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Status of Lean Manufacturing Practices and Its Influence on the Adoption of Industry 4.0 in the Malaysian Furniture Industry

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Abstract: *Status of Lean Manufacturing Practices and Its Influence on the Adoption of Industry 4.0 in the Malaysian Furniture Industry.* Lean Manufacturing practices is being promoted throughout the manufacturing industry in the country to boost industrial productivity. Therefore, a study was carried out to determine the level of adoption, benefits, and challenges faced by furniture manufacturers in adopting LM. Further, it was also evaluated if LM facilitated the transition towards Industry 4.0 adoption. The questionnaire-based survey involved 484 furniture manufacturers, of large-size and SMEs. The results found that the adoption of LM was prevalent among large-sized companies, and LM improved product quality and customer satisfaction, while reducing manufacturing lead time in the companies. The 5S method of work place organization, process mapping and waste reduction and elimination were the most common LM tools adopted by the companies. On the other hand, the major challenges encountered when implementing LM were lack of know-how, backsliding to old work ways, and resistance to adopt among the employees. The result also revealed that companies practicing LM also suggested that they were more prepared to adopt Industry 4.0 technologies, as the practice of LM has not only reduced waste on the production shopfloor, but also improved the information flow that is important for digital tools of Industry 4.0.

Keywords: Lean manufacturing, Furniture, Industry 4.0, Sustainability, Productivity, Customer Satisfaction

INTRODUCTION

Since 2011, the global manufacturing industry was introduced to the concept of the 4th Industrial Revolution, which is also known as Industry 4.0 (IR 4.0). In this concept, there is an amalgamation of manufacturing and logistics systems in the form of cyber-physical production systems (CPSS), leading to a very flexible, yet versatile manufacturing system (Chay *et al.* 2015). In fact, IR 4.0 has been touted as the most desirable manufacturing system to be presented to the global manufacturing industries, in almost all spectrum of manufacturing (Yi *et al.* 2021).

In order to boost the competitiveness of the manufacturing sector, and also to possibly reduce the dependence of foreign contract workers in the country, the Malaysian government formulated and launched the National IR 4.0 Master Plan in 2018 (MIDA 2018). The master plan had a two-pronged objective, (1) to improve the overall manufacturing productivity, and (2) to ensure greater value-added manufacturing activities through flexible

and technology application. These objectives were deemed important as the manufacturing sector was under greater competitive pressure from other low-cost producers, especially China, Vietnam and Indonesia, and it continues to contribute about one-third of the country's annual gross domestic product (GDP). Further, the government also aspires that through relevant technological application, more high-skilled employment opportunities could be created, apart from transforming the manufacturing sector into a high value-added manufacturing sector (MITI 2018). This was particularly important as the country's economic performance in the manufacturing sector has been reliant on its cost competitiveness, and much of the country's export revenue continue to be derived from the export of commodities (such as petroleum, oil palm, rubber, wood products and furniture, etc.). According to Malaysian External Trade Development Authority (MATRADE) (2022), commodities and products based on commodities accounted for almost 25% of the total exports of the country in 2021.

Although, Malaysia is ranked within the top 15 largest exporters of furniture in the world (MTIB 2020), the growth rate of the Malaysian furniture industry from 2003 to 2019 has been stagnating, reflecting its reducing competitiveness (Yi *et al.* 2021). The main reasons for this performance have been the lack of value-added products manufacturing, and the industrial growth driven primarily by incremental factor inputs, rather than productivity gains (Ratnasingam *et al.* 2018).

According to the studies by Ratnasingam *et al.* (2018, 2019), the main challenges faced by the Malaysian furniture industry are: (1) inconsistent raw materials supply, (2) high dependency on labor-force, (3) slow industrial transformation from the original equipment manufacturing (OEM) to the original design manufacturing (ODM) and original brand manufacturing (OBM) strategies, (4) limited value-addition and creativity, and (5) uncertainty in policy directions with the overall timber industry. Inevitably, these challenges continue to have an adverse impact on business sentiments, which is somewhat reflected in the reducing investments, both from foreign and domestic parties, into the industry (Yi *et al.* 2021). In light of this trend, it may appear that the opportune time has come for the labour-intensive furniture manufacturing sector to explore and adopt greater automation and technologies to reverse the flagging fortunes of the furniture industry, which is increasingly affected by other low-cost producer nations.

The Concept of Industry 4.0

Industry 4.0, is also referred to as "smart factory", and it is governed by four underlying principles (Bartodziej 2017). (1) Interconnection, which emphasizes the sharing of information between interconnected objects and people *via* the Internet of Things (IoT). (2) Transparency of information, which allow operators to make more accurate decisions based on the information arising from the interconnection (Seseni and Mbohwa 2018). Inevitably, such interconnectivity leads to significant improvements in the manufacturing processes (Agostini and Nosella 2019; Frank *et al.* 2019). (3) Decentralization of decision-making, where the cyber physical systems make decisions automatically, which triggers the tasks to be performed automatically (Chay *et al.* 2015). (4) Technical assistance for humans to support and execute the activities much more productively, through improved aggregation and visualization of the information. The most notable characteristics of the IR 4.0 concept is that the system accelerates decision making on short notice, while at the same time, carrying out a range of tasks that were unconsidered unsafe, repetitive, unpleasant, and even

too exhausting for humans. and solving urgent problems on short notice. The cyber physical systems also conduct a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.

In essence, IR 4.0 has much relevance to the labour-intensive manufacturing sectors, such as the furniture industry, and as reported in the study in Yi *et al.* (2021), the application of IR 4.0 offers both tangible and intangible benefits such manufacturing industries, which cannot be ignored.

Challenges Faced in the Adoption of Industry 4.0 in the Furniture Industry

The application of IR4.0 can have a lasting impact not only on humans, but also the equipment, processes, and products (Büchi *et al*. 2020). The application of automated technologies will reduce the number of manual workers required, although many high-skilled jobs may be created, which will emerge from the need to monitor these automated machines and robots through decentralized decision-making (Chay *et al.* 2015). However, the manufacturing organization's complexity will be transformed, in which manufacturing becomes more agile, flexibility, and with greater value-addition.

