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Lean manufacturing practices in Indonesian manufacturing firms: Are there business performance effects?

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Abstract

Purpose – Contradictory findings regarding the implication of Lean manufacturing (LM) implementation to business performance (BP) have been observed in prior studies. Hence, more studies are required to be capable of finding the status of LM implementation and its impacts on BP. Accordingly, this study examines and scrutinizes the effects of LM practices on the enhancement of BP from a developing country standpoint.

Design/methodology/approach – This empirical study uses a survey-based quantitative data collection approach through a cross-sectional research design. A total of 139 large manufacturing companies in Indonesia participated, selected through stratified random sampling technique. Three hypotheses regarding the effect of LM on BP were examined.

Findings – The results empirically reveal that comprehensive implementation of LM practices is necessary. Also, this study unravels that high BP (in terms of profitability, sales and customer satisfaction) is dependent upon the comprehensive implementation of LM practices. In other words, LM practices are not recommended to be implemented as a subset.

Research limitations/implications – Although this study is free from the common method bias as an implication of self-reporting by single respondent from one company, future researchers should consider of collecting data from multiple individuals in one company. Additionally, due to the study conducted in limited industries and large manufacturing firms, the results may not be applicable in other industries as well as in small and medium enterprises.

Practical implications – This study has further confirmed and established the LM–BP relationship. In line with the complementarity theory, it provides an insight that all the LM practices should be implemented simultaneously in a holistic manner because they are mutually supportive. In such a situation, piecemeal adoption is highly not recommended.

Originality/value – This study emphasizes on how LM contributes to the superior BP. Meanwhile, little attention has been paid to investigate the LM and its implication on BP from a developing country standpoint. Thus, this study is initiated to fill the gap.

Keywords Indonesia, Business performance, Lean manufacturing, Lean practices

Paper type Research paper

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1. Introduction

In today's global competitive business, many companies are struggling to enhance their performance to survive against the competition. This competition has challenged the companies to look for new manufacturing strategies to move forward and lead the market. To remain at the top, a company should adopt and implement an effective strategy to enhance the organizational performance. Nowadays, implementation of Lean manufacturing (LM), especially in manufacturing organizations, has become very scorching and popular. The LM system was first brought to bear by the Toyota Motor Corporation in the late 1950s and was named Toyota Production System (Shingo, 1981). The term "Lean manufacturing" was formerly initialized by Krafcik (1988) and was made popular by Womack *et al.* (1990) to illustrate manufacturing processes without waste. In LM, all activities that attract resources without value creation are termed as waste and must be thoroughly exhumed (Chauhan and Singh, 2012; Chen and Chang, 2013), not only within the company but also along its entire supply chain network (Shah and Ward, 2007) and within and across companies.

The contributions to success of companies by LM as detailed by Hofer *et al.* (2012), Marodin and Saurin (2013), Thanki and Thakkar (2014), Yang *et al.* (2011) have gone beyond the country where it originated; it has spread across numerous companies in the USA and Europe. Recently, the transfer of the concept of LM has become very popular with many industries, and countries are getting actively involved. In fact, the dramatic increase in the number of researches in developing countries, particularly in Asia, such as China (Taj and Morosan, 2011), Malaysia (Agus and Hajinoor, 2012), Thailand (Rahman *et al.*, 2010), India (Panizzolo *et al.*, 2012) and Indonesia (Susilawati *et al.*, 2011), provides evidence to support the success of LM in enhancing the performance of companies. Those findings agree with Krafcik (1989) that high performance of companies is dependent upon an LM system.

Currently, organizations' quest for attaining higher sales, gaining high profit and improved customer satisfaction has warranted notable attention and focus on LM globally. In spite of these, several studies hold contrasting views (Ahmad *et al.*, 2004; Huson and Nanda, 1995; Marodin and Saurin, 2013). This contradiction was attributed to a couple of reasons by a couple of authors. For instance, Fullerton and Wempe (2009) and Furlan *et al.* (2011b) pointed out that the disagreement is due to the inability to examine LM and business performance (BP) comprehensively, instead of individually. In a similar fashion, Bhasin (2008) and Chen and Tan (2011) also argued that very limited research has scrutinized the effects of multiple dimensions of LM on organizational performance, especially BP. On the other hand, Chavez *et al.* (2013) believe that the mixed findings were as a consequence of the complication of the LM practices–performance relationships. Thus, it still requires further investigation (Agus and Hajinoor, 2012; Losonci and Demeter, 2013).

