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EXPLORING CRITICAL SUCCESS FACTORS FOR THE IMPLEMENTATION OF LEAN MANUFACTURING IN MACHINERY AND EQUIPMENT SMES

CHONG JIA YUIK ^{ID} PUVANASVARAN A. PERUMAL ^{ID}
CHIN JENG FENG ^{ID}

ABSTRACT

This study aims to explore the predominant critical success factors (CSFs) for the implementation of lean manufacturing (LM) in small and medium-sized enterprises (SMEs) producing machinery and equipment (M&E). The convergent parallel mixed-methods (qualitative and quantitative) were employed in three Malaysian M&E manufacturing SMEs. The study identified four predominant CSFs that significantly impact on the LM application in M&E manufacturing SMEs, namely, leadership and commitment of the top management, training to upgrade skills and expertise, employee involvement and empowerment, and the development of LM implementation framework for SMEs. This study can assist the M&E manufacturing SMEs in prioritising these predominant CSFs so that the management teams can work on the improvement strategy and achieve a higher level of lean sustainability. It offers valuable insights into the LM implementation that could provide a practical reference guide to other industrial companies.

KEY WORDS

lean manufacturing, critical success factors, machinery and equipment, small and medium-sized enterprises

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Chong Jia Yuik

Universiti Teknikal Malaysia
Melaka, Malaysia
ORCID 0000-0003-3822-415X
Corresponding author:
e-mail: chongjiayuik@gmail.com

Puvanavar A. Perumal

Universiti Teknikal Malaysia
Melaka, Malaysia
ORCID 0000-0002-2144-6277

Chin Jeng Feng

Universiti Sains Malaysia, Malaysia
ORCID 0000-0002-9547-3673

INTRODUCTION

In Malaysia, small and medium-sized enterprises (SMEs) include firms with sales turnover below RM 50 million or the number of full-time employees below 200 (SME Corp. Malaysia, 2020). Manufactur-

ing SMEs always faced challenges in business sustainability and productivity as well as cost issues. Lean manufacturing (LM) is an effective management system which can help enterprises to create value-added activities and eliminate unnecessary waste (Achanga

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et al., 2006; Driouach et al., 2019; Womack et al., 1990). The LM system contributes to operational excellence and improves the quality services (Driouach et al., 2019; Liker, 2004; Shah & Ward, 2002; Ulewicz & Kucęba, 2016; Womack et al., 1990; Yahya et al., 2019). Despite its prevalence in large enterprises (Shah & Ward, 2002), several surveys showed inconsistent adoption across industries and countries (Abu et al., 2019; Khusaini et al., 2014; Nordin et al., 2013; Shah & Hussain, 2016). Many SMEs either have not adopted LM (Achanga et al., 2006) or still struggle to introduce LM into their processes (Driouach et al., 2019). Malaysian sectors manufacturing machinery and equipment (M&E) are classified into four major sub-sectors (Malaysian Investment Development Authority (MIDA), 2019):

- Specialised process machinery or equipment for a specific industry;
- Metalworking machinery;
- Power generating machinery and equipment;
- General industrial machinery & equipment, components, and parts.

M&E sectors in Malaysia have shown a tremendous contribution to the total export of RM 40.5 billion in the year 2018 and has seen a dramatic rise over the past five years. They are expecting to grow at an average annual growth rate of 4.1 per cent to reach RM 43 billion in 2020 (MIDA, 2019). However, the existing literature on LM adoption for M&E in Malaysia only amounts to 2.3%, which is very little as compared to the automotive industry with 37.1% (Osman et al., 2020). Therefore, this study aimed to explore the predominant critical success factors (CSFs) of LM in M&E manufacturing SMEs. Many CSFs, which had been discussed in the previous literature, are generic for all types of organisations. Nevertheless, they may exert different degrees of impact on SMEs depending on the company and industry. Therefore, proper identification of predominant CSFs is essential to increase the chance of success in LM adoption for SMEs. This study will help the management or lean practitioners of M&E manufacturing SMEs to prioritise predominant CSFs so that the lean committee can work on the suitable improvement strategy to move forward and become more sustainable in lean manufacturing. It will be beneficial for SMEs aiming to sustain business, profitability, and growth.

This paper has six sections: the first section introduces the LM adoption in M&E manufacturing SMEs and presents the problem statement. The second section discusses a structured literature review on LM

and CSFs for the implementation of LM in SMEs. The research methodology and description of the company profiles are presented in the third section. The fourth section contains the data analysis, which is followed by a discussion of the results in the fifth section. Finally, the last section states the conclusions, implications, and recommendations for future research efforts.

