different scale properties (e.g., 6-point interval scale for LM, 7-point interval scale for PCR, and 3-point interval scale for LMAT) were used to prevent common method bias in the measurement scales (MacKenzie & Podsakoff, 2012). During the development stage, three academicians and two industry practitioners were invited to review the content validity. This research involved discrete manufacturing in medium and large-scale industries listed in the Federation of Malaysian Manufacturers (FMM) and focused on Malaysian medium and large-scale discrete manufacturing companies. Small businesses will not be considered since they are less likely to implement LM owing to several limitations and constraints (Dieste, Panizzolo & Garza-Reyes, 2020). The unit of analysis for this study was organization, with the element of the unit of analysis being middle management and top management. This element was selected assuming they had relevant information (Grix, 2002). As a result, respondents should thoroughly grasp the knowledge in LM and LMAT. The population was sampled using cluster random sampling based on industry classifications.

The data was acquired using a Google Form, considering respondents may fill out the questionnaire at their leisure and reasonable cost. Table 3 displays the background and demographics of 151 respondents, including industry types, years of operation, plant location, respondent positions, years of service, and years of experience. In general, all respondents are eligible to participate in this study.

Categories	Demographic	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

Table 3. Demographics Profile of Respondents

4. Results

PLS-SEM using SmartPLS4 software was used to investigate the causal relationships between constructs even when there are minor outliers, and the data will not be distorted (Ringle, Wende & Becker, 2015). PLS-SEM is a non-parametric multivariate approach for estimating latent variable path models, able to handle complicated research models and capable of the reflective and formative models (Hair, Sarstedt, Ringle & Gudergan, 2017). Based on the two-stage analytical procedure, this study examined the measurement model (i.e., construct validity) and the structural model (i.e., hypotheses testing). Since this study is composed of reflective and formative constructs, the measurement model of the reflective constructions was studied first, followed by formative constructs.

4.1. Construct Validity for Reflective Constructs

The convergent validity was measured based on outer loading, composite reliability (CR), and AVE. Following the suggestion from Hair et al. (2017), the values of loadings should be > 0.4, the AVE should be >0.5, and the CR should be >0.7. The AVE was greater than the intended level of 0.50 from the first run, the loading was higher than 0.40, and the CR was all higher than 0.70, indicating that all of the measurements are valid and reliable. Details of the convergent validity assessment result for the reflective constructs are depicted in Table 4.

Construct	Item Code	Measurement Item	Outer Loading	CR	AVE
JIT	JIT1	We produce a product based on the current demand from its users.	0.764	0.913	0.523
	JIT2	We perform machines' setup quickly if there is a change in process requirements.	0.820		
	JIT3	Our production processes are located close together to support the smooth flow of materials.	0.773		
	JIT4	We group dissimilar machines to process a family of parts with similar shapes or processing requirements.	0.735		
	JIT5	We level our production, in which production volume is distributed equally to have the same daily quantity of outputs.	0.759		
	JIT6	We produce different models of products daily based on the composition of monthly demand.	0.734		
	JIT7	Our suppliers deliver materials to us just as it is needed (in just-in-time basis).	0.621		
TQM	TQM1	We have standardized work documents (e.g., SOP, work instruction, etc.) to guide workers in performing activities in the production system.	0.819	0.910	0.609
	TQM2	We standardize the works in our production line to reduce processes variation.	0.808		
	TQM3	Production processes on shop floors are monitored with statistical quality control techniques to control the process variance.	0.785		
	TQM4	We apply a human error prevention mechanism with error-proof devices (*pokayoke*) in our production line.	0.786		
	TQM5	We implement an automated stopping mechanism, in which when an abnormality/irregularity happens, the process will automatically stop.	0.703		
	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.	0.777		
TPM	TPM1	We implement preventive maintenance (i.e., planned maintenance of equipment to prevent failure) for all equipment in the production line.	0.830	0.921	0.711
	TPM2	We ensure that machines are in a high state of readiness for production at all the times.	0.888		
	TPM3	We scrupulously clean workspaces (including machines and equipment) to make unusual occurrences noticeable.	0.881		
	TPM4	Our operators continuously monitor and perform minor adjustments/maintenance on their equipment.	0.750		
	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.	0.861		

Table 4. Demographics Profile of Respondents

Assessment of reflective measurement models includes discriminant validity used to check the dissimilarity in the measurement tools of different constructs. This study follows the heterotrait-monotrait ratio of correlations (HTMT) procedure prescribed by Ringle et al. (2015) to assess discriminant validity, with HTMT value above 0.900 suggesting a lack of discriminant validity. Table 5 shows that the values for discriminant validity through the HTMT test were lower than 0.900, proving that all construct questions were different and not interchangeable in their meaning, reflecting satisfactory discriminant validity.