In an industry predominated by small and medium-sized enterprises (SMEs), such a complex manufacturing organization may pose serious challenges. The study by Yi *et al.* (2021), identified several reasons for the poor adoption of IR 4.0 in the Malaysian furniture industry, which include, (1) lack of finance, (2) lack of information & computer technology (ICT), (3) lack of knowledge workers, (4) insufficient government support and incentives, (5) lack of awareness of the benefits to be gained through IR 4.0, and (6) the lack of industry peers who have adopted IR 4.0. One notable point highlighted in the study was the overall lack of an industrial system, such as 'lean manufacturing' that would facilitate the SMEs to gradually shift towards IR 4.0 (Abu *et al.* 2021; Yi *et al.* 2021). Therefore, the research question on the impact of lean manufacturing towards the adoption of IR 4.0 among SMEs in the furniture manufacturing industry is worth exploring.

Lean Manufacturing as an Industrial Practices

According to previous studies, lean manufacturing, or abbreviated as LM, has had a profound effect on the success of many enterprises throughout the developed countries, especially in Japan, Germany and the United States of America (Abu *et al.* 2021a). Interest in the LM concept only gained momentum in the mid 2000 in many developing countries, particularly in the automotive and electric manufacturing sectors (Abu *et al.* 2021b). Therefore, it is no surprise that the application of LM concepts among wood and furniture manufacturing enterprises has been limited, even in China, which is regarded the manufacturing hub for the world (Abu *et al.* 2019). According to the argument posed by Ratnasingam *et al.* (2022a, 2022b), this could be attributed to the fact that wood and furniture companies are relatively young, and domestic-owned, and do not have long-term view of the industry devoid of matured thinking.

In light of this scenario, many small and medium enterprises (SMEs) in the wood and furniture industries have rejected the idea of adopting LM (Pirraglia *et al.* 2009). Despite prior evidence of the benefits of lean implementation, there are several barriers to it as well including perception, lack of tangible benefits, and problems encountered on the factory shopfloor (Moeuf *et al.* 2018). This may largely be due to: 1) the fear of implementation cost and the successive benefits of lean; 2) the lack of job security among employees and the risk

of losing their job if it is non-value added; 3) the lack of a supportive organizational culture to overcome the fear of failure, change, retrenchment, and uphold greater responsibilities; 4) the lack of governmental support which emerged as one of the significant factors to the success of lean implementation in SMEs, and, most importantly, 5) the lack of knowledge or training (Martinelli *et al.* 2021; Pearce *et al.* 2018).

In general, the concept of lean means manufacturing without waste (Powell 2013). On the other hand, Abu *et al.* (2019), defined lean as a method to deliver the upmost value to customers by removing waste through process and human design elements. Others defined LM as manufacturing with minimal buffering costs (Powell 2013), eliminating waste throughout a product's value chain, and waste reduction throughout the supply chain (Marodin *et al.* 2018). Yin *et al.* (2018) proposed that lean practices have a positive relationship with the four dimensions of operational performance, *i.e.,* quality, lead time performance, flexibility performance, and cost performance. Abu *et al.* (2021a) pointed out that lean is an effective method in enhancing operations performance via improvements in its quality, minimization of inventory, delivery, productivity, and minimization of cost. Further, Marodin *et al.* (2018) showed that LM practices resulted in better performance in terms of lead time, inventory, and turnover metrics, but not in quality and on-time delivery. Lean manufacturing is also considered as a powerful technique in enhancing business performance via improvements in profitability, sales, and customer satisfaction (Yin *et al.* 2018; Stentoft *et al.* 2020), social performance (Henao *et al*. 2019), green supply chain performance (Yin *et al.* 2018), and sustainable performance (Ratnasingam *et al.* 2017). According to Rymaszewska (2014) and Dieste *et al.* (2019) LM practices also positively influenced business organization to improve their environmental performance.

With the onset of the IR 4.0 concept throughout the manufacturing world, many enterprises have reported that prior adoption of LM practices have facilitated towards to the transformation towards IR 4.0 application, yet most of these anecdotal and empirical evidence about the benefits of LM towards transiting to IR 4.0 is available for automotive, electrical, and electronic sectors, rather than wood and furniture industries (Yi *et al.* 2021). In this context, LM is a new manufacturing paradigm especially for the furniture industry in Malaysia, which leads to the question of the *'status and motivation of adopting LM in the furniture industry?' 'Further, to what extent, companies that have adopted LM are ready to transit towards IR 4.0 manufacturing concepts in the furniture sector?'*

The lack of research on the recognition of barriers and challenges faced by the small and medium enterprises (SMEs) dominated furniture industry in Malaysia is indeed apparent. To complement and support the narrow body of knowledge on the under-researched scope, this paper aims to shed further light into the relationship between LM adoption and IR 4.0 application in the furniture industry. Specifically, this study is undertaken to clarify the aforementioned questions, which were fundamentally formulated to propagate the research purpose. Therefore, the objectives of this study were to: (1) evaluate the degree of awareness of LM among the respondents, (2) identify the common process improvement tools used by the respondents, (3) examine the status of LM implementation and the challenges faced by the respondents, and (4) examine the readiness of adopting IR 4.0 concepts among companies that have adopted LM and those who have not. The outcomes of this study will provide useful insights to industry players and policy makers in making the necessary industrial development strategy to support the country's overall aspiration towards becoming a high added manufacturing nation.

METHODOLOGY

In this study, both quantitative and qualitative methods were used to collect and compile the research data required. Prior to the start of the study, secondary data related to the objective of the study were collected and compiled from relevant agencies, including the Department of Statistics Malaysia (DOSM), Malaysian Timber Industry Board (MTIB), Malaysian Investment Development Authority (MIDA), and the Malaysian Furniture Council (MFC). The data collected showed the current status of LM adoption in the furniture industry, and the number of manufacturers that have participated in the readiness assessment (RA) survey, which is a reflection of the number of companies that are keen to explore and adopt IR 4.0 technologies. This was followed by a questionnaire-based survey of selected furniture manufacturers located throughout the country to gather first-hand information related to this study.