1. LITERATURE REVIEW

LM originated in Toyota Production System (Ohno, 1988) and was later popularised by Womack et al. (1990) in their book “The Machine That Changed the World”. The essence of the concept is to eliminate non-value-added activities, generally referred to as waste. Ohno (1988) derived seven forms of wastes, which are overproduction, waiting, transportation, excess processing, inventories, motion, and defects. According to Liker (2004), three primary sources of wastes in production are Muda (waste), Mura (unevenness), and Muri (overburden). Womack & Jones (2003) proposed five underpinning lean principles. They start with identifying the value from the voice of the customer and mapping the value stream which specifies the process creating the value; the process should run in a continuous flow to deliver a quality product just in time to the customer; a pull system is used to prevent any overproduction and, finally, the system must be continuously improved in the pursuit of perfection. It is essential to understand these principles well before starting to implement LM (Bakar et al., 2017; Wong & Wong, 2011a, Wielki & Koziol, 2018). The most substantial challenge encountered by SMEs is to know which principles, tools and practices to implement and how to apply them effectively (Belhadi et al., 2016). People are a critical factor in LM, and having adopted the right approach of “think lean” and “act lean”, they form the essential three constructs that support the LM implementation (Wong & Wong, 2011a). Toyota Production System had strongly emphasised the principle of “respect for people” as an essential element for organisations when embarking on an LM programme (Liker, 2004).

CSFs are defined as the limited number of areas in which satisfactory results ensure successful competitive performance (Griffin, 1995). The structured literature review intends to study CSFs for the LM implementation in SMEs. The materials dated 2016–2019 were searched and adopted from online knowl-

edge database sources, such as Google Scholar, Science Direct, ResearchGate, Scopus and Emerald. The main keywords used to search the study area included: “lean manufacturing”, “lean”, “critical success factors”, “SMEs”, and “implementation”. The papers were examined and sorted to ensure the contents matched the research topic. Other irrelevant papers, such as “lean six sigma”, were filtered out, leaving only those that discussed “lean” or “lean manufacturing” topics. As a result, 17 journal articles focused explicitly on SMEs were selected. The LM implementation would move progressively with a strong knowledge of lean philosophy and lean tools (Almanei et al., 2017). Management knowledge is extremely significant in the LM implementation for SMEs (Pearce et al., 2018), as strong management knowledge can buy-in the lean project idea confidently and strengthen the knowledge gaps for their employees to foster lean implementation. Jani & Desai (2016) concluded that management commitment towards the lean concept was essential to ensure

that a project or activity achieved management objectives with the right direction of business growth. According to some authors, the LM implementation always faces minor support from the top management, resistance to change by the middle management, and weak or non-qualified lean training programmes (Viagi et al., 2017). Every management level in SMEs is playing an essential role in connecting each other with great teamwork to encourage employee involvement in the lean project. Experienced employees with lean expertise can become the driver for the LM implementation and produce sustainable lean results. The criticality of success factors is progression-dependent and needs a more dynamic model of lean implementation (Knol et al., 2018). Prioritisation of the sequence order of these factors during every different stage of the LM implementation can increase the chances of success. The introduction of the lean through the change in organisational culture is critical, and SME owners or managers need to make sure that this is a part of

Tab. 1. CSFs for the LM implementation in SMEs

CSFs FOR THE LM IMPLEMENTATION IN SMEs	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Lean knowledge and experiences of the managers		x	x							x	x						
Leadership and commitment of the top management	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Resource capability (financial, time, workforce)	x	x	x	x	x	x		x	x	x	x		x		x	x	x
Change in the organisational culture	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x
Understanding of lean tools and knowledge	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x
Employee involvement, empowerment, and motivation	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
External support from consultants	x	x	x			x			x		x						x
Training, education, and skills	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Effective communication	x			x	x	x	x	x					x	x	x		
Customer focus	x			x		x			x		x		x			x	x
LM implementation strategy plan, goal and vision	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Performance management system			x	x	x	x		x					x		x		
Technology resource								x		x	x						x
Government intervention	x								x	x							
Supplier management			x	x		x			x				x		x	x	x
Project management and planning			x			x		x						x	x	x	

Note: A (Almanei et al., 2017); B (Pearce et al., 2018); C (Viagi et al., 2017); D (Knol et al., 2018); E (Alkhorraif et al., 2019); F (Belhadi et al., 2019); G (Pereira & Tortorella, 2018); H (Driouach et al., 2019); I (Belhadi et al., 2018b); J (Nyoni & Bonga, 2018); K (Grigg et al., 2018); L (Belhadi et al., 2017); M (Jani & Desai, 2016); N (Elkhairi et al., 2019); O (Siegel et al., 2019); P (Sahoo, 2018); Q (Belhadi et al., 2018a)

critical considerations in the lean transformation strategy (Alkhorraif et al., 2019). The change in organisational culture must have a reasonable timeline to deal with the resistance among employees and to provide them with more chances to get familiar with the changes that occur in the lean transition period.

Belhadi et al. (2019) prioritised CSFs using the analytical hierarchy process (AHP) method and showed that the “policy, leadership and management” category was the most significant for SMEs in the LM implementation. Sahoo (2018) revealed that the alignment to strategy and long-term planning was the most critical factor in determining a successful lean project. Therefore, the management shall demonstrate their strong leadership commitment by establishing the lean policy and overall LM implementation strategy framework direction for other employees to meet the objectives. The CSFs, barriers and lean tools or practices of the processes should be integrated into the LM implementation framework in SMEs (Driouach et al., 2019; Pereira & Tortorella, 2018). The Sustainable Lean Iceberg Model was used to present the vitality of “strategy and alignment”, “leadership” and “behaviour and engagement” (Grigg et al., 2018). This clearly showed that the sustainability of the LM implementation in SMEs mainly depended on the top management leadership commitment as well as the LM implementation strategy direction which aligns with the company goal, and the employee attitude and involvement. Employee engagement and the understanding of lean tools and skills can be enhanced through the provision of intensive training. Excellent communication is vital for lean practices because improvements always require active two-way interaction among colleagues, especially when focusing on shop-floor activities (Knol et al., 2018). The lean consultant with a superb knowledge of the subject can avoid confusion in the LM implementation (Almanei et al., 2017). Siegel et al. (2019) stated that employee involvement, management commitment, and measurement and metrics are the essential factors for the success of Green-Lean implementation. The CSFs from the discussed articles (Table 1) show that by employing these factors in the LM implementation journey, SMEs could move progressively towards the success of the lean transformation. Symbol “x” indicates that the CSFs were included in the article’s content. The predominant CSFs that are important for the LM implementation in SMEs (Table 1) were identified, i.e., leadership and commitment of the top management, employee involvement