Construct	JIT	TPM	TQM
JIT			
TPM	0.837		
TQM	0.817	0.848	

Table 5. Discriminant Validity: Heterotrait-Monotrait Ratio Statistics

4.2. Construct Validity for Formative Constructs

To validate the formative construct, it is required to check whether the formatively measured construct is highly correlated with the reflective measurement of the same construct through redundancy analysis measured using global item. The standardized β value for PCR was 0.836 specified that the formative indicators represent the construct (Hair et al., 2017). Subsequently, the variance inflation factor (VIF) was used to measure the indicator collinearity, showing the result of VIF for PCR ranged between 2.020 to 2.175, which has not violated the cut-off value of 3.3, concluding that multicollinearity was not a major concern relative to the set of variables (Kock & Lynn, 2012). Next, the formative indicator's contribution using the item weight significance was assessed, and all PCR indicators were found highly significant. Table 6 summarizes the construct validity of the formative construct.

Item Code	Measurement Item	Std Beta	Outer weight	Outer loading	VIF	T-Value	P-value
PCR1	Cost of poor quality (internal and external failure cost) have reduced	0.844	0.419	0.896	2.175	4.313	0.000
PCR2	Labour cost have reduced		0.262	0.828	2.020	2.308	0.015
PCR3	Overall inventory cost has reduced		0.451	0.905	2.146	4.172	0.000

Table 6. Construct Validity of Formative Construct

4.3. Common Method Variance

Common Method Variance (CMV) is a common systematic error variance among variables assessed using the same sources or methodologies. CMV may jeopardize the concept validity and introduce systematic bias into a study (Tehseen, Ramayah & Sajilan, 2017). Full collinearity was assessed in this study to see whether common method bias was an issue given that the data were acquired from a single source. As a result common method bias did not present as all VIF values were below 3.3, ranging between 1.000 to 3.256 (Kock & Lynn, 2012).

4.4. Hypothesis Testing

After determining that the measurement model had adequate validity and reliability, bootstrapping was used to test the hypothesis. According to Hair et al. (2017), the 95% confidence level is used in most settings, implying that the p-value must be smaller than 0.05 to render the relationship under significant consideration. To determine the significance level, a one-tailed test was used as the hypotheses generated in this study are the directional hypotheses (Rice & Gaines, 1994). Due to this justification, such predictions in directional hypotheses were tested with a one-tailed test with critical values of 1.645 (significance level = 5%). Table 7 displays the results of the hypothesis testing.

Path	Std. Beta	Std. Error	t-value	p-value	Bias	Confidence Interval		Decision
						5%	95%	
H1: LMI to PCR	0.076	0.085	0.932	0.176	-0.002	-0.057	0.219	Not supported
H2: LMAT*LMI to PCR	0.080	0.042	2.438	0.008	-0.011	0.032	0.139	Supported

Table 7. Summary of Hypotheses Testing

Table 7 shows that *H1* presents an effect of LM on PCR at 5% significant level. The hypothesis was not supported with the outcome of standardized β=0.076, t-value=0.932, p-value=0.176, and confidence interval ranges between -0.057 and 0.219. *H2* predicts the last hypothesis presents the moderating effect of LMAT on the positive effects of LM implementation on PCR. The finding shows that the hypothesis is supported at 5% significant level with a standardized β of 0.080, t-value of 2.438, p-value of 0.008, and 0.032 to 0.139 confidence interval level.

Because the R^2 is the squared correlation of the actual and anticipated values, it measures the amount of variance in the endogenous constructions that is accounted for by the exogenous constructs. It contains all the information required to estimate the model and evaluate the in-sample prediction capability. (Hair et al., 2017). R^2 have substantial value with JIT, TQM, and TPM are 0.821, 0.822, and 0.856, respectively. The evaluation of f^2 shows how much an exogenous variable contributes to an endogenous variable. The f^2 of JIT, TQM, and TPM are 5.036, 4.829, and 5.619, respectively, which indicates large effects, meanwhile no effect (i.e., 0.004) on the relationship between LMI and PCR (Hair et al., 2017). 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 correctly predicted. The value of Q^2 for JIT, TQM, and TPM is 0.456, 0.492, and 0.600, respectively, indicating a large predictive relevance (Hair et al., 2017).

5. Discussion

This study investigated the relationship of lean manufacturing implementation on production cost reduction and the moderating role of lean manufacturing maturity on this relationship. The research put forward two hypotheses. The first hypothesis, H1, investigated the relationship between LM implementation on PCR, and based on the findings, H1 was not supported as LM implementation does not leverage PCR. Lean philosophy focuses on eliminating all forms of waste during production while improving efficiency by removing non-value-added processes (Besseris, 2021; Santos & Tontini, 2018). This finding is aligned with research from Browning and Heath (2009), who reported that implementing LM might result in positive returns after a certain point, depending on the stabilities of the implementation. Additionally, inventory reduction is advantageous to a point, but it could put manufacturers at risk in the event of an unforeseen event.

