

Conceptual Model for Assessing the Lean Manufacturing Implementation Maturity Level in Machinery and Equipment of Small and Medium-sized Enterprises

Jia Yuik Chong^{a1}, & Puvanasvaran A. Perumal^{a2}

^aFaculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Jalan Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

^{a1} chongjiayuik@gmail.com, ^{a2} punesh@utem.edu.my

Abstract:

The adoption of lean manufacturing (LM) in small and medium-sized enterprises (SMEs) is not as vigorous as in large organizations. This purpose of this study is to assess the maturity level of LM implementation in the machinery and equipment (M&E) SMEs. The close-ended survey questionnaire method was adopted in three Malaysian manufacturing M&E SMEs, and data was collected for the descriptive analysis. The findings showed that these case companies are generally at a low-to-moderate level in terms of LM understanding. Meanwhile, the extent of LM implementation and the success level is still moderate. The proposed LM conceptual model provides valuable perspectives and establishes a holistic understanding of the phenomena in LM maturity status for M&E SMEs. The proper synchronization of LM understanding, implementation, and success are vital to building the strong LM maturity foundation for lean organizational transformation. It serves as useful guidance and strategic framework to other companies in dealing with the operational excellence challenges. The significance of this study will help M&E SMEs to identify their current position and promote progress in the lean application journey. This will benefit the management team and lean practitioners in decision-making and enhance tactics to attain a higher level of success.

Key words:

Lean manufacturing, Small and medium-sized enterprises, Lean maturity, Machinery and equipment, Conceptual model.

1. Introduction

Small and medium-sized enterprises (SMEs) are always constantly searching for new chances to continuously develop their business sector transformation in the globally competitive market. Nowadays, the manufacturing industry faced various challenges in business sustainability, operational efficiency, and cost-saving. Lean manufacturing (LM) is one of the systematic management systems or tools that can help firms provide value-added processes to customers and minimize unnecessary waste (Achanga et al., 2006; Driouach et al.,

2019; Womack et al., 1990). Lean production implementation leads to operational excellence and enhances product quality (Driouach et al., 2019; Liker, 2004; Shah and Ward, 2002; Ulewicz and Kucęba, 2016; Womack et al., 1990; Yahya et al., 2019). In Malaysia's manufacturing sector, SMEs are classified as companies with sales of RM50 million or not exceeding 200 full-time employees (SME Corp. Malaysia, 2020). SMEs are the core of the economy and contribute to the nation's development. Malaysian SMEs gross domestic product (GDP) grew by 5.8% in 2019 compared to 6.2% in 2018. The share of GDP contributed by SMEs rose to 38.9% in 2019 from 38.3% in the previous year (DOSM,

2020). Although LM is commonly applied in large enterprises, many existing studies still illustrated the inconsistency of LM adoption in different industries and countries, especially in SMEs (Abu et al., 2019; Khusaini et al., 2014; Nordin et al., 2013). Achanga et al. (2006) stated that many SMEs had not adopted LM. Driouach et al. (2019) claimed that many SMEs are still struggled to introduce LM to their processes.

In the Malaysian 11th Programme, the machinery and equipment (M&E) sector serves as a driving force to shift to higher economic growth. The sub-sectors of M&E had contributed RM41.5 billion to exports in 2019 compared to RM40.5 billion in 2018 (MIDA, 2020). This reflects Malaysia's efficient and fast-expanding economy in achieving towards Regional Production Hub for M&E. Malaysian M&E sectors are categorized into four main sub-sectors (MIDA, 2020):

- i. Specialized process machinery or equipment for specific industry;
- ii. Metalworking machinery;
- iii. Power generating machinery and equipment;
- iv. General industrial machinery & equipment, components, and parts.