Being viewed from the perspective of developing countries, particularly in Indonesia, it is seen that both the level at which LM is being implemented and the implications of LM on BP are still partial (Susilawati *et al.*, 2011). Indonesia is a country located in South East Asia, a place where the manufacturing sector plays a paramount role in both domestic and international markets and remains a major contributor to the country's economy development. Statistically, as evidenced in the BPS-Statistics Indonesia (2013), the manufacturing sector significantly contributed about 23.71 per cent of the gross domestic product in the first quarter of 2013, which is comparatively greater than the contribution of agriculture (15.01 per cent) and trade, hotel and restaurants (14.26 per cent); bigger than what the mining sector (10.90 per cent) and services (10.64 per cent) contribute; larger than what comes from construction (10.25 per cent) and finance and real estate (7.56 per cent); even much greater than the contributions of transportation and communication (6.84 per cent); and more than those of electricity gas and clean water (0.83 per cent).

Despite the aforementioned alluring significance of the manufacturing sector in Indonesia, in particular, not enough studies on LM have been carried out (Nawanir *et al.*, 2013; Susilawati *et al.*, 2011). For that reason, the need for such studies to be able to have empirical evidence to support the impact of LM on BP is urgent. Consequently, more studies are needed to add to the existing literature to be capable of finding out the status of LM implementation and its impacts on BP, particularly from the developing countries' standpoint (Jasti and Kodali, 2014; Panizzolo *et al.*, 2012; Thanki and Thakkar, 2014). In addition, the existing facts and figures also indicate that there is no specific evidence regarding the level of LM implementation in the Indonesian context. Hence, this study attempts to survey the level of LM implementation among manufacturing firms in Indonesia in terms of flexible resources, cellular layouts, pull system, small lots production, uniform production level, quick setup, quality at the source, total productive maintenance and supplier networks. In unison, its impacts on BP (in terms of profitability, sales and customer satisfaction) are also investigated.

The paper has the following structure. This section introduces the study. It is followed by a review on the existing literatures and hypotheses' development in Section 2. Subsequently, Section 3 describes the research methodology. Section 4 then presents the result of data analysis, in which the results are discussed in Section 5. The paper closes with implications and limitations in Section 6 and suggestions for future research in Section 7.

2. Literature review

It is imperative to note that LM needs to have some basic practices to function well and yield better performance; these practices, as argued by Ahmad *et al.* (2003), Bhasin (2011) and Shah and Ward (2007), are not universal. As a result of that, different attempts by different researchers and practitioners were made to identify the main LM practices (Marodin and Saurin, 2013). Despite those attempts, overall consensus is still lacking. Some studies compiled a number of activities and grouped them into several practices. This study could incorporate many components into related practices, although it does not exhaust all the LM practices discussed within the literatures. As shown in Table I, common practices of LM used in previous studies were identified, namely, flexible resources, cellular layouts, pull system, small lots production, quick setups, uniform production level, quality at the source, total productive maintenance (TPM) and supplier networks. Even though this study does not comprise some of the LM elements deliberated in the literatures as separated components, many were integrated into related practices. Further, Table II displays the common measures of BP. It is seen that profitability, sales and customer satisfaction are categorized as the most frequently selected measures of BP (Ahmad *et al.*, 2004; Green and Inman, 2007; Nawanir *et al.*, 2013). BP encompasses the actual outputs of an organization viewing an organization as a whole and not just at the operational level.

Table I.
Common measures of LM

LM practices	Definition	Literature
Flexible resources (FR)	It is a practice of LM directing to achieve machine flexibility and employees' flexibility in a production system	1, 2, 3, 4, 7, 10, 12, 13, 15, 16, 19
Cellular layouts (CL)	It is a practice of LM combining flexibility of process layout with efficiency of product layout based on the concept of group technology to ensure flexibility of production layouts	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 18, 19
Pull system/Kanban (PS)	It is a production system that performs production processes just when requested by customers. Kanban is used to authorize production and material movement	1, 2, 3, 4, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19
Small lots production (SLP)	It is a type of a production process that produces small quantity of product at a time, with ideal lot size is one	4, 5, 6, 7, 11, 14, 15, 16, 17, 18
Quick setup (QS)	It is a practice of LM that focuses on reducing setup time in a production system	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
Uniform production level (UPL)	It is a practice of LM aiming to reduce variability at the production level caused by variability in customer demand	1, 3, 5, 6, 7, 8, 14, 15, 16, 19, 20
Quality at the source (QAS)	It is a practice to ensure that sources of the quality problem can be detected early and accurately, and at the same time, reworks can be done in small quantity, and each process supplies no defect unit to subsequent processes	1, 2, 3, 4, 7, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20
Total productive maintenance (TPM)	It is a maintenance concept combining preventive maintenance with total quality principles, aiming to maximize equipment effectiveness	1, 2, 3, 4, 6, 11, 12, 13, 16, 18, 19, 20
Supplier networks (SN)	It is a strategic and mutual collaboration between suppliers and manufacturer with a goal of waste elimination	1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 14, 15, 16, 17, 19, 20