Target Respondents

Based on the preliminary data obtained from the MFC and MTIB, a total of 1840 registered furniture manufacturers, of different company-sizes, were identified as potential respondents for this study. The manufacturers who participated in this study were producing either wooden, panel-based, plastic, or metal furniture, or a combination of several types of furniture. These potential respondents were contacted individually with the assistance of the MFC to seek their consent to participate in this study. From this total, 616 of the respondents agreed to participate in this study. The response rate of 33.4% was considered good, given the fact that many companies were not fully operational during the Covid-19 pandemic that had affected many economic sectors in the country since late 2019. In fact, carrying out the survey was also challenging, as most factories' office staff were working remotely, and therefore, responses to the survey were relatively slow.

Questionnaire-based survey

To achieve the objectives of the study, the questionnaire was prepared and designed after consultation from industry experts, particularly those in the Malaysian Furniture Council (MFC), Malaysian Timber Industry Board (MTIB), Malaysian Investment Development Authority (MIDA), academics, and previous studies by Ratnasingam *et al.* (2019, 2020), Abu *et al.* (2019), and Yi *et al.* (2021). In designing the questionnaire, it was important to ensure that the survey covered furniture manufacturers of different product types, and of all sizes in the country. The survey instrument developed for this study was compiled from applicable questions developed after several intensive discussions among the research team in collaboration with MIDA and MFC. The survey consisted of twenty questions that included single, multiple-choice, and open-ended questions.

Part I of the survey considered demographic questions about the respondent firms for classification purposes. Part II consisted of general questions about process improvement employed, and specific questions about the awareness of the LM concept for manufacturing. Part III included specific questions to establish the most common tools used for process improvements by furniture manufacturers of the different sizes. Part IV was aimed at establishing the status of implementation of LM among the respondents and challenges faced. Part V of the survey included questions aimed at comparing the level of readiness among companies that have adopted LM and those who have not adopted

towards adopting IR 4.0 technologies. Prior to implementing the survey, the questionnaire was pre-tested among a pilot sample of 20 furniture manufacturers in the Klang Valley, to prove the robustness of the measurement instrument. This pilot consisted of sending the survey to people related to the industry to verify clearness, ambiguity, time, and effectiveness of the questions. After modifying the measurement instrument according to recommendations obtained from thepilot sample, the survey was corrected and finalized for distribution. The questionnaire was then transformed into Googe Form, and the link was shared with the potential respondents via email.

Data Collection

A first contact email was sent as a courtesy to the potential respondents in order to inform them of the forthcoming questionnaire survey. Further, the email also provided the respondents some back ground information to assist them in filling out the survey form. The email also assured the confidentiality of the responses.

After the instrument was sent by email together with the link, two reminders were sent to the respondents, trying to keep the respondents aware of the importance of their support and collaboration. A total of 484 responses were obtained after the closing date, from the initial 616 targeted respondents. The response rate of 78.5% was considered significant in order to drive analysis and conclusions for the behavior of that specific population (*i.e.,* furniture manufacturers). After the closing date, the surveys were processed and analyzed based on the responses received, and the evaluation of the open-ended questions was carried out.

Data Analysis

The data from the questionnaires were compiled and tabulated using Microsoft Excel (2016) software (Microsoft Corp., Redmond, WA, USA). The statistical software Statistical Package for Social Sciences (SPSS) version 24 (2016) (SPSS LLC, Chicago, IL, USA) was used to analyse the collected data from the questionnaire-based survey. In order to analyse and study the relationship between different variables, a bivariate correlation was conducted utilizing Pearson[2] as a correlation coefficient with a significance level of 5% (two-tailed).

RESULTS AND DISCUSSION

The results of this study are presented in five parts: (1) the characteristics of the respondent companies, (2) the degree of awareness of LM concepts among respondents, (3) current process improvement tools used in the factories, (4) status of implementation of LM practices, and the motivation as well as challenges faced among respondents, and (5) level of readiness to adopt Industry 4.0 technologies among companies that practiced LM concepts, and among those who do not.

Characteristics of Respondent Companies

Figure 1 shows that most of the respondent companies were operating in Muar, Klang Valley, Taiping, and Sg. Petani which were 33%, 22%, 11%, 16.5% respectively, of the total respondent companies. The other areas, such as Melaka and Kuantan contributed 11% and 6.5% of the respondent companies. This distribution of respondents is line with the report by the Malaysian Furniture Council (MFC) (2020), which reported that the two major

furniture producing areas in Malaysia were Muar and Klang Valley, and most of the manufacturing activities were concentrated along the west coast of Peninsular Malaysia. This is attested by the fact that Muar furniture factories had accounted for 55% of the total furniture export of MYR 11 billion from Malaysia in 2020 (MTIB 2021).

The respondent companies in this study were grouped into four categories of large, medium, small, and micro (Figure 2). The previous study by Yi *et al.* (2021) has shown that company-size played an important role in determining their willingness and appetite to adopt new ideas and technologies, and therefore, it is pertinent to carry out similar evaluation in this study. According to the MFC (2020), the small and medium enterprises (SMEs) together with the micro-sized companies make up almost 83.5% of all registered furniture manufacturers in the country. In fact, the study by Powell (2013), which alluded that larger companies are more receptive to new ideas and technology application compared to SMEs is a point to note. Inevitably, SMEs are often found to be lagging in terms of process improvement and productivity compared to the large-sized companies as reported by Ratnasingam *et al.* (2018). Under such circumstances, the impact of company-size on their willingness to adopt LM concepts is a relevant and warrants investigation.