and empowerment, lean training and education for employees to acquire the specific skillset, and the development of LM implementation framework. These top four predominant CSFs were selected for further investigation in the studied case of M&E manufacturing SMEs.

2. RESEARCH METHOD

Only the M&E companies that corresponded to definitions of the Malaysian manufacturing SMEs were eligible for this study. This research was conducted by using a multi-case study to analyse the selected companies expressing the high interest and willingness to participate. The method of multiple case studies could be used for a good comparison of the common similarity and main differences among the M&E manufacturing SMEs on their LM implementation perspectives and experiences (Creswell, 2014). The general profile of the analysed companies is shown in Table 2. The three analysed companies from the targeted M&E sub-sectors were chosen using the purposive sampling method, as they could provide the information required to achieve the study objective. All companies were operational for more than ten years with different degrees of the LM implementation.

The percentage of research methods used to investigate the LM implementation in SMEs by Alkhorraif et al. (2019) showed that multiple case studies and mixed-methods only consisted of 11% and 7%, respectively, as compared to the single case study (34%) and survey (30%). Osman et al. (2020) presented that most literature on LM research in Malaysia were empirical articles, mostly with survey studies (42%) as compared to mixed methods (2%). Therefore, convergent parallel mixed-methods (qualitative and quantitative) research was employed in the case of the three M&E companies to provide a comprehensive analysis of the research problems and increase the accuracy of the results. The qualitative study was carried out by using the semi-structured open-ended interview. Ainul Azyan et al. (2017) developed the interview questionnaires to identify success factors and barriers faced in implementing lean in the printing industry. The respondents in the case study were asked about their barriers faced in the LM implementation and CSFs in a structured manner. The interview questionnaires were revised and adapted from Ainul Azyan et al. (2017) to match the purpose of this study.

The interview questionnaires were divided into two sections:

- the general company background and the respondent's profile;
- the predominant lean CSFs and barriers.

All companies were notified at least three weeks in advance before the visit. The interview protocol was emailed to them for reference preparation. Prior to interviews, the questionnaires were verified by two local university lecturers who are experts in the best practice of LM and manufacturing. This was done to confirm that the SME respondents would understand the meaning of the questions and ensure the reliability of the obtained results. Each analysed company was represented by three employees (Table 3) selected from the management level to participate in the face-to-face interview in their premises. This was done to ensure the insight could be more comprehensive and generalise from different levels of the organisations.

Each interview session was conducted within one to two hours on different days due to a tight schedule and completed in around 3.5 months. The respondents were initially briefed about the interview protocol and were also provided with a copy of the questionnaire for reference. The interviews were audio-recorded and transcribed during data collection for analysis with the permission of the respondents. A total of 40 targeted case respondents were chosen to answer the quantitative survey from execu-

tive-level staff in the first visit. In the survey questionnaires, there were a total of four closed-ended 5-point Likert questions. The respondents were asked to rate answers to the questions (variables) by measuring their agreement using values ranging between 1 (lowest) and 5 (highest). Additionally, the manufacturing process on the production floor was observed. Site plant tours were also arranged for verification of responses from respondents as well as for the overall picture of the work environment and operation systems.

3. RESEARCH RESULTS

Company A has been mainly producing rubber machinery since 1990. It provides the design and installation of natural rubber processing machinery according to customer needs, primarily focusing on automation. This has dramatically reduced labour demand and improved productivity. Basic 5S and visual display have been implemented in the company, but the result was considered far from the expectation. Middle management responded that the shop floor operators were not familiar with the LM philosophy and did not possess the relevant know-how and skills to execute the lean application. For example, the production line leader and shop floor employees still did not know how to initiate the lean

Tab. 2. Profile information of companies included in the study

COMPANY NAME	A	B	C
Establishment year	1990	2006	1997
Company ownership	Family own	Joint venture	Joint venture
No. of full-time employees	32	60	40
Year sales turnover (RM)	Within a range of 5–10 million	Within a range of 5–10 million	Within a range of 10–15 million
Main products	Rubbery machinery	Surface treatment	Industrial wires
Certifications/achievements	Achieved SMEs SCORE 4 star (2019)	ISO 9001:2015; AS9001; NAD-CAP; SME Award 2015	ISO 9001:2015; ISO 14001:2015
No. of years of the LM implementation	≈3 years	≈7 years	≈15 years
Production type	High mix low volume	High mix low volume	Low mix high volume
Type of an M&E sub-sector	General industrial M&E parts	Specialised process in M&E agriculture	Specialised process in M&E aerospace