Notes: 1 = Fullerton *et al.* (2003); 2 = Ahmad *et al.* (2004); 3 = Olsen (2004); 4 = Shah and Ward (2007); 5 = Abdallah and Matsui (2007); 6 = Matsui (2007); 7 = Dal Pont *et al.* (2008); 8 = Hallgren and Olhager (2009); 9 = Jayaram *et al.* (2008); 10 = Fullerton and Wempe (2009); 11 = Rahman *et al.* (2010); 12 = Taj and Morosan (2011); 13 = Yang *et al.* (2011); 14 = Furlan *et al.* (2011a); 15 = Furlan *et al.* (2011b); 16 = Panizzolo *et al.* (2012); 17 = Chavez *et al.* (2013); 18 = Losonci and Demeter (2013); 19 = Singh and Ahuja (2014); 20 = Thanki and Thakkar (2014)

BP measures	Definition	Literature
Profitability (PROF)	It is an ability to gain profit, which is measured in terms of profit margin, return on investment (ROI)	1, 2, 4, 6, 7, 8, 9, 12, 13, 14, 15, 16
Sales performance (SALE)	It is related to the ability to gain the targeted sales, which is measured in terms of market share and sales growth	6, 7, 8, 9, 12, 14, 15, 16
Customer satisfaction (CUST)	It is an ability of a company to serve and satisfy the customers in terms of lead time, overall quality of product, responsiveness and competitive prices of product	1, 3, 6, 7, 9, 10, 11, 12

Notes: 1 = Callen *et al.* (2000); 2 = Fullerton and McWatters (2001); 3 = Chong *et al.* (2001); 4 = Fullerton *et al.* (2003); 5 = Ahmad *et al.* (2003); 6 = Ahmad *et al.* (2004); 7 = Olsen (2004); 8 = Kannan and Tan (2005); 9 = Green and Inman (2007); 10 = Matsui (2007); 11 = Abdallah and Matsui (2007); 12 = Bhasin (2008); 13 = Fullerton and Wempe (2009); 14 = Yang *et al.* (2011); 15 = Agus and Hajinoor (2012); 16 = Losonci and Demeter (2013)

Table II. Common measures of BP

Profitability has frequently been measured by a number of criteria such as profit margins and return on investment (ROI) (Finch, 2008). Particularly, profit margin is defined as the profit generated per dollar of sales, while ROI is an indication of profit per dollar of assets, which shows how proficient management is, by its assets to make earnings (Finch, 2008). Numerous studies such as Bhasin (2013), Carlborg *et al.* (2013), Claycomb *et al.* (1999), Fullerton *et al.* (2003), Green and Inman (2007), Jasti and Kodali (2014) and Ringen *et al.* (2014) tend to suggest a significant impact of LM on profitability. Earlier, Callen *et al.* (2005), Karim and Arif-Uz-Zaman (2013) and Kinney and Wempe (2002) compared the profitability of LM and non-LM adopters. They provide scant evidence that the LM adopters are more profitable than the non-LM adopters. Consequently, many manufacturers have turned to LM to become more profitable (Bhamu and Sangwan, 2014). This is because by applying LM, non-value added activities are totally eliminated. This leads to the following hypothesis:

H1. The higher the level of implementation of LM practices, the higher the profitability.

One of the expected benefits of LM implementation is superior sales performance. In measuring the effectiveness and efficiency of sales in its relationship with LM implementation, sales performance is the commonly used term. Nevertheless, a number of previous studies also indicate that market share and sales growths are the prominent measures of sales performance (Ahmad *et al.*, 2004; Green and Inman, 2007; Olsen, 2004). Lean manufacturers continually concern on how to reduce or eliminate all the non-value-added activities in the entire supply chain network, making them struggle to improve their product quality (Nawanir *et al.*, 2013), lead time (Jasti and Sharma, 2014) and flexibility (Chavez *et al.*, 2013) in increasing their sales performance (Losonci and Demeter, 2013). In regard to that, Carlborg *et al.* (2013), Green and Inman (2007) and

Agus and Hajinoor (2012) confirmed that there is a significant effect of LM implementation on sales performance. In accordance, the following hypothesis is stated:

H2. The higher the level of implementation of LM practices, the higher the sales.

The fundamental objective of LM with customers is very simple and straightforward to satisfy the customers (Bhasin, 2013; Carlborg *et al.*, 2013; Zelbst *et al.*, 2010). Developing customer satisfaction is a valuable and profitable competitive advantage. Customer satisfaction depicts the degree to which customers perceive that they receive products and services that are worth more than the price they pay (Zhang *et al.*, 2006). In conjunction, companies implementing LM are encouraged to produce their products at a lower cost (Chen and Tan, 2011) without compromising quality (Sangwan *et al.*, 2014). At the same time, they can sell the products at a competitive price (Chauhan and Singh, 2013) and deliver quickly (Chavez *et al.*, 2013). In addition, LM companies attempt to satisfy the customers in terms of their responsiveness to sales enquiries (Green and Inman, 2007). Empirically, the studies conducted by Flynn *et al.* (1995), Sakakibara *et al.* (1997), Chong *et al.* (2001), Green and Inman (2007) and Abdallah and Matsui (2007) conclude that customer satisfaction is significantly affected by LM practices. Accordingly, the following hypothesis is posited:

H3: The higher the level of implementation of LM practices, the higher the customer satisfaction.