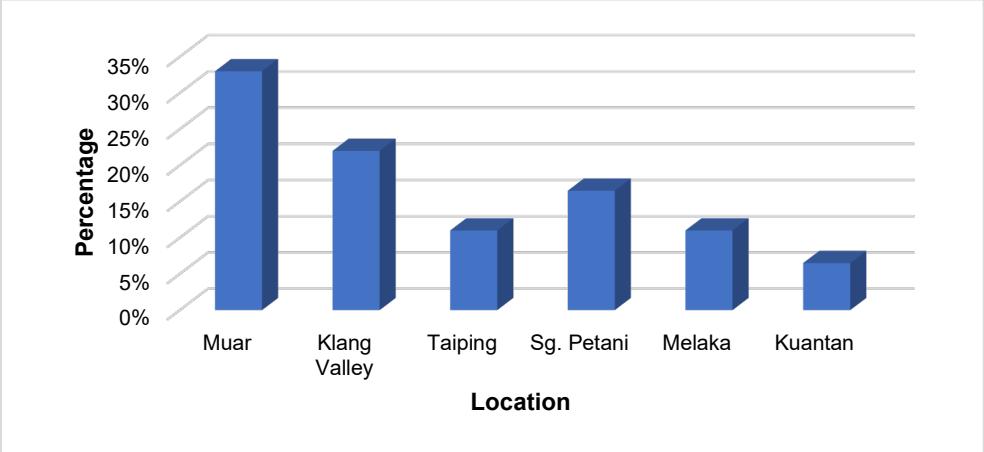

Figure 1. Location of respondent's company

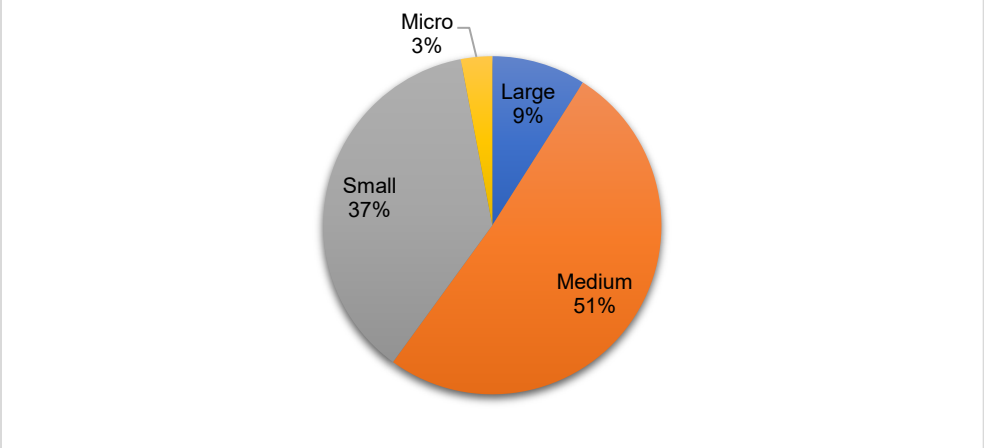

Figure 2. Size of the respondent's company

Figure 3 shows that most of the respondent companies were producing wooden furniture products. This observation is in line with the report by MFC (2020), which showed that Malaysian furniture exports has been dominated by wooden furniture, which accounts for 80% of the total furniture exports annually.

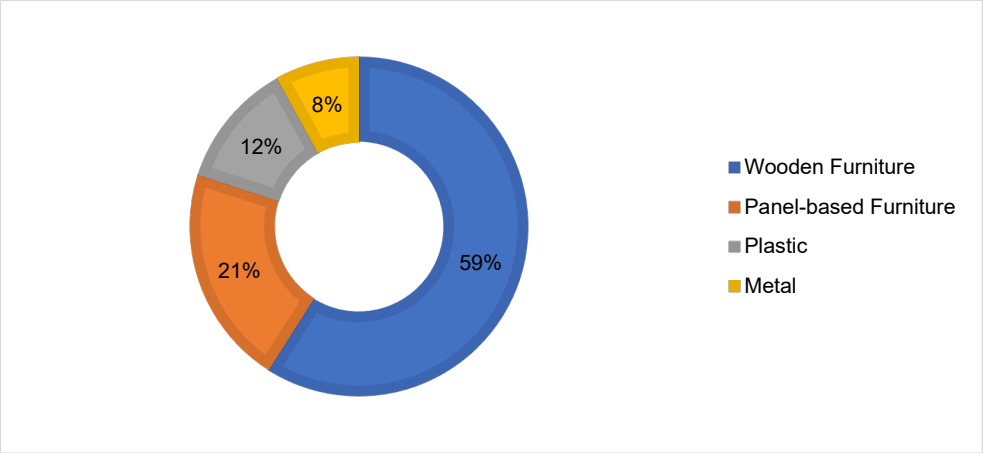

Figure 3. Types of Furniture Products

Degree of Awareness of LM Concepts Among Respondents

All the respondents in this study indicated that they are involved in one or more of the following activities: cost reduction (100%), improvement in product quality (95.3%), improvement in customer satisfaction (90.5%), and improvement in delivery speed (80.7%). From these results, it is apparent that furniture manufacturers in Malaysia are focused on cost reduction, while producing quality products to meet customer needs, in the shortest possible time. This is in line with previous studies by Zawadzki and Żywicki (2016) and Ratnasingam *et al.* (2018), who alluded to the fact that the competitiveness of the Malaysian furniture industry is highly dependent on its cost competitiveness.

In terms of the level of awareness of LM, Figure 4 shows that 57% of the respondents have implemented LM in their respective factories, while 17% were planning to implement LM within the next six months. This result suggests that the initiatives of the Malaysian Timber Industry Board (MTIB) and Malaysian Investment Development MIDA has been successful in ensuring an industry-wide adoption of LM, especially in labor intensive sectors, such as furniture manufacturing (MTIB 2020).