Tab. 3. Designation and management level of interviewed respondents

COMPANY/RESPONDENTS	A	B	C
Senior management	Senior engineering manager	Senior factory manager	General manager
Middle management	Research & development manager	Planner	Business manager
Lower management	Finance executive	Quality engineer	Quality executive

implementation, project selection, who was the primary responsible person to be involved and so on. The lower management revealed that there was no regular daily production meeting conducted which consisted of the management level staff and shop floor employees to discuss the problems faced during the LM implementation and communicate their opinions for solutions. There was a lack of lean strategic planning and policy enforcement from the senior management level in overseeing the LM implementation. The critical challenges faced by the company during the 5S programme implementation came from the employee attitude and the lack of a lean mindset from the middle management's perspective. The shop floor employees mainly intended to complete the work within the scope of their responsibility, therefore neglecting the LM implementation. Resistance to change by employees caused the lean initiative to fail prematurely. Middle management revealed that the lack of employee motivation and self-initiative to involve in the lean project entailed inconsistent results. For instance, the production technicians were still unable to perform their job satisfactorily if the intention of LM was ignored. Lean projects were deployed ad-hoc by taking short-term measures whenever production problem emerged and always caught into the fire-fighting mode. This often inadvertently led to the creation of other wastes. For example, 5S was implemented since 2018 in the equipment store, which resulted in the significant waiting time during operation by maintenance employees rummaging for tools. However, continuous improvement mechanisms and leader standard work were not in place to regulate the 5S system. Most of the shop floor employees practised the basic 5S, especially in the first 3S: Sort, Set in Order and Shine without a deep understanding of the lean concept purposes. The most important of the last "2S" in 5S — Standardise and Sustain — were not adequately followed up with consistent execution during the lean implementation due to the lack of persistent and low commitment to seek continuous improvement. Senior management highlighted that there was an urgent need to have the systematic LM implementation strategy framework in-place and initiate formal intensive 5S training to involve all the employees. Only very few job training sessions were related to LM previously; therefore, senior management feedback that lean training was vital to upgrade the employee knowledge towards the build-up of the lean thinking mindset and application in the workplace. LM projects are usually initiated using the top-down

approach from senior management. Middle management leads the lean project as assigned, and then lower management works with the shop floor employees in execution parts based on the given instructions. There is no specific step-by-step process framework planning to follow for the lean project implementation. There is no synchronisation in the common objectives between the management and the shop floor employees, and this caused the lean results to end up not able to meet the expected outcomes. While the LM implementation was sparse in the company A, the top management hoped the concept could bring positive transformation to productivity, working culture and skill competency. The company strategy clearly outlined the plan to strengthen the lean foundation, followed by the incorporation of automation.

Company B is a total solution with a full-service custom metal finishing company with many years of experience in the surface treatment industry. The company specialises in surface finishing for aluminium and anodising of aluminium alloys and other ferrous or non-ferrous electroplating. It owns a land plot of 72 000 square feet with a wide range of process capabilities for various industries, including the aerospace sector. The operating level staff, mostly fresh to the lean concept, naturally required more time to acquire the knowledge. The implemented lean tools include kaizen, Gemba, one-point lesson (OPL), 5S, visual control, standard operation procedure (SOP), and statistical process control (SPC). Company B started LM on a small scale and gradually expanded the proven practice across the plant. Top management showed excellent leadership by introducing many new LM ideas sourced from external parties, such as competitors and customers. The factory manager oversaw the entire LM implementation, and the LM project was led by the respective managerial level staff with cross-functional team collaboration between each relevant department. The lean project management included planning the required timeline and resources for implementation. The company B would typically use the current resources in LM implementation unless the lean project was justifiable for the return of investment (ROI), and this was also subject to the approval of the top management. It actively identified the opportunity for improvement through the lean foundation established many years ago. For example, the SPC was implemented in 2014, which was incorporated with the process automation at the in-house testing laboratory to monitor the chemical process mixture and concentration-related

parameters. Besides, shop floor operators also monitored the trend performance of daily critical process yields using the online SPC chart, and the technician performed troubleshooting whenever the machine detected any abnormality. The top management reviewed the progress of lean projects and discussed the next stage of action. The top management was always open to employees for discussion, and any good suggestions or ideas were appreciated. The middle management highlighted that the employees were practising the new knowledge by applying it in their work independently, following the step-by-step guidance from experienced senior staff. Job rotation was applied as an opportunity to improve the lean knowledge skills of employees and to ensure their self-development. High involvement of employees and the achieved results in the LM implementation improvement projects were also related to the assessment criterion of key performance indicators. The latest challenges faced by the company were lean sustainability and transformation at the juncture of Industrial Revolution 4.0 and smart manufacturing. They looked for highly skilled employees with adequate lean knowledge to manage advanced manufacturing technology and machine digitisation. Barriers faced by the management were human-related, by and large. Low-level shop floor staff resisted lean practices and often made avoidable mistakes. Comprehensive lean training and coaching programs in OPL and SOP were conducted periodically by internal trainers. Besides, lean projects and employee contributions were monitored closely. The management demonstrated its commitment by regularly reviewing lean status and clarified strategy of execution to employees. The prevalence of LM in the organisation was mostly constrained to certain production areas. LM was driven by organisational key performance indicators (KPI), assessed through quantifiable data.