3. Methodology

This study has been carried out in a cross-sectional design. With organizations as the unit of analysis, they were issued a questionnaire with ordered options and close-ended questions. The measurement items for each measure were adapted from several sources (Table I and Table II). The extents of LM implementation and BP were measured on a perceptual scale using a five-point Likert scale:

(1) strongly disagree;

(2) disagree;

(3) neither agree nor disagree;

(4) agree; and

(5) strongly agree.

The BP was examined based upon the accomplishments in the past three years to lessen the influence of temporary changes in the variable. Specifically, for each measure, the levels of practices and BP were represented by the average of measurement item ratings for that measure.

The Data and Information Center of the Indonesian Ministry of Industry (2008) provided a complete list of 22,259 Indonesian manufacturers. All large manufacturing firms (more than 100 employees) are the population of this study; this is because those companies habitually implement LM rather than small and medium firms (Shah and Ward, 2003, 2007). In the end, stratified random sampling procedure was used, and 2,421 manufacturing companies were selected, out of which 1,000 companies were administered the questionnaire.

The questionnaires were distributed via mail to the middle and top management in production/manufacturing. The respondents were requested to fill in and return the completed questionnaire, in which a self-addressed stamped envelope was enclosed, within 15 days of receipt. To increase the response rate, a series of reminders followed via e-mail and telephone calls were sent after one month of the first attempt.

Out of the 1,000 questionnaires administered, 161 (16.10 per cent) were properly filled, completed and returned. It is good enough for a study conducted in a developing country. It meets the experience by Lazim and Ramayah (2010) on their response rate of 10.07 per cent among Malaysian manufacturing companies. Likewise, Hofer *et al.* (2011) obtained a response rate of 8.49 per cent among Chinese manufacturing executives. Similarly, a response rate of 12.60 per cent was obtained by Wong *et al.* (2009) in their study in Malaysian electrical and electronics industries.

After data screening, 139 responses remained; these comprise 11.51 per cent from paper and allied products; 10.07 per cent from chemical and allied products; 15.11 per cent from rubber and plastic products; 6.47 per cent come from non-metallic mineral products; 11.51 per cent were returned from basic metals and fabricated metal products; 5.76 per cent were duly filled and returned by the industrial machinery; 16.55 per cent from electronic, electrical equipment and components; 8.63 per cent from instrumentation; and 14.39 per cent were returned from motor vehicle and accessories. From the aforesaid composition, it could be said that the sample taken by this study provides reasonably representative industry coverage. Although the composition includes both a discrete part and continuous product industries, according to Shah and Ward (2003), universality of LM practices across the industrial continuum was unknown. In terms of respondents, manufacturing managers command 62.59 per cent of the majority of respondents; others comprise the heads of manufacturing department (20.86 per cent); manufacturing directors (5.04 per cent) and senior manufacturing engineers and LM implementers (11.51 per cent).

The data are analyzed by applying multivariate data analysis method, including correlation and regression analyses. Detailed data analysis steps are described in the next sections.

4. Results

4.1 Construct validity and reliability

In assessing construct validity, confirmatory factor analysis (CFA) was applied on each dimension separately because of the constraint in the sample size (Hair *et al.*, 2010), and assumption of unidimensionality among the items in one dimension. The results of CFA recommended omitting some measurement items. However, following the argument of Hair *et al.* (2010), this study retained the recommended-to-omit items with factor loading greater than 0.45. Having assessed the construct validity, results are exhibited in Table III. It is seen that all the retained items have factor loadings between 0.47 and 0.88. Besides, all the measures (except for flexible resource which was marginally considered) explain more than 50 per cent of the total variation of the particular measure. Outstandingly, the values of variance obtained in this study are better than those in previous studies in the literatures, such as Abdallah and Matsui (2007) (between 43.49 and 67.44 per cent). The Kaiser-Meyer-Olkin (KMO) measure, which was undertaken to determine whether items are adequate for each factor, was also ascertained. Kaiser (1974) recommended that KMO should be greater than 0.50. In this study, all the KMO values are greater than 0.50. Further, Bartlett's test reveals a significant result at