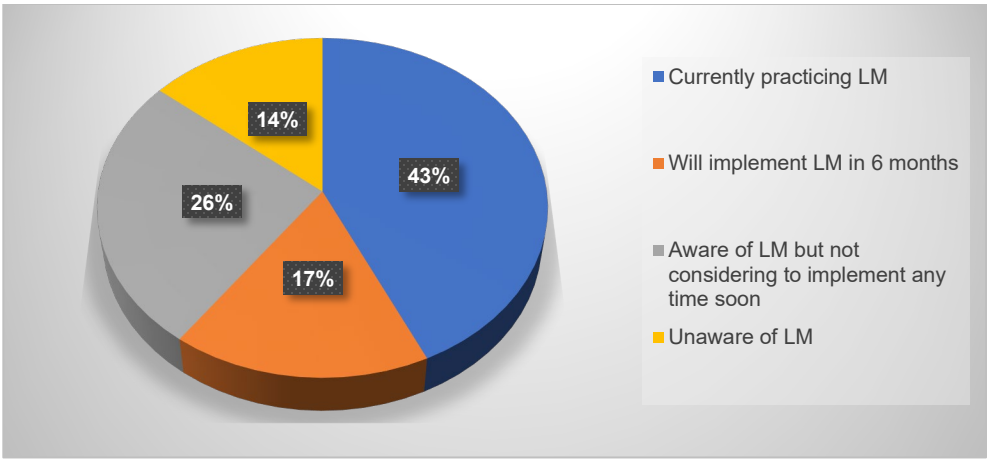

Figure 4. Awareness of LM Among Respondents

From those respondents who have claimed to have implemented LM (43%), 33% stated that they have implemented LM to some degree throughout their respective factories, while 58% responded to have an early implementation referred to as starting toimplement in key production areas, and only 19% claimed to have achieved advanced implementation of LM, where it is extensively used as standard operating procedure throughout the factory shopfloor and overall business. As alluded by several previous studies by Agostini and Nosella (2019), Türkeş *et al.* (2019) and Abu *et al.* (2019), the implementation of LM in the furniture industry is often challenged by the lack of knowledge, resources, and the acceptance among workers. Interestingly, almost all the respondents with the advanced stage of LM implementation were large furniture manufacturers, indicating that such companies are usually more receptive to new ideas, management tools and technologies (Ratnasingam *et al.* 2020; Yi *et al.* 2021).

Current Process Improvement Tools Used in Factories

In 2019, a survey conducted by the Malaysian Industrial Development Authority in collaboration with the Malaysian Productivity Corporation (MPC) found that the automotive, electrical and electronics, aerospace, chemical industries, petroleum refining andrelated industries, were ahead of the wood products and furniture industries in terms of the implementation of LM (MIDA 2019). In this respect, it is apparent that the wood products and furniture industries were laggards when dealing with uptakes of new ideas and technologies, as previously reported by Ratnasingam *et al*. (2019) and Yi *et al.* (2021).

Figure 5 shows that workplace organization (5S's)technique was practiced by all respondents that have implemented LM or in the early stage of implementing LM. The next most used tools were process mapping, followed by waste identification and elimination, then visual management, and the kaizen technique. Value stream mapping appears to be preferred by 40% of the respondents. It appears that respondents would rather use process mapping due to its simplicity. The study also showed that large companies has adopted more of the LM tools compared to SMEs, clearly suggesting that large-sized companies are more receptive to new ideas and technologies as alluded previously in the study by Yi *et al.* (2021).

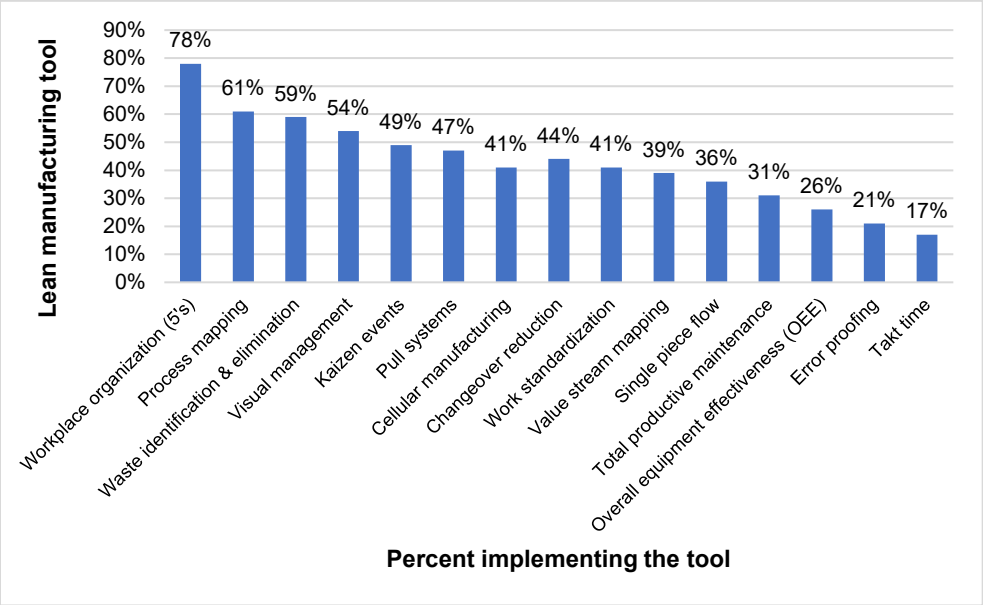

Figure 5. Lean Manufacturing tools usage

Motivation, Benefits, and Challenges Faced in Implementing LM

When asked about the motivations that lead respondents to implement Lean Manufacturing, the majority of respondents stated that the three most important motivations that led them to embark on Lean Manufacturing was the incentives provided by the relevant agencies, followed by attending training program, and finally examples and/or case of studies on the benefits of Lean Manufacturing. These results indicate that a valuable way to learn and convince companies to implement Lean Manufacturing tools or programs is through experiences and programs previously implemented by other companies (Figure 6). In this context, the initiatives taken by MTIB and MIDA in promoting LM to the wood products and furniture industries appears to have paid dividends (MTIB 2020).