Shah and Hussain (2016) found that the textile sector in Pakistan just begin to implement LM, and more than half are in-transitional due to insufficient understanding of the lean concept. Kherbach et al. (2019) indicated that 87% of the surveyed small manufacturers in Romania need lean training, especially for their engineers and supervisors. Based on the study conducted by Antosz and Stadnicka (2017), 55% of the automotive SMEs in Poland did not implement LM, and for those who have, 29% are used the 5S lean tool solely. Sumantri (2017) recorded low lean implementation in logistic operations among SMEs in East Java of Indonesia, attributed to internal resistance, unavailability of resources, lack of leadership, and inadequate training. From the survey of 84 manufacturing SMEs in North Africa, Belhadi et al. (2018) concluded that despite their great need for lean, its implementation is very low due to the lack of resources and cultural issues. Nordin et al. (2013) revealed weak LM implementation in their preliminary survey at 30 Malaysian automotive component manufacturing firms. The LM practices implementation in the Malaysian food and beverage industry is at its infancy based on the questionnaire survey of 53 organizations (Khusaini et al., 2014); besides, the majority of surveyed firms considered the negative

perception towards LM as the most critical barrier. Abu et al. (2019) studied the LM implementation in 148 Malaysian furniture companies, found that employee-related matters such as lack of labour resources, poor application of know-how, and employee resistance to change are the barriers in lean organizations. Ali Maasouman and Demirli (2015) presented a lean maturity model, which is crucial in achieving a sustainable lean status but is limited to manufacturing cells. Yadav et al. (2019b) highlighted that SMEs are frequently overlooked by researchers when it comes to lean adoption in comparison to large enterprises. Even though there are no statistically significant differences between SMEs shown in the maturity of lean practices adoption in Brazilian manufacturing companies, the findings vary when smaller companies are compared to large enterprises (Bento and Tontini, 2019).

Accordingly, the above studies indicated that LM implementation remains surprisingly low and lacks attention by the researchers. Although it was introduced in several industries in many countries other than the automotive industry, most SMEs still struggle to advance their lean practices. Furthermore, the present literature research on LM adoption for Malaysian M&E is just 2.3%, much less than the automobile industry's 37.1% (Osman et al., 2020). As a result, this study aims to assess the maturity level of LM implementation in M&E SMEs to close the current gaps. According to literature reviewed by Zanon et al. (2020), a greater lean maturity status is linked to better operational performance. The created LM conceptual model provides useful perspectives into understanding phenomena in LM maturity progress in M&E SMEs. It serves as useful guidance and strategic framework to other companies in dealing with operational challenges. The significance of this study will help M&E SMEs to identify their current position in the lean application journey.

This paper is outlined into six sections: the first section mentions the overall LM implementation maturity level at different countries or industries. It highlights the problem statement and gap analysis. The second section reviews the current LM maturity assessment frameworks or models application. The third section contains the research methodology and overview of the case companies background. The fourth section presents the survey analysis. The LM maturity conceptual model is developed and discussed in the fifth section. Lastly, the sixth section explains the conclusions, research implications, and future works recommendations.

2. Review of LM Maturity Assessment Frameworks in SMEs

[Driouach et al. \(2019\)](#) stated that SMEs, especially Very Small Business (VSBs), still have difficulties adapting LM to their process within the organizations based on the various lean implementation frameworks presented in their literature review. [Carvalho et al. \(2019\)](#) revealed that the large organizations in Brazil have already demonstrated some reluctance in implementing LM. Still, small businesses are unaware that LM exists or is too cozy to rethink and implement it practically. [Majava and Ojanperä \(2017\)](#) stated that the lean philosophy application is a workable and famous approach in developing and enhancing production activities from a case study analysis in Finnish-based manufacturing SMEs. The findings from [Sahoo and Yadav \(2018\)](#) suggested overall positive effects on a firm's operational performance as a result of adopting lean tools and philosophy in Indian SMEs. [Rose et al. \(2010\)](#) recommended fifteen feasible lean practices for SMEs split into three category levels: basic, intermediate, and advanced. Basic lean techniques are fundamental tools and soft skills executed at the operational level, such as 5S, visual control, quality circle, and teamwork. Intermediate lean practices would require cross-department initiatives and include cellular manufacturing, setup time reduction, continuous improvement, etc. Finally, advanced lean methods use the first two categories to carry out more intricate lean functions, such as small lot sizes, Kanban, and continuous flow. [Belhadi et al. \(2016\)](#) proposed an implementation framework for lean production in SMEs, comprising of the necessary components (process, tools, success factors) in three phases.