Table III.
Construct validity and reliability

Construct	No. of items	Range of factor loading	KMO	Eigenvalue	(%) Variance	Cronbach's α
LM Practices						
Flexible resources	5	0.47 to 0.83	0.72	2.33	46.57	0.69
Cellular layouts	4	0.63 to 0.81	0.70	2.02	50.40	0.66
Pull system	5	0.75 to 0.88	0.85	3.51	70.22	0.89
Small lot production	6	0.75 to 0.86	0.85	4.08	67.93	0.91
Quick setup	3	0.70 to 0.82	0.61	1.68	56.06	0.60
Uniform production level	4	0.64 to 0.79	0.72	2.01	50.31	0.67
Quality at the source	5	0.64 to 0.82	0.79	2.61	52.11	0.76
TPM	4	0.63 to 0.81	0.63	2.14	53.44	0.70
Supplier networks	8	0.62 to 0.82	0.87	4.35	54.38	0.87
BP Measures						
Profitability	4	0.62 to 0.82	0.60	2.10	52.46	0.70
Sales	3	0.60 to 0.82	0.57	1.60	53.30	0.56
Customer Satisfaction	4	0.63 to 0.79	0.70	2.09	52.29	0.68

α = 0.05 for all dimensions. These results explain that the questionnaire is valid and eligible (Coakes and Steed, 2007).

On the other hand, reliability was assessed using Cronbach's α. Referring to Table III, the α values range between 0.56 and 0.91, which are passable and acceptable as suggested by George and Mallery (2003) and Nunnally (1967). However, the α value is sensitive to the number of items in the scale. According to Pallant (2011), in a short scale, it is common to find a low alpha value. So that, in case of a short scale, Pallant (2011) suggests to report the mean inter-item correlation to justify the reliability. As cited by Pallant (2011), Briggs and Cheek (1986) recommended an optimal range for the inter-item correlation of 0.20 to 0.40. Regarding this, Table III shows that the α value for sales is the lowest (α = 0.56, consist of three items); however, the mean inter-item correlation among the items ranged between 0.29 and 0.38, which is considered acceptable. Thus, internal consistency of the questionnaire is satisfactory.

4.2 Non-response bias and common method variance

To examine the possibility of the non-response bias, the early responses (i.e. 89 respondents) and late responses (i.e. 50 respondents) were compared following the technique recommended by Armstrong and Overton (1977). Those responding to the first request were categorized as early responses, whereas those responding after the follow-up telephone calls or e-mails were categorized as late responses, which are considered as non-responding companies. The assessment was performed for all the measures of LM and BP. The results indicate that there is no significant difference (at α = 0.05) between the early responses and the late responses. In other words, there is no difference between responding companies and non-responding companies.

Besides, the issue of common method variance (CMV) was also handled, as the gathered data are perceptual basis and were obtained from single informants. In the first attempt, to control item-to-item priming effects, several items in the questionnaire were reverse-worded (Furlan *et al.* 2011a), which were reverse-scored (i.e. 1 indicates "strongly agree" and 5 indicates "strongly disagree"). Second, the CMV was statistically assessed through Harman's single-factor test (Podsakoff *et al.*, 2003). All the measures were loaded into an exploratory factor analysis. The results show the presence of multi-factors from the factor analysis, and therefore, it is unlikely that the CMV causes any bias among the researched measures. Third, Bagozzi *et al.* (1991) suggest anticipating the presence of CMV in the extremely high correlation among the measures. When there is no extreme correlation coefficient based on the results in Table IV, a substantial amount of CMV is not an issue in the study.

4.3 Descriptive statistics and Pearson's correlation

The descriptive statistics in Table IV reveal that the mean values of LM practices range between 3.27 and 4.22, with standard deviations between 0.46 and 0.99. These results imply that those Indonesian manufacturing firms do implement LM. Similarly, the BP measures show high mean values between 3.96 and 4.15, with corresponding standard deviations between 0.49 and 0.59. Further, there are significant correlations among all the LM practices at $\alpha = 0.01$ (Table IV). Even though a few values of the correlation coefficients (r) are low and medium, the majority of the r values among LM practices depict high correlations. Besides, the correlations between LM practices and BP measures are also confirmed positive (r values range from 0.16 to 0.48). In the end, it is ascertained that apart from one r value (the relationship between uniform production and sales) with $r = 0.16$ and significance at $\alpha = 0.05$, the entire r values are significant at $\alpha = 0.01$.

4.4 The relationship between Lean manufacturing practices and business performance measures

As normal distribution of data is required prior the regression analysis, the normality was appraised by using skewness–kurtosis statistics and normal probability plot. The results indicate that the normality assumption is fulfilled. Linearity and homoskedasticity assumptions are also not violated.