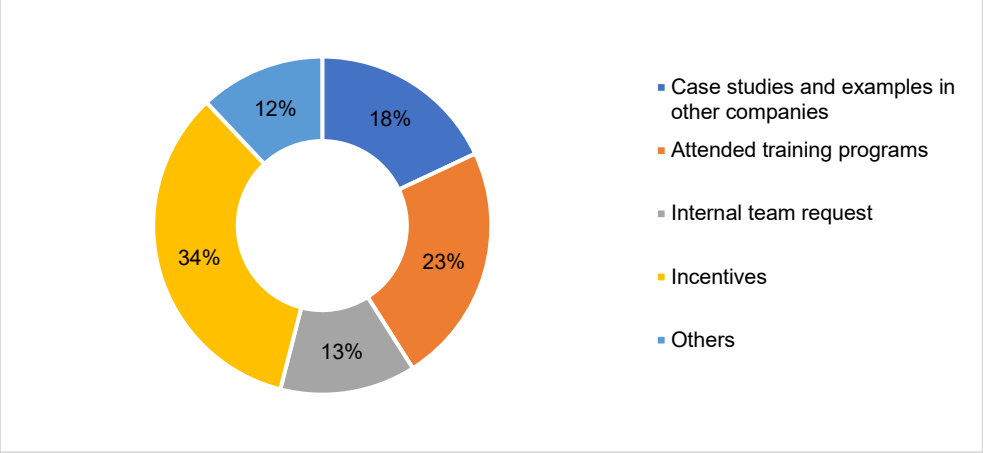

Figure 6. Motivations to embark on Lean Manufacturing

Therefore, incentivizing and provision of more training programs based on case studies and successful examples may be an important tool to convince key personnel about the benefits of a LM implementation.

In order to analyze and study the relationship between different variables, a bivariate correlation was conducted utilizing Pearson as a correlation coefficient with a level of significance of five percent (two-tailed). A significant result from this non-parametric test indicated that there is a positive relationship between the practice of LM and the improvements achieved in product quality, reduction in lead time/cycle time, and improvement in customer satisfaction (Table 1). The results show that improving customer satisfaction seemed to have a higher correlation with those companies that are implementing LM, attributed to the focus on related activities that add value for customers.

Table 1. Bivariate Correlation between the Respondents Implementing Lean Manufacturingand the Benefits

	Improvementin product quality	**Reduction in mgf. lead time/cycle time**	**Improvement in customer satisfaction**	
Pearson Correlation	.370(*)	.318(*)	.623(**)	**Implementing of Lean Manufacturing**
Sig. (2-tailed)	0.046	0.022	0.001	
N	108	108	108	

*. Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level(2-tailed)

The results of the survey also suggested that respondents were improving in customer satisfaction while improving in service quality, on-time delivery, manufacturing flexibility agility, product development and time to market, and by reducing in manufacturing lead time/cycle time(Table 2).

In addition, a significant relationship was found when comparing the respondents who have reported to be currently improving in customer satisfaction activities, and those respondents that believe that LM could result in other benefits, such as revenue growth, improvement in market share, customer loyalty, customer satisfaction, the diminishing in rework and duplication work, and a low employee turnover (Abu *et al.* 2019; Ghobakhloo and Fathi 2019). For these respondents, they seem to believe that customer satisfaction in their products is closely related to how well these other activities are accomplished.

Table 2. Bivariate Correlation between Customer Satisfaction and Improvementin Service Quality, On-Time Delivery, Flexibility, Product Development and Reduction in Manufacturing Lead Time

	Improvement in service quality	**Improvement inon-time delivery**	**Improvement in product developmentand time to market**	**Improvement in flexibility agility**	**Reduction in mfg. lead time/cycle time**	
Pearson Correlation	0.575(**)	0.270(***)	0.366(*)	0.318(**)	0.384(*)	**Customer satisfaction**
Sig. (2-tailed)	0.000136	0.072	0.035	0.001	0.021	
N	108	108	108	108	108	
*** Correlation is significant at the 0.10 level (2-tailed), ** Correlation is significant at the 0.05 level(2-tailed), and * Correlation is significant at the 0.01 level (2-tailed)						

Given the apparent dependency of these two activities with several other competitive advantage activities that were explained above, LM could not only offer furniture manufacturers cost reduction and customer satisfaction, but also other benefits such as resource savings, improvement in service quality, on-time delivery, manufacturing flexibility/agility, product development and time to market, and reduction in manufacturing lead time/cycletime (Ghobakhloo and Fathi 2019).

As mentioned previously, larger companies showed a higher tendency to readily adopt LM and its many tools to improve their operations. In this context, by applying a bivariate correlation (10% significance level), it was found that there is a positive relationship between the size of the company and the improvement in product development/time to market activity (*Pearson correlation=-0.244, and sig.(2-tailed) =0.06*) (Table 3). Thus, large companies practicing LM are also reporting improvements in product development and time to market, attributed to the more financial resources and receptiveness to new ideas and technologies (Dieste *et al.* 2019).

Table 3. Relation between the Size of Companies and the Level of Improvementin Product Development and Time to Market

	Improvement in product development/time to market		
	Practicing LM	Not Practicing LM	No, but planning to Practice LM
SMEs	4.0%	96.0%	66.0%
Large Companies	96.0%	4.0%	34.0%
Total	100.0%	100.0%	100.0%

To question if LM assisted furniture manufacturers gain competitiveness, 43% of the respondents responded positively, while another 22% suggested that LM need to be combined with other management tools in order to be effective in the furniture sector.

Another 11% argued that LM is not suitable for the furniture industry, and is more appliable to other manufacturing industries (Figure 7).