Similarly, Rymaszewska (2014) investigated the implementation of lean manufacturing and cost-cutting strategies, stating that successful lean adoption necessitated a long-term mindset and willingness to forfeit short-term gains to achieve long-term lean improvements, which should eventually lead to the establishment of a lean culture. In short, for any lean effort, the cost increases as investment and money are needed and suppose the lean journey has been implemented over time. In that case, the cost becomes significant. It ultimately leads to valid cost reduction. Reke, Powell, Olivencia, Coignet, Chartier & Ballé (2019) reported that the initial focus of lean implementation is not to have cost reduction as an immediate impact. Still, management should focus on teamwork that has continuous learning through encouraging people to learn and understand the causes of non-productivity. In the end, once the collaboration is established, lean will enable productivity and lead to cost reduction.

On the other hand, the next hypothesis, H2, discovered that the moderating role of LMAT on the relationship between LM and PCR was supported. Therefore, H2 is maintained. This finding is consistent with previous research from Galeazzo (2019), Santos and Tontini (2018), and Zanon et al. (2020). Manufacturers with a low level of LMAT do not regularly employ lean tools and do not have the necessary habit to sustain LM. As a result, LM has a minimal impact on performance. On the other hand, manufacturers with a greater degree of LMAT have a more consistent quality culture, problem-solving strategy, and waste reduction efforts, resulting in improved manufacturing performance (Santos & Tontini, 2018). A mature lean manufacturer will undoubtedly achieve manufacturing excellence that rivals find difficult to imitate (Galeazzo, 2019).

6. Conclusion and Limitation

The study has contributed to the existing body of knowledge in identifying the impact of LM on PCR. The hypotheses were developed based on the conceptual framework, and two hypotheses were subsequently analyzed using a cross-sectional quantitative analysis. The smart-PLS software was used to analyze data using the PLS-SEM approach. For further data analysis, 151 valid responses were used, and according to the findings, LM implementation did not influence PCR. However, the effect becomes significant and positive with the introduction of LMAT. The introduction of LMAT (i.e., fidelity, extensiveness, and experience) makes the impact significant and positive when it is introduced into the model.

This research makes several important contributions to scholars and practitioners. This research hoped to widen the knowledge and help the body of knowledge to significantly explore the effects of LM implementation from a resource-based view (RBV) and contingency theory. RBV aims to gain a competitive advantage with valuable, rare, inimitable, and non-substitute resources (Barney et al., 2001). On the other hand, contingency theory explains that common recommendations are not universal but depend on the situation. This study also contributes as many studies have presented positive evidence of LM implementation on manufacturing performance (Kie, Hassan, Aripin & Yunus, 2019; Nawanir et al., 2016). However, Staedele et al. (2019) stated that practice–performance findings are inconsistent, claiming that several studies have established a positive relationship between lean and operational performance, but several others have demonstrated different results. Previous literature indicated a lack of studies on the moderating effects of LM implementation on manufacturing excellence, as proposed by Belekoukias et al. (2014). Thus, to present a more comprehensive view of LM implementation on manufacturing excellence, this study will explore the role of LMAT as a moderating effect.

Moreover, the research offers fruitful managerial implications. From the practical perspective, this present study will draw several suggestions to lean practitioners to gain more profound knowledge, and better equip them to address the impact of LM implementation on PCR and the role of LMAT. Cost reduction is a firm's central tenet to survive in the competitive market. The positive relationship between the costs and benefits of lean has been proven over time. Many LM business cases flatten the time dimension to arrive at single numbers for costs and savings, resulting in little cost-benefit (Browning & Heath, 2009). As a result, this study will aid lean practitioners in strategizing the roadmap for LM and ensure the implementation is well sustained to reap the maximum benefit of LM on cost reduction.

Several study limitations were identified during the research process, and these constraints should be addressed in the future for a more thorough investigation. To begin, the design of this study was cross-sectional, future research should include longitudinal settings. Furthermore, future research might put the present model to the test in multiple industries and regions, including a cross-country comparison to improve the generalizability of the findings. In addition, further studies could extend this study using a mixed-method approach. Applying both methods will contribute significantly to providing a holistic view and provides a breadth and depth to understanding phenomena that neither qualitative nor quantitative research approaches alone could support to answer the research questions (Myers & Powers, 2017; Tashakkori, Teddlie & Teddlie, 1998).

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