Furthermore, the results of multiple regression analysis show that the relationship between LM and BP measures is significant. As evidenced in Table V, the values of adjusted R^2 range between 0.14 and 0.37. In detail, profitability dominates the adjusted R^2 (37 per cent variance of profitability can be explained by LM practices). It is also discovered that the result of F-statistic testing $H0{:}R^2 = 0$ is significant for the entire BP measures at $\alpha = 0.05$. Even though F-statistics reveal significant result, most of the t-statistic testing $H0{:}\beta i = 0$ shows insignificant relationship at $\alpha = 0.05$. For instance, while sales are only supported by supplier networks ($p = 0.00$), customer satisfaction is supported by two LM practices, i.e. quality at the source ($p = 0.04$) and supplier networks ($p = 0.06$). Nevertheless, numerous regression coefficients depict a theory contradicting sign, such as the relationship between quick setups and customer satisfaction. Again, the coefficients bear the negative sign, whereas theory, common sense and correlation hold a positive relationship. These could be attributed to the likelihood of multicollinearity (Grapentine, 1997; Hair *et al.*, 2010; Mueller, 1996; Wang, 1996).

4.5 Decreasing the effects of multicollinearity among independent variables

The concept of Multicollinearity is interpreted to mean high correlation among independent variables (Agus, 2000; Hair *et al.*, 2010; Timm, 2002). In a multiple

Table IV. Descriptive statistics and correlation matrix of the variables

			LM Practices									BP Measures		
Construct	$\bar{x}$	SD	1	2	3	4	5	6	7	8	9	10	11	12
LM Practices														
FR	3.87	0.66	1											
CL	4.21	0.46	0.42**	1										
PS	3.59	0.99	0.58**	0.35**	1									
SLP	3.27	0.99	0.52**	0.26**	0.74**	1								
QS	3.84	0.65	0.39**	0.50**	0.30**	0.29**	1							
UPL	4.06	0.64	0.29**	0.40**	0.23**	0.26**	0.46**	1						
QAS	4.22	0.52	0.42**	0.43**	0.46**	0.41**	0.33**	0.42**	1					
TPM	4.12	0.53	0.45**	0.41**	0.56**	0.43**	0.40**	0.27**	0.48**	1				
SN	3.54	0.71	0.51**	0.34**	0.66**	0.53**	0.32**	0.23**	0.47**	0.52**	1			
BP Measures														
PROF	3.96	0.49	0.46**	0.31**	0.46**	0.45**	0.31**	0.26**	0.48**	0.48**	0.53**	1		
SALE	3.99	0.59	0.30**	0.23**	0.25**	0.20**	0.25**	0.16*	0.29**	0.24**	0.40**	0.46**	1	
CUST	4.15	0.51	0.38**	0.34**	0.40**	0.38**	0.24**	0.33**	0.46**	0.38**	0.44**	0.54**	0.41**	1

Notes: **Correlation is significant at the 0.01 level (one-tailed); *Correlation is significant at the 0.05 level (one-tailed)

IV: LM practices	Unstd. β	SE	Std. β	t	Significance	Unstd. β	SE	Std. β	t	Significance	Unstd. β	SE	Std. β	t	Significance
	DV: PROF					DV: SALE					DV: CUST				
Constant	1.42	0.37		3.82	0.00	1.97	0.53		3.76	0.00	1.56	0.42		3.72	0.00
FR	0.10	0.07	0.14	1.53	0.13	0.10	0.10	0.11	1.05	0.29	0.06	0.08	0.07	0.76	0.45
CL	−0.03	0.09	−0.03	−0.31	0.76	0.02	0.13	0.01	0.13	0.90	0.09	0.10	0.08	0.90	0.37
PS	−0.03	0.06	−0.07	−0.54	0.59	−0.05	0.08	−0.09	−0.61	0.54	−0.01	0.07	−0.02	−0.13	0.89
SLP	0.06	0.05	0.13	1.26	0.21	−0.03	0.07	−0.05	−0.42	0.68	0.05	0.06	0.10	0.87	0.39
QS	0.03	0.06	0.04	0.50	0.62	0.10	0.09	0.11	1.11	0.27	−0.05	0.07	−0.07	−0.75	0.46
UPL	0.00	0.06	0.00	0.02	0.99	−0.01	0.09	−0.02	−0.16	0.87	0.11	0.07	0.14	1.62	0.11
QAS	0.19	0.08	0.20	2.30	0.02	0.14	0.12	0.12	1.16	0.25	0.19	0.09	0.20	2.08	0.04
TPM	0.15	0.08	0.16	1.79	0.08	−0.02	0.12	−0.02	−0.20	0.84	0.07	0.09	0.07	0.73	0.47
SN	0.18	0.07	0.25	2.65	0.01	0.29	0.09	0.35	3.11	0.00	0.14	0.07	0.20	1.92	0.06
R^2			0.41					0.20					0.32		
Adjusted R^2			0.37					0.14					0.27		
Significant F			0.00					0.00					0.00		

Notes: IV = independent variable; DV = dependent variable

Table V. Results of multiple regression analysis on the relationship between LM practices and BP regression, the independent variables should not be highly correlated among each other. If so, one dimension can be explained by others; thus, it may complicate the interpretation on the relationship because of the difficulties to determine the cause of every particular measurement due to other inter-relationships (Hair *et al.*, 2010). In regard to that, Grapentine (1997), Liao (2010), Mueller (1996), and Wang (1996) suggest five signs of multicollinearity:

(1) high magnitude of the correlation coefficient (*r*) among the independent variables. For this sign, MacDuffie *et al.* (1996) underline that *r*-value of 0.60 is considered high;

(2) very high standardized beta of some relationship;

(3) high overall R^2 and *F*-statistics with some insignificant relationships;

(4) large standard errors; and

(5) theory contradicting signs (either positive or negative) of some regression coefficients.