[Afonso and Cabrita \(2015\)](#) developed a lean supply chain framework based on the performance measurement perspective, but it lacks process performance indicators and other soft lean practices (human elements). [Leite et al. \(2016\)](#) formulated a roadmap for applying lean techniques within SMEs' product development teams; [Hemilä and Vilko \(2015\)](#) developed a model in manufacturing industry supply chain SMEs, but both lean methodologies are not applicable in terms of production operation perspective. [Sousa et al. \(2018\)](#) implemented project management good practices with lean production methodologies to enhance the process efficiencies in a SMEs Portuguese innovation company via an action research methodology. Five phases of

implementation were developed to enhance the production from the "As-Is" model to the future "To-Be" model by applying lean principles and tools. [Belhadi et al. \(2017b\)](#) presented a significant improvement in the lean performance indicators with the successful deployment of the framework of lean principles through a set of success factors. [Ali Maasouman and Demirli \(2015\)](#) proposed a visual maturity model to evaluate the overall leanness for LM cells through analysis of lean in seven axes. [Zanon et al. \(2020\)](#) developed the integrated lean maturity model showed that the performance assessment practices through the application of a performance measurement system (PMS) could foster lean practices and promote improvements in the organizations.

[Kolla et al. \(2019\)](#) stated that there are many evaluation models which are available to assess the performance of an organization in accordance with either Lean Production System (LPS) or Industry 4.0; however, these models are also complicated and do not meet the specific needs of SMEs for further progression. This is one of the key issues that prohibit the effectiveness and advancement of LM applications in SMEs. [Ramadas and Satish \(2018\)](#) showed that employee barriers in LM implementation for SMEs are substantial inadequate training and experienced staff, lack of knowledge of experienced specialists, and cultural resistance to change. [Shah et al. \(2019\)](#) proposed the lean manufacturing in small-sized engineering organizations (LEMSEO) model for implementing LM successfully in three phases which consists of 20 steps for SMEs, namely LM awareness, the confidence of successful implementation, and full-scale sustainable LM projects. [Abu et al. \(2021\)](#) presented that culture and human behaviour, knowledge, and resources are three main factors that have a synergetic impact on LM implementation in manufacturing industries.

Based on the presented literature review, there is an apparent lack of investigation of the detail regarding LM implementation maturity level, specifically mapping with the M&E SMEs. So far, this subject's research does not furnish a comprehensive LM framework for enhancing lean maturity among employees and establishing a robust lean culture in SMEs. Most of the existing frameworks are focused on the LM implementation operational steps, lean principles enhancement, lean tools application, and lean performance measurement. Before proceeding with the actual LM implementation, the current LM maturity level assessment is still less highlighted

in the early beginning stage. Besides that, there is a lack of synchronization and proper alignment for the thorough LM understanding, implementation, and success level to enhance the effectiveness and efficiency of the lean application in SMEs. This always resultant in poor LM implementation and caused the lean initiative to fail eventually. Therefore, there is a strong need to develop a practical LM maturity assessment model specifically created to provide a valuable guide for LM adoption in M&E SMEs to bridge this gap.

3. Research Methodology

This study was carried out by using a multiple case studies approach. The purposive sampling approach was used to choose three SMEs that shown high interest and desire to partake. The case study explored a holistic understanding of the phenomenon for LM implementation experiences in M&E SMEs. The selection criteria are M&E companies that fulfilled the Malaysian manufacturing SME's definitions are eligible for this study. Table 1 depicts the overall background of the three case companies. All organizations have been in operation for more than 10 years and have varying degrees of LM implementation. The targeted respondents were questioned about their current extent of LM implementation maturity in the company in terms of three different dimensions of assessments (understanding, implementation, and success). The interview questionnaires structures are divided into two sections as following:

- i. The first part is about the general company information and the background of respondents.
- ii. The second part is to assess LM maturity in terms of understanding, implementation, and success level.