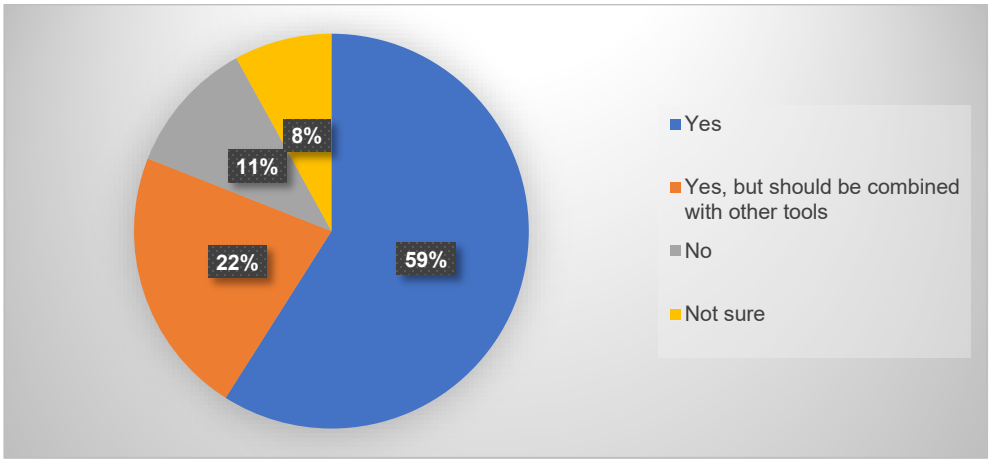

Figure 7. Respondents' opinions about LM as a competitive advantage tool for the furniture industry

Figure 8 shows that main reasons cited by the respondents as being the challenges faced in implementing LM in their respective factories. The three main barriers that were seen as preventing the adoption of LM principles were the lack of implementation know-how, the backsliding to the old ways of working, and employee and middle management resistance. In fact, a similar finding was also reported by Abu *et al.* (2019), who suggested that overcoming work culture appears to be the major stumbling block in implementing LM in the wood products and furniture industry. In this respect, it could be inferred that companies have to work hard in making their people to believe in all the benefits that LM offers and that there is a better way in which their job can be performed, before acceptance and adoption can be realized.

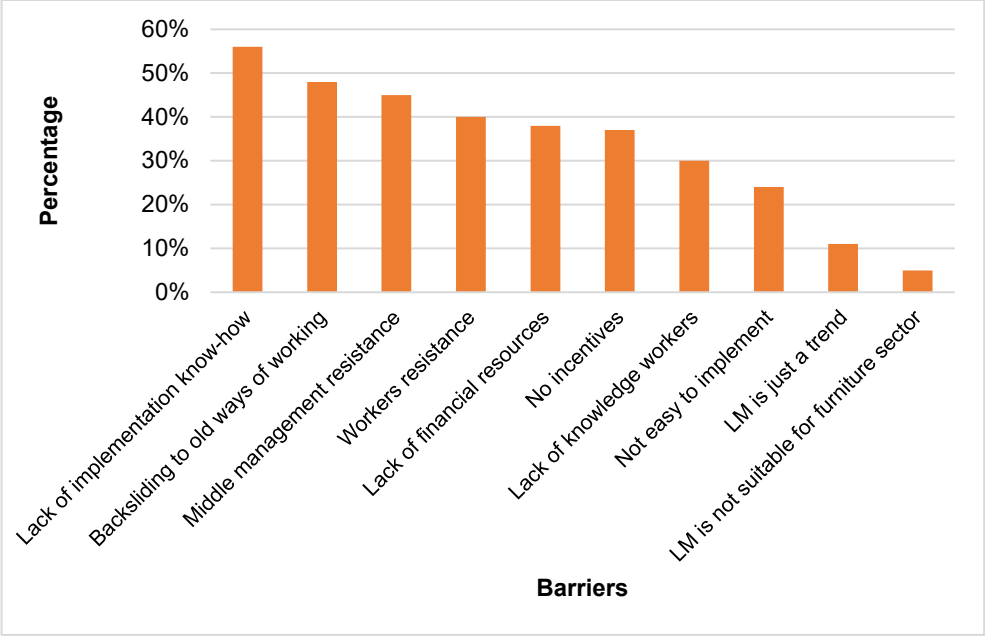

Figure 8. Barriers to Lean Manufacturing implementation

Readiness to Adopt IR 4.0 Among Companies Practicing LM

The question whether companies practicing LM were ready to adopt Industry 4.0 compared to the counterparts who are not, is important due to its implication on the overall government's aspiration to have Industry 4.0 technologies adopted extensively throughout the full spectrum of the manufacturing industry. The results from this study reaffirm the fact that companies practicing LM are more prepared to adopt Industry 4.0 compared to their counterparts who are not practicing LM. This observation runs across large companies and SMEs, suggesting that LM paves the way for the adoption of Industry 4.0. Figure 9 shows the three important LM tools that facilitates adoption of Industry 4.0, which include process mapping, visual management, and cellular manufacturing.

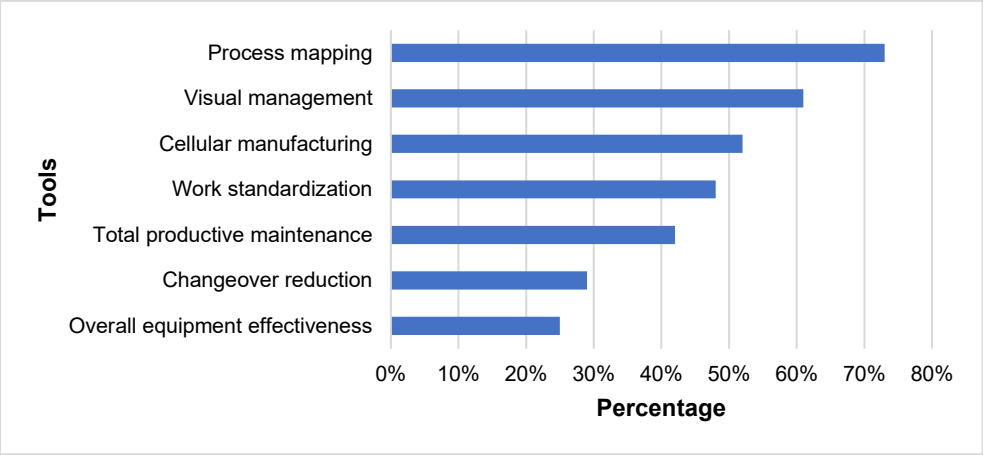

Figure 9. Lean Manufacturing tools that facilitate Industry 4.0 adoption

A similar finding was also reported by Pearce et al. (2018) and Henao et al. (2019) who also suggested that LM principles contributed positively towards the company's efforts to adopt Industry 4.0 technologies by streamlining the work and information flow, which is important in integrating the cyber-physical systems of Industry 4.0. The study by Ghobakhloo and Fathi (2019) also reaffirmed the fact that Industry 4.0 transition requires the organizational integration of many IT-based modern technologies and the digitization of entire value chains. In this respect, companies with an advanced stage adoption of LM sets up a viable strategy to shift into the Industry 4.0 setting.