Additionally, tolerance and variance inflation factor (VIF) are the two common indicators of multicollinearity. Some literatures, such as Lim *et al.* (2006), Miles and Shevlin (2001), Quresh *et al.* (2010) and Nawanir *et al.* (2010) recommend that if the value of tolerance is less than 0.40 and VIF is greater than 2.50, then serious multicollinearity may affect the analysis. Regarding that, Table VI exhibits the results from this study. It is seen that the values of tolerance and VIF of the pull system are 0.32 and 3.13, respectively. For production of small lots, tolerance and VIF are 0.43 and 2.32, respectively. These may introduce multicollinearity issue in the analysis, because the values are close to the recommended threshold. Nonetheless, to ensure the presence of multicollinearity, according to Liao (2010), condition indices, eigenvalues and variance proportion should also be considered, while VIF and tolerance alone are inadequate. Further, according to Lani (2009), it is conditioned that unless the condition index is between 15 and 30, multicollinearity becomes an issue. Meanwhile, a condition index greater than 30 points to a very serious multicollinearity. Likewise, if an eigenvalue is

Dimension	Eigenvalue	Condition index	Variance proportions									
			Constant	FR	CL	PS	SLP	QS	UPL	QAS	TPM	SN
1	9.813	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.082	10.945	0.01	0.00	0.01	0.08	0.18	0.01	0.01	0.00	0.00	0.00
3	0.026	19.442	0.00	0.00	0.00	0.11	0.50	0.03	0.09	0.00	0.01	0.21
4	0.017	24.134	0.06	0.01	0.00	0.16	0.12	0.58	0.00	0.05	0.01	0.02
5	0.015	25.321	0.01	0.53	0.01	0.02	0.00	0.00	0.30	0.00	0.00	0.18
6	0.015	25.863	0.00	0.00	0.00	0.50	0.15	0.13	0.10	0.01	0.00	0.49
7	0.013	27.632	0.03	0.41	0.01	0.01	0.03	0.09	0.36	0.00	0.13	0.07
8	0.007	36.400	0.05	0.05	0.25	0.05	0.00	0.00	0.07	0.02	0.74	0.01
9	0.007	37.510	0.11	0.01	0.11	0.00	0.01	0.07	0.06	0.90	0.02	0.02
10	0.005	43.633	0.73	0.00	0.61	0.07	0.01	0.08	0.00	0.01	0.08	0.00
VIF				0.56	0.62	0.32	0.43	0.63	0.69	0.60	0.56	0.50
Tolerance				1.79	1.61	3.13	2.32	1.60	1.45	1.68	1.78	2.00

Table VI. Multicollinearity diagnostic close to zero, then a serious multicollinearity is suspected. In addition, if a variance proportion value is greater than 0.30, then the multiple regression analysis is termed problematic. In this study, the results of multicollinearity are displayed in Table VI. Multicollinearity analysis shows that the dimensions in LM practices indicate condition indices greater than 15, while three dimensions are greater than 30. Also, there is an indication of a high condition index of one dimension (i.e. 25.86), which is associated with the pull system (with 0.50 variance proportions) and supplier networks (with 0.49 variance proportions). Thus, it indicates that there is a likelihood of β weights of pull system and supplier networks have not been estimated well (Liao, 2010; Pedhazur, 1997). Additionally, the closeness to zero of the eigenvalues of some dimensions is a strong indication of multicollinearity issue.

As a result, this study ran a simple regression on the first principal component (PC) score of independent variables to be able to reduce the consequence of multicollinearity (Agus, 2000; Hair *et al.*, 2010; Timm, 2002). The reason for this is that the PC analysis can summarize the majority of the variance into a least number of factors and the transformation of the original set of variables into a considerably lesser set representing nearly all the variance in the set of variables (Dunteman, 1989; Hair *et al.*, 2010).