All case companies were informed three weeks in advance before the visit. The survey questionnaires were distributed on site. The questionnaires developed were checked by the two local university academicians who are specialist in the LM area and good manufacturing practices for pilot study before ready for field data collection. This validated that the SMEs' respondents comprehended the questions' context and ensured the results' trustworthiness. A total of 40 respondents from M&E SMEs were selected from executive-level and manager-level staff to answer the close-ended survey in the company premises. In the survey questionnaires, there is a total of three questions. These questions were formed based on a five-point Likert scale in order to gauge each variable's level of implementation. The scale was ranged from 1 to 5 where 1=very low, 2=low, 3=moderate, 4=high, and 5=very high. The respondents were briefed and requested to rate against the questions (variables) in assessing their agreement by given values ranging from 1 (lowest) to 5 (highest). During the site plant tours, the operation process on the production floor was examined to verify the respondents' replied. This is followed by descriptive analysis of the data collected using Microsoft Excel, and the results were tabulated for discussion.

Table 1. Case Studies Company Background Information.

Company name	A	B	C
Year of establishment	1990	2006	1997
Company ownership	Family own	Joint venture	Joint venture
No. of full-time employees	32	60	40
Year sales turnover (RM)	Within 5 million to 10 million range	Within 5 million to 10 million range	Within 10 million to 15 million range
Main products	Rubber machinery	Surface treatment	Industrial wires
Certifications/ achievements	SMEs SCORE 4 Star (2019)	ISO 9001:2015; AS9001; NADCAP; SME Award 2015	ISO 9001:2015; ISO 14001:2015
No. of years LM implementation	≈3 years	≈7 years	≈15 years
Manufacturing type	High mix low volume	High mix low volume	Low mix high volume
Type of M&E sub-sector	General industrial M&E parts	Specialized process in M&E agriculture	Specialized process in M&E aerospace

4. Survey Analysis of LM Maturity Level in the Case M&E SMEs

Most respondents of the case SMEs stated that the level of understanding towards LM in their company was only moderate (73%), while 13% indicated that it was at a high level. Likewise, the extent of LM implementation in the case companies was around 58% at a moderate level and 30% at a high level. Half of the total respondents claimed that the level of success towards LM implementation projects was at an intermediate level, and 30% agreed it was high. None of the respondents replied that the status of LM implementation maturity was very high. The extent of LM maturity of the three M&E cases was evaluated, as shown in Figure 1. In summary, the overall mean score achieved for the level of LM understanding in the M&E SME cases was found at low-to-moderate level (2.90), while the extent of LM implementation (3.15) and present success (3.08) is at a moderate level.

Employee involvement and the lack of appropriate lean subject matter knowledge and personnel skills, especially in SMEs, need to be emphasized as a key issue. In each case, the top management leadership teams support the lean initiative programs and are willing to allocate relevant resources to the project to ensure the LM implementation is successful. However, fundamental lean training on lean principles must be provided to all employees at the beginning stage of the project management and encourage them to practice the lean principles in the workplace. This will make the employees feel that what they have learned is valuable and can be applied

directly to achieve successful outcomes. However, the correlation for the respondents' perception in the context of the current lean adoption versus the actual real-life LM application in the case companies still needs to be practically validated via in-depth empirical study. From the results analysed, there was still much room for improvement to achieve a better performance in these three case companies towards mature lean organizations and readiness of LM implementation from end-to-end in a higher level for the long-term sustainability.

The study found a similar perception of LM in terms of understanding, implementation, and success level in these cases, echoing the literature review (Nordin et al., 2013; Punnakitikasem et al., 2012; Shah and Hussain, 2016). In general, lean applications in the case of SMEs are still fragmented and imbalanced. The current extent of LM implementation in these SMEs was far from being world-class.