IMPLICATIONS OF THE STUDY

The results of this study reveal some important points that must be taken into account by policymakers in developing a sustainable furniture manufacturing industry in the country. The fact that the furniture manufacturing industry in Malaysia is predominated by SMEs, which lack the financial resources and knowledge-workers to adopt new management tools and technologies has been previously highlighted by Yi et. al. (2021). In this respect, incentivizing the adoption of LM especially for SMEs must be seriously considered, if the

adoption gap of LM practices among large-sized companies and SMEs are to be narrowed. As alluded by Ratnasingam *et al*. (2018), the larger-sized companies have greater appetite and more financial resources to take full advantage of these management tools as well as new technologies, which in turn pushes them further ahead in the productivity scale compared to the SMEs. This point has been emphasized in the report by the Malaysian Productivity Corporation (MPC), who suggested that the productivity gap between large furniture manufactures compared to their SME counterparts could be as high as 17% (Yi et al. 2021). In order to ensure a wider adoption of LM principles throughout the furniture industry specialized training programs and awareness campaigns based on case studies and examples must be intensified, in order to ensure a higher degree of traction among furniture manufacturers for LM principles. The benefits to be gained through the adoption of LM principles should also be highlighted to entice many more furniture manufacturers to seriously considered adopting LM. Further, upskilling of the present workforce through intensive training programs apart from producing knowledge workers competent to handle LM and Industry 4.0 technologies should also be considered seriously (Agostini and Nosella 2019). The results from this study, similar to previous research also suggest that companies that are more systematic and have adopted the LM principles are often suitable candidates for further embracing automated technologies (Kumar *et al.* 2020). Because the uptake of the LM system is more prevalent among larger furniture manufacturers compared to the SMEs in the industry (MTIB 2020), this may also imply that the adoption of Industry 4.0 could be significantly higher among large-sized companies (Yi *et al.* 2021). Therefore, this study also recommends that the readiness assessment (RA) for Industry 4.0, which is presently carried out with the assistance of MIDA should be made available throughout the furniture and wood products industry, without any consideration of company-size. This may provide a better picture to policymakers on the necessary action plan that must be implemented to ensure a sustainable growth of the furniture industry.

In fact, the findings of this study also run parallel with the Census of the Malaysian Timber Industry conducted in 2019 (MTIB 2020). It was shown conclusively that the growth of the Malaysian furniture sector is fuelled by incremental capital inputs, especially raw materials, and workforce, rather than actual productivity gains. The predominance of the SMEs in this sector also implies that uptake of LM principles and other tools will be slow, and without the necessary incentives and government support, an industry-wide adoption may not be fully realized. It must also be emphasized that the availability of knowledge and skilled workers, capable of handling these management tools and technologies must also be ensured, if this aspiration is to be become fruitions in the near future (Ratnasingam *et al.* 2022). In this context, it is important that the necessary tweaking of the strategies and action plans are undertaken to ensure that the furniture industry draws the desired benefits from National Wood Industry Strategic Policy (MTIB 2021).

CONCLUSIONS

1. The status of LM adoption among the furniture manufacturers in Malaysia is relatively low, and is primarily focused on the larger-sized companies.
2. The companies that have adopted LM reported significant improvements in product quality, reduction in manufacturing lead time and customer satisfaction.
3. The three most widely used LM tools among the respondents, include the 5S method, process mapping and waste reduction and elimination.

4. The two most important motivations for the adoption of LM among respondents include the availability of incentives and training programs, which in turn underscores the important role the relevant government agencies play in promoting LM adoption.
5. The challenges faced by companies in implementing LM were lack of implementing know-how, sliding back to the old work ways, and resistance among the workforce.
6. The LM tools that facilitate the adoption of Industry 4.0 among companies that have adopted LM are process mapping, visual management, and cellular manufacturing, which in turn suggest that these tools ensure free flow of information, important for the for implementing Industry 4.0.

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Streszczenie: *Status praktyk Lean Manufacturing i ich wpływ na przyjęcie Przemysłu 4.0 w malezyjskim przemyśle meblarskim*. Praktyki Lean Manufacturing (LM) są promowane w całym przemyśle wytwórczym w kraju w celu zwiększenia produktywności przemysłowej. W związku z tym przeprowadzono badania mające na celu określenie stopnia inkluzji, korzyści i wyzwań, przed jakimi stoją producenci mebli stosujących lean manufacturing. Ponadto sprawdzono również, czy LM ułatwiło przejście do przyjęcia Przemysłu 4.0. W badaniu ankietowym wzięło udział 484 producentów mebli, dużych, średnich I małych przedsiębiorstw Wyniki wykazały, że stosowanie LM było powszechne wśród dużych firm, a LM poprawiło jakość produktów i satysfakcję klientów, jednocześnie skracając czas realizacji produkcji w firmach. Metoda 5S organizacji miejsca pracy, mapowanie procesów oraz redukcja i eliminacja odpadów były najczęstszymi narzędziami LM stosowanymi przez firmy. Z drugiej strony, głównymi wyzwaniami napotkanymi podczas wdrażania LM był brak know-how, cofanie się do starych sposobów pracy i niechęć pracowników do adopcji. Wynik ujawnił również, że firmy praktykujące LM sugerowały również, że były bardziej przygotowane do przyjęcia technologii Przemysłu 4.0, ponieważ praktyka LM nie tylko zmniejszyła ilość odpadów na hali produkcyjnej, ale także poprawiła przepływ informacji, który jest ważny dla cyfrowych narzędzi Przemysłu 4.0.

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