Company C was established in the year 1997 to manufacture industrial wire. It has a good set up of M&E, which provides the advantage of producing the wire as specified by the customers with a different type of imported machines. Company C exports the wire to more than ten countries in the world with a guarantee for the quality, quantity, and the service. The lower management highlighted that lean knowledge of the shop floor operators was relatively shallow during the recruitment as most of them were foreigners with language barriers and diverse educational backgrounds. The higher-level operational staff, such as executives, also lacked a more in-depth lean con-

cept to complete their jobs effectively. For example, the engineers faced difficulties in specifying the value stream of the wire winding process mapping to create a smooth flow. Each employee had strengths in their field of expertise but no lean-specific knowledge. The right selection of lean tools is essential for problem-solving and the cost of quality improvement. Lean tools and practices adopted by the company were kaizen, Gemba, 5S, visual display, SOP and work instruction as part of their ISO management system requirements. Company C started the LM implementation in 2004, in tandem with their pursuit of certification for the ISO 9001 quality management system. The defect of products was the primary form of wastes to influence the lean project selection. Major defective products, such as rejects due to wire entanglement, would be returned to the company by the customer for sorting and rework, and this caused considerable productivity loss and cost of quality. The company lacked experienced lean personnel to train the workers internally in lean-related skills. The training was conducted in response to the critical quality issues on hand, with an emphasis on lean awareness and preventive measures. Internal meetings were called to discuss the non-conformance issues and brainstorm for practical solutions. The supervisor communicated the steps-by-steps guidance to the relevant operators by following the SOP documents with practical demonstration until there was clear understanding. The SOP was in place to ensure the prescribed steps were followed during operation. The senior management showed excellent leadership by allocating the necessary resources, such as finance, time, workforce, and facility for the LM implementation. The LM implementation was led by middle management with the relevant executive staff to monitor the implemented system. A lean committee was formed to plan the LM implementation and assess the risks before seeking the approval of the top management to release. The lean status was reviewed by the senior management as a key decision-maker to make the final call, and the approved procedures were documented. Despite promising results in the lean implementation, standardisations of the lean management system were limited. Some shop floor employees thought that lean was not needed for them, and they did not pay much attention to lean due to the tight production schedule. Employees were likely to revert to old habits due to the lack of motivation, resulting in an eventual setback of the initiative. The top management addressed the challenge by sustaining the LM working culture. Shop floor

employees needed to be continuously reminded of performing the work following the SOP properly and creating lean initiatives to resolve problems. The middle management underlined the importance for managers to lead by example in the LM implementation aiming to cultivate teamwork and positive change in the working culture. The senior management believed that the encouragement, motivation, performance review with rewards, training and communication could improve employee capability to perform their jobs. The senior management also underlined the integration of the lean management system into daily work to effectively deal with production problems and add value to customers. Aiming to gauge the success of the LM implementation, CSFs highly depend on strong employee teamwork and high involvement, integration of a lean thinking mindset into the working environment as well as following the SOP aligned with the system requirement and outline of the LM implementation framework. The management team was very committed to achieving lean success through workforce skill transformation in alignment with the company strategy to get customer recognition. As quoted from senior management: “Lean is the backbone for the company, which must always underlie and be in line with the daily jobs in the business management”.

The hypothesis testing was undertaken to determine whether the outcomes of these four predominant CSFs from the literature review were essential in contributing to the implementation of LM for the analysed SMEs.

Null hypothesis: There are no significant differences for CSFs on the importance level in the LM implementation.

Research hypothesis: There are significant differences of CSFs on the importance level in the LM implementation.

Conducting the Kruskal–Wallis test on independent samples, the tested significance level was at 0.589, which is more than the chosen p-value at 0.05. Therefore, the null hypothesis was retained, and the result showed that there were no significant differences for all four CSFs on the critical level in the LM implementation. The distribution of the significance level was the same across all categories of these factors. The mean ranked values showed that in the population where the sample was drawn, training (86.61) was the most important factor, followed by the leadership and commitment of the top management (83.46). These findings were aligned, indicating that the commitment of the top management and employee involvement were crucial factors and, therefore, they must be embedded during lean implementation process steps (Belhadi et al., 2017; Jani & Desai, 2016). Meanwhile, the LM implementation framework development specifically designed for SMEs, and employee involvement and empowerment had comparable scores with means between 76.49 and 75.44, respectively. In short, all these four identified predominant CSFs showed the importance and had a significant impact on lean adoption in SMEs, as shown in Fig. 1.