4.6 The simple regression analysis on the relationship between combined Lean manufacturing practices and business performance measures

The results of the analysis of the first PC of LM practices indicate the following combination: 0.35 (flexible resources) + 0.31 (cellular layouts) + 0.38 (pull system) + 0.35 (small lot production) + 0.29 (quick setups) + 0.25 (uniform production) + 0.34 (quality at the source) + 0.35 (TPM) + 0.36 (supplier networks). This combination clearly explains 48.70 per cent of the change in the LM practices. Although the percentage of variance explained by the first PC score is marginally accepted, the value obtained in this study is comparatively better than the 46.15 per cent obtained in the study conducted by Shah and Ward (2003). These point out that the measures of BP are positively affected by the set of LM practices as depicted in Table VII. Thus, this implies that the LM practices comprehensively contribute to the BP, with good R^2 values

Model	Unstd. β	SE	Std. β	t	Significance	R^2
DV = PROF						
Constant	1.69	0.26		6.50	0.00	0.36*
Regression	0.20	0.02	0.60	8.82	0.00	
DV = SALE						
Constant	2.33	0.37		6.34	0.00	0.13*
Regression	0.15	0.03	0.36	4.53	0.00	
DV = CUST						
Constant	2.07	0.29		7.15	0.00	0.28*
Regression	0.18	0.03	0.53	7.22	0.00	

Notes: The first PC score of LM practices obtained from PCA is the IV; *F-statistics are significant at the 0.05 level

Table VII. The relationship between combined LM practices and BP measures: simple regression analysis for sales performance (13 per cent), customer satisfaction (28 per cent) and profitability (36 per cent) (at $\alpha = 0.05$). These sufficiently evidence that *H1*, *H2* and *H3* are not rejected.

5. Discussion

The implementation of LM contributes significantly to the enhancement of BP. However, to achieve expected benefits from the implementation, the companies ought to focus on the implementation of all the LM practices holistically instead of piecemeal adoption, because all the practices are interdependent. The analysis indicates that the linear combination of LM practices has positive loading and close resemblance values among themselves with about 49 per cent of the change in LM practices. Thus, each practice has an equal representation in the linear combination (Agus, 2000; Dunteman, 1989; Lim *et al.*, 2006). Again, the importance of all LM practices is about the same. Several studies support this result, such as Dabhilkar and Åhlström (2013), Furlan *et al.* (2011b), (2011a), Singh and Ahuja (2014) and Shah and Ward (2003, 2007).

As argued by Shah and Ward (2003, 2007), "bundles" of LM practices, depict a high inter-correlation and inseparable features among them. Recently, Dabhilkar and Åhlström (2013) postulated that plants having an integrated adoption of LM principles are believably more successful, which in turn leads to improved organizational performance. Additionally, Furlan *et al.* (2011a), Dal Pont *et al.* (2008) supported the complementarity among the LM practices. In the perspective of complementarity theory, separate practice cannot be independently polished up to achieve better performance. In this study, the results show that LM practices tend to be adopted together because they are complementarity, inter-dependent or mutually supportive among each other. It is suspected that the total impact on the ongoing improvement will be marvelously greater than adopting it as a standalone practice (Nawanir *et al.*, 2013). In fact, according to Milgrom and Roberts (1990), Tanriverdi (2005), implementing single organizational practice without implementing the others may not produce the desired improvement; it may even reduce overall organizational performance. In short, when all the practices comprehensively collaborate, they would significantly enhance the performance development within a company.

The correlation and regression analyses imply a positive relationship between LM practices and BP measures, in which it illustrates that LM practices significantly lead to all the BP measures. Therefore, the results offer strong supports that a rise in LM implementation leads to a corresponding rise in BP. Several investigations have been conducted to ensure the impact of LM on the ability of companies to make superior profit. As an example, Claycomb *et al.* (1999), Fullerton *et al.* (2003), Green and Inman (2007) and Hadid and Mansouri (2014) suggest a significant impact of LM practices on profitability. LM aims to increase value-added activities, and, at the same time, reduce non-value added activities within a production system. Hence, LM strategy helps companies to increase net income and profitability through eliminating costs and increasing revenue. In terms of sales, Parry *et al.* (2010) provide similar evidence that better sales performance can be gained by improving their processes, especially in the shop floor. Eventually, customer satisfaction was found to be influenced by the implementation of LM in the production system. Particularly, customers are satisfied when their expectations regarding services or products are met or exceeded (Krajewski and Ritzman, 2005). In other words, if the products and services meet their expectation, then the customers are well satisfied. In LM, by reducing the costs without compromising the quality, products could be marketed at competitive prices and ensured quick and efficient delivery. Hence, the LM implementation leads to a high customer satisfaction.

Having understood that Agus and Hajinoor (2012), Chong *et al.* (2001), Forrester *et al.* (2010), Losonci and Demeter (2013), Rahman *et al.* (2010), Yang *et al.* (2011) support that LM has positive significant consequences on BP. In a similar fashion, in the context of Malaysian manufacturing companies, Agus and Hajinoor (2012) revealed that LM practices could help Malaysian manufacturing companies enhance their BP. Forrester *et al.* (2010) also revealed alike findings in the study of agricultural machinery in Brazil that significant improvement