Human factors (soft lean methods) are critical for SMEs (Mamat et al., 2015). Despite sufficient training provided, SMEs are usually unable to achieve the intended results of LM adoption ultimately. Staff needs to put their newly acquired abilities into action as fast as possible in order to build up and deepen their grasp of LM. This should be incorporated into the employee's performance management plan. Employees will value lean concepts more if they are connected to and convinced that LM will make their jobs easier. SMEs are often found to be overconfident in their abilities and capabilities to apply lean practices in one go (Rose et al., 2017). However, SMEs are unable to sustain massive losses in business due to their financial capacities. The

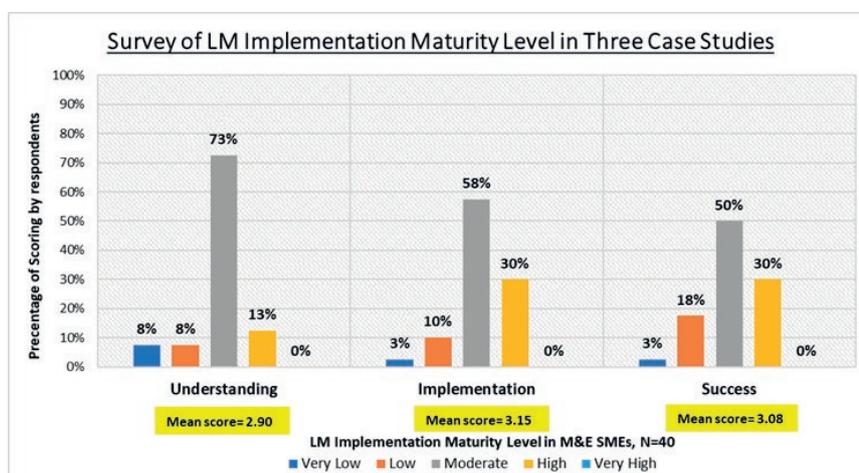


Figure 1. A Survey Analysis of LM Maturity Level.

LM adoption is obviously still not broad but rather restricted to specific parts of the organization with minimal success. The issue is common among SMEs that are dealing with more acute resource and LM skills limitations.

5. Development of LM Maturity Conceptual Model

The LM implementation maturity in M&E SMEs was assessed in the three critical dimensions: the level of LM understanding, the extent of LM implementation, and the LM implementation success level. All these three dimensions were investigated independently rather than together in previous studies. The analysis shows that the overall LM implementation maturity level in the M&E SMEs is low to moderate. This finding aligns with the research presented by [Yadav et al. \(2019b\)](#), which indicates that the lean implementation in SMEs are not explicit, as many SMEs have minimal understanding and knowledge in LM. The M&E SMEs respondents perceived that they have obtained the basic LM understanding and adopted the fundamental lean tools practices in a particular process application. However, the extent of LM implementation is still very limited or covered in specifically selected areas but not expand on a large scale at the entire organizational level. [Figure 2](#) shows the combination of these three dimensions and their integrated elements that formed the LM maturity conceptual model for enhancement.

From analysis, the success level achieved was fragmented, as there is still inconsistency of LM implementation in SMEs. SMEs management and lean practitioners can utilize this proposed model to gauge the status of LM maturity and define the right strategy to move on. [Abdallah et al. \(2021\)](#) stated that both social (human aspects) and technical (tools and techniques) LM were discovered to have a beneficial impact on operational performance in manufacturing SMEs. [Puvanasvaran et al. \(2015\)](#) performed a study of lean behavior in business development and information technology (IT) found out that the employees were lack of substantial lean implementation expertise and skillsets. The results revealed that employees' lean behaviour practices had been improved after adopting the lean tools. The strong connection of these dimensions, with the total commitment of employees from all organization levels, play an essential role to create a sustainable LM maturity culture for continuous improvement as follows:

- i. LM thinking improvement mindset – Right lean thinking and positive attitude can speed up the improvement efforts.
- ii. LM theory learning and application – The fundamental knowledge about lean concepts or principles of learning needs to be appropriately applied in the workplace for problem-solving.
- iii. LM key performance measurement – The relationship of key performance input variables

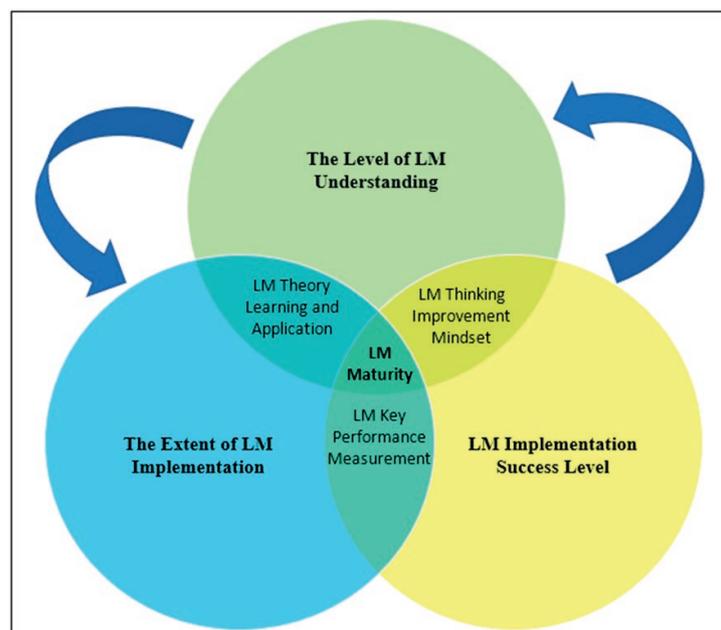


Figure 2. Conceptual Model of LM Maturity Level.

with process approach adoption aligned with key performance output variables (cost, quality, time, delivery, etc.) in LM result assessment.

Amrani et al. (2018) conducted the lean maturity assessment by calculating the leanness level divided into three categories: structural, organizational, and human metrics. The continuous improvement cycle is another essential component of this LM maturity model. Lean maturity evaluation process steps are an iterative cycle and an ongoing improvement journey. Thus, SMEs must practice the feasible lean tools to grasp the in-depth understanding and expand the LM implementation to other critical areas in order to achieve tremendous success at entire organizational level.

5.1. LM Thinking Improvement Mindset

The LM change management is essential as early readiness for all employees towards the cultural changes in SMEs. The creation of the LM environment and culture will build a positive lean thinking mindset towards a continuous improvement journey. The end in mind concept shall be instilled in every employee's mindset to visualize the LM success result in the future. Critical lean thinking has been introduced by Liker (2004) with emphasized the five key lean principles, which are: specify the value, mapping the value stream, creating flow, establishing pull, and pursuing perfection. The LM thinking involves eliminating the waste and creating value-added activities in fulfilling the customer's requirements. The application of lean thinking in SMEs can significantly improve organizational efficiency in India (Yadav et al., 2019a). The process-based approach and risk-based thinking can assist in identifying the top pareto of waste areas. The top management shall inform the strategic planning in the company and support the employees in working towards the common lean goals successfully. The current state of "As-Is" needs to define and the future state "To-Be" state in a lean roadmap established. The right LM thinking mindset will affect the employee's attitude and strive to achieve excellent job performance in LM implementation. Management is crucial in deciding an organization's success or failure. The management should always promote the benefits of LM and convince their employees of the significant implication of LM if they execute systematically. The employer can develop their employee and nurture the talents to unleash their workforce's limitless potential by instilling them with correct lean behaviours.