Kruskal-Wallis Test		
Ranks		
Factors	N	Mean Rank
Important		
Top management leadership commitment	40	83.46
Training education (skill expertises)	40	86.61
Employee involvement and empowerment	40	75.44
Lean manufacturing implementation framework	40	76.49
Total	160	

Test Statistics ^{a,b}	
	Important
Chi-Square	1.919
df	3
Asymp. Sig.	.589

a. Kruskal Wallis Test
b. Grouping Variable: Factors

Fig. 1. Kruskal–Wallis test for predominant CSFs on importance of the LM implementation

4. DISCUSSION OF THE RESULTS

Soft lean practices (human-related aspects) are essential to SMEs (Mamat et al., 2015) and they encompass human resource management, employee motivation, lean training, ethics and professionalism (Abu et al., 2019; Antosz & Stadnicka, 2017; Nordin et al., 2013). Even with an adequate provision of training, SMEs were often unable to deliver the result in LM fully. Staff must practise the learned skills on time, to reinforce and enhance their understanding of LM as a part of a knowledge retention strategy. SMEs find themselves overambitious to embrace lean principles all at once (Grigg et al., 2018; Rose et al., 2017). Employees appreciate lean practice more when it is linked to their daily tasks and convincingly make them easier. The studied SMEs emphasised the critical defect waste of the product as one of the major focus areas in lean project prioritisation. SMEs have a high concern that a customer complaint regarding rejected products that do not meet the requirements would directly affect customer satisfaction and cause long-term business market loss. Returned defective products require rework or end up as scrap, increasing the cost of quality and impacting the production efficiency. SMEs could not afford to have significant financial losses. LM was not widespread but rather restricted to specific areas of the company. The phenomenon was typical to SMEs having a more immediate concern with the constraint of the resource.

Ultimately, sustaining LM aims to realise the lean culture in the organisation (Caldera et al., 2019). Rose et al. (2013) showed the prevalence of 5S, standardisation and kaizen among SMEs operating in the Malaysian industry of automotive components. Similar undertakings were observed in these case studies. Kaizen has been implemented as the team-based collective initiative and strategic management towards the incremental improvement in the critical manufacturing processes of the SMEs. Simple visual management tools, such as display board and signboard, were used as an effective communication tool to convey quick and clear messages to the employees SMEs. The management staff of analysed SMEs were willing to have Gemba walk with the employees to have a first-hand understanding of the real issues occurring on the production floor and immediately discuss the next action plans to solve the problems. This was aligned with the SME characteristics, in which the simple system structure allowed faster communication and facilitated quick decision-making

in the LM implementation process (Yusof & Aspinwall, 2000). SMEs preferred lean practices with the least financial investment and fundamental to LM (Rose et al., 2011). However, many small firms lack knowledge regarding lean methods (Matt & Rauch, 2013). For example, the analysed SMEs perceived that lean practices were applied in the organisations, but they were still unfamiliar with the actual lean terminology and lean principles. This conclusion aligns with the findings by Ulewicz & Kucęba (2016), who stated that a major challenge was the lack of knowledge of the techniques and tools used in lean. The intermediate or advanced lean tools, such as small lot sizes, continuous flow, value stream mapping and so on, which are already used by large companies, are still ineffectively introduced into the SME production systems. No specific framework or roadmap exists to guide the analysed companies in the LM implementation. They implement lean tools using different methodologies and unsystematically. Regardless of the perceived level of understanding in LM, SMEs often failed to demonstrate the concept during actual implementation (Kherbach et al., 2019). Wong & Wong (2011b) stressed the prerequisite for an organisation to have its staff adequately immersed in lean thinking and acting to succeed in the lean initiative. Shop floor employees should always transfer lean knowledge into the know-how practice (“act lean”). The primary barrier to lean adoption is the worker attitude or their resistance to change (Chan et al., 2019). An employee should have a positive attitude towards the adoption of LM, in addition to the nurtured desire for a continuous improvement. The case studies of SMEs explored the perception of the determinant CSFs from the interviewee’s perspective (Table 4). The rank order was determined based on how many times a critical success factor was referred to during the interview sessions and highly stressed by the interviewees. The categorisation of each level was indicated as H — High, M — Medium, and L — Low.

The leadership and commitment of the top management are pivotal in LM (Gandhi et al., 2018), as well as training and encouragement of employees. The top management supports a lean management system, restructures organisation accordingly, sets the strategic direction, and communicates the lean policy effectively to all employees. The top management must lead by example and render unwavering support (and resource allocation) to lean initiatives. The top management should act as a “change agent” in the company and convince others of the lean ben-

Tab. 4. SME perception of the determinant CSFs

COMPANY NAME/SME PERCEPTION OF THE DETERMINANT CSFS	A	B	C
Lean knowledge and experiences of the managers	L	M	M
Leadership and commitment of the top management	H	H	H
Resource capability (financial, time, workforce)	H	H	H
Change in the organisational culture	H	H	H
Understanding of lean tools, employee knowledge	H	H	H
Employee involvement, empowerment	H	H	H
External support from consultants	L	L	L
Training, education and skills	H	H	H
Effective communication	M	M	H
Customer focus	H	H	H
LM implementation strategy plan, goal, vision	H	H	H
Performance management system	L	H	M
Technology resource	L	M	L
Government intervention	H	M	M
Supplier management	L	M	M
Project management and planning	M	M	H

efits. It is essential for companies to identify a motivated “change agent” who can serve as a catalyst for change (Dora et al., 2016). This includes empowering employees by giving them responsibility for the LM implementation. All respondents of the analysed companies were in high agreement that the leadership and commitment of the top management were the primary determinants for the success of the LM implementation in their companies. To quote the quality executive from company C: “The top management will provide the strategic direction, advise and resource commitment (including financial support for training and facilities) to staff in the LM implementation”.

The voice of customers was emphasised by the analysed companies as critical. It is the key determinant of the business market growth, which places it in the centre of attention. Indeed, LM aims to create value-added products or services for customers that they are willing to pay for. In contrast, this finding is opposite to the conclusion by Belhadi et al. (2019), who started the priority list with the lowest critical success factor “market, customers and suppliers”. One of the advantages of SMEs is their better understanding of customer needs and the ability to respond quickly to immediate customer feedback (Yusof & Aspinwall, 2000). York & Danes (2014) presented a review of the customer development model for entrepreneurial activities to improve decision-making within the lean startup for new product development. According to the business marketing manager

in company C: “The motivation of lean adoption is to satisfy the customer’s requirements and to get their recognition. It will be more advantageous for SMEs to survive in the global business market competition if SMEs are able to adopt the lean idea recommended or specially required by the customers. The customer’s valuable feedback at the early new product development stage is essential for the continuous internal lean improvement in achieving the smooth run of the mass production later”.

Resource capabilities, such as finance, time and workforce, are instrumental for SMEs in the LM implementation. SMEs often face the capabilities of the resources due to cash flow issues and high operating costs. Therefore, SMEs should utilise the resources wisely and effectively, with the measurable return of investment. Financial inadequacy is a major challenge in lean adoption and affects the implementation of LM within SMEs (Achanga et al., 2006). For example, neither of the three SMEs hire lean consultants to conduct training for the guided implementation due to the lack of urgency. SMEs focused on settling the major issues faced on the production shop floor first, which were already known to them before they need to consider hiring a consultant. A quality engineer in company B said: “Due to the low workload and small capacity in SMEs compared with other large organisations, it is not justifiable to allocate the budget for hiring a lean consultant to be fully and only in-charge of the lean project”. The lack of low-level operators is the constraint for SMEs due to high

overhead fees for foreign workers and the high turnover rate for the contract workers. This hinders the progress of the LM implementation in SMEs due to the shortage of the workforce. Lean project planning is essential to avoid any disruption to the shop floor during the implementation, especially the time when SMEs need to meet the production deadline. As a senior factory manager from company B said: “We have to slow down the productivity and arranged extra workforce and overtime to ensure the shop floor employees can attend the lean training. Meanwhile, the company must plan wisely in annual budgeting to purchase the upgrade of automation equipment for the lean integrated system in SPC and so on, to optimise the labour force utilisation and improve productivity”.

High-performing companies are those with a sustainable lean culture and proactive improvement (Achanga et al., 2006). SMEs should always promote communication with all levels of employees regarding the critical need for early lean transformation. The drastic method is least preferred at the initial stage, as the employee resistance to change easily offsets any effort. Lean culture needs stimulation from the lean-minded leadership; therefore, companies should coach their leader at any level to support the lean culture (Azuan et al., 2017). One of the characteristics for SMEs is the corporate mindset, which is conducive for new change initiatives and behaviour of employees as influenced by the owner or manager (Yusof & Aspinwall, 2000). SMEs can be relatively flexible in their operations compared to large companies (Majava & Ojanperä, 2017). Therefore, the top management of SMEs can adopt the flexibility in the lean change management system to motivate positive thinking among the employees and cultivate the high awareness towards the readiness for the lean implementation. The general manager from company C claimed that: “Flexible change management system should be more practically adapted to suit the need for organisational culture and the situational level to facilitate the lean transformation”.

Most SMEs employ people with relatively low skills and do not foster the ideology of skill enhancement (Achanga et al., 2006). Language barriers faced, especially of foreign workers, can be solved via effective communication by using simple words translation and visual aid tools, such as videos to increase their understanding. Although most shop-floor staff members saw the lean benefits, there was still a general lack of lean knowledge among them (Grigg et al., 2018). For example, company A highlighted that it

was hard to recruit qualified staff, as graduates of polytechnic schools were insufficiently competent to perform the hands-on lean tasks such as preventive maintenance. There is a visible gap between the skills acquired through formal learning in connection with the industrial applications. Small enterprises should work with the public and private associations on an integrated know-how transfer through cross-collaboration such as training, further education, internship, consulting service and coaching to close the gaps (Matt & Rauch, 2013). Company C also engaged internship students and assigned them with some lean projects especially in machine utilisation during the industrial training period, as the management wanted to know the perspective of outsiders regarding the possibility to expedite the improvement. The teamwork between the internship students and the shop floor employees in a small group can enhance their lean skills through the exchange of in-depth knowledge. Lean knowledge transfer in SMEs is significant for ensuring the success of lean management implementation (Mohd Zahari, 2019). SMEs should train their employees to become experts on the lean subject matter and act as drivers to propagate lean knowledge to others within the organisation. The selected lean trainer should be certified in lean expertise areas and use the opportunity to become a lean coordinator by expanding the knowledge. SMEs also optimise the training fund in tax rebates from government agencies, such as the Human Resources Development Fund (HRDM), to send their employees to external training courses. As a senior engineering manager from company A said: “The technical application knowledge in lean projects can be enhanced with the training grant support from the government sectors and through cross-collaboration with the higher learning institution in terms of knowledge exchange or sharing of lean experiences”. The lack of expertise observed in SMEs produces the main conflict with the LM management principles (Moeuf et al., 2016). Shop floor employees could build strong lean knowledge, including technical know-how through intensive training. A finance executive from company A mentioned that: “The majority of the production workers in the company are low-skilled and come from different industries. Extensive internal lean training is essential for upgrading their expertise to handle the job independently”. The fundamental training on lean philosophy must be conducted to stimulate the lean awareness (“think lean”) of employees during the pre-implementation stage and make them practice the lean

principles through “act lean” in their workplaces. SMEs must be proactive in conducting the training which concentrates on early detection approaches and adopts preventive measures on the production quality issues. SMEs must develop a comprehensive lean training plan for staff which covers introduction courses during job orientation, training matrix, regular training program and a formal training assessment method. Employee training should be incorporated into promotion criteria.

The involvement of people is a crucial element in the LM implementation. However, some employees have a misunderstanding of the lean concept and think that lean is unnecessary for them. Thus, SMEs should convince their employees to believe that lean change is required, and it can improve their working aspects. Employees should be given enough lean concept training first at the initial stage before they practically apply the lean tools directly at their workplaces. Some employees have a negative perception that LM brings an extra burden to their current workload. The management should explain the objectives and advantages of lean to let the employees feel and view the dominant effect on lean. Lean involves teamwork support and responsible commitment of employees towards the common goals. The lower management staff who are the connection bridge to the shop floor employees must buy-in the lean initiatives and promote the improvements to others. This fosters the acceptance and participation of shop floor employees in lean adoption. Roslin et al. (2019) suggested that an organisation could build trust and mutual interest to increase employee involvement and empowerment. A good start for lean implementation with excellent results can change the employee mindset and give the momentum to move forward. Lean is not about a quick fix to problems; it needs a desire for continuous improvement from employees. To quote a research & development manager from company A: “One of the factors for the lack of shop floor employee involvement in lean is their lack of confidence in lean. Thus, the company is responsible for understanding employee concerns, motivating them to apply lean practices in their initiatives and acknowledging their efforts”.

There is no specific roadmap to implement lean as it needs to be matched with each organisation’s culture (Almanei et al., 2017). The critical drivers to enhance the LM adoption are the improvement of shop-floor management, quality management, and manufacturing strategy (Yadav et al., 2019). SMEs need to have a systematic LM implementation frame-

work planning first before actual implementation and ensure that a proper execution by shop-floor employees is managed carefully with right lean tools used to achieve the high quality of lean success at the end. The development of a useful LM implementation framework for SMEs can help them in standardising and sustaining the lean with high efficiencies in waste elimination. Shelleman & Shields (2014) provided an easily feasible and practical framework, by which SMEs can start designing a sustainable development plan to incorporate sustainability considerations. SMEs should explore the right methodology for the LM adoption to suit their business nature and match it with the SMEs characteristic features in terms of their strengths and weaknesses. To quote a planner from company B: “A good LM implementation framework can be used as guideline references for SMEs to plan and follow the important steps through the systematic working instructions formed, and it should be adaptable to suit a different company culture”.

CONCLUSIONS

There are some difficulties or barriers faced during the implementation, especially human-related issues, such as the adoption of lean understanding knowledge for the enhancement of employee expertise in lean skills, that need to be addressed seriously by the top management. Several predominant CSFs were identified, which impacted the LM implementation in the studied SMEs. M&E manufacturing SMEs must emphasise much on these CSFs during their lean implementation stages to increase the chances of success. The SME management teams have shown a commitment and high interest in the LM implementation in their organisation. M&E manufacturing SMEs firstly need to gain an exceptional understanding of the lean philosophy culture and only then adapt the systematic methodology of the integrated lean management system to suit the company’s strategic goals. A comprehensive understanding of these CSFs would help organisations who would like to apply lean principles (Kundu & Murali Manohar, 2012). The level of success of the LM application is mainly dependent on strong support from the top management leadership and active involvement from all levels of employees in SMEs with those necessary lean resources provided, such as extensive training and effective LM framework planning. Lean implementation can be accomplished successfully and effi-

ciently by manufacturing companies if they take commit and spend the necessary resources on the key CSFs (Nguyen & Chinh, 2017). In short, the study achieved the objectives, and the qualitative results (of the interview) were confirmed by the quantitative findings (of the survey) in this convergent parallel mixed-method research.

This research has made three major contributions. First, it was probably the first to explore the details of CSFs, specifically in the M&E manufacturing SMEs. It provides useful references for the LM implementation, which could provide the right direction for M&E manufacturing SMEs as practical guidelines in industrial application. Second, the in-depth interviews and survey covered the holistic perspectives from the lower management to the senior management levels. This shows that the success of the LM implementation is highly dependent on the involvement and commitment of all stakeholders in the company. Third, most of the CSFs for SMEs were matched with findings of the literature review. This study was further extended to the importance of customer focus on business sustainability. This research was limited to the M&E manufacturing SMEs located in the Malacca state of Malaysia, which restricts the generalisation of the findings. Future research is recommended to explore the priority order or criticality levels of the identified predominant success factors in the LM implementation in other manufacturing sectors of different states with large sample size and including the shop floor employees to validate the findings.

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