5.2. LM Theory Learning and Application

The LM theory learning is still very poor, especially in SMEs; this is due to the lack of an in-depth understanding of the real meaning of the lean concept. Belhadi et al. (2017a) stated that the true meaning of the lean theory and principles does not seem to be readily grasped or perceived by SMEs, which could be a major obstacle to achieving anticipated results. It is claimed that if stakeholders understand the lean benefits, they will be more inspired to implement the initiative (Yadav et al., 2019c). Many SMEs claimed that they already apply lean but without knowing that in detail. This caused them to apply the wrong lean tool and techniques in their workplace. The common barrier in LM implementation is the misuse or wrong application of LM tools practices. Belhadi et al. (2017a) claimed that the deficiency of tailored lean implementation approaches in the improvement programs always leads SMEs to a major problem in adapting the implementation process to suit their requirements. This always caused the LM initiative to fail and not able to deliver the intended results. SMEs should adopt suitable approaches in the LM application as not all the lean tools are appropriate to apply in SMEs. Puvanasvaran et al. (2010) proposed the People Development System (PDS) to improve the problem-solving capabilities among its staff while applying lean process management. The management should allocate the necessary resources and encourage the employee to upgrade their skills expertise in problem-solving. The management shall lead as a role model in cultivating the applied learning environment in the organization. The engagement of lean consultants will transfer the elementary knowledge for the employees in order to for them to be well prepared for the lean task assigned. The lean principles learned should have cross-link to their respective daily jobs perform in the workplaces and apply it directly to assess the effectiveness in problem-solving.

5.3. LM Key Performance Measurement

The proper selection of key performance measurement matrices is crucial to determine and assess the success level of LM implementation in SMEs. The more remarkable LM maturity level will create better operational performances. It has been found that after lean practices have been completely applied in the targeted areas with established key indicators, the intended results will be attained (Santos Bento and Tontini, 2018). The active involvement from all the employees will motivate each other and move

forward with teamwork. The individual or team performance in job competency and capability is strongly tied with the performance measurement in providing the rewards and promotion to higher-level jobs. Amrani et al. (2018) analyzed the leanness metrics across three elements: consistency, frequency, and relevancy to evaluate the advancement of lean implementation. The lean assessment can be carried out to assess the various key performances such as people, process, and technology for continuous improvement. The high involvement of employees in lean will increase LM implementation at the entire organizational level and create a solid lean culture. According to the findings from Galeazzo (2019), the degree of leanness is unrelated to financial performance, while lean maturity favorable influence on financial performance. Therefore, the key focuses on performance outcomes are cost, quality, and time, creating value-added to customers. The critical success factors for enhancing the LM implementation in SMEs need to be identified to improve the possibility of success. SMEs need to place the top pareto of waste areas with prioritization, as knowing that the SMEs have limited resource capability in lean project implementation. The selection of key performance input variables (process parameter setting) is vital to match with its corresponding key performance output variables (cost, quality, time, delivery, etc.), producing the quantifiable result in fulfilling the customer requirements with good product quality.

6. Conclusions

This study aims to assess the current maturity level of LM implementation, specifically in M&E SMEs.

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The findings from the three case studies revealed that the LM understanding level in the M&E SMEs is low to moderate. In contrast, the present LM implementation level and success level is still moderate. There are some critical challenges and inhibitors encountered during the LM adoption, especially on the human-related factors such as lean understanding knowledge adoption in enhancing employee's lean skills expertise application that needs to be focused thoroughly by top management. The LM maturity level in M&E SMEs is assessed in three dimensions combined with three essential integrated elements to form a conceptual model. The implication of the proposed model provides the strategy guidelines for M&E SME's lean practitioner and management level staff in prioritizing the available resources in enhancing the LM maturity sustainability to a higher level of success. The proper synchronization of LM understanding, implementation, and success are vital to building the strong LM maturity foundation towards the lean transformation in Industry 4.0 for M&E SMEs. The limitation of this study is this conceptual model is still not yet practically validated. It is suggested that it be applied in the actual case study to verify the effectiveness further. The correlation of the key elements presented can be expanded via statistical analysis to test the significance level of the relationship in future studies.

Acknowledgements

The authors would like to thank the SMEs case companies and Universiti Teknikal Malaysia Melaka (UTeM) as the research institution for their strong support in completing this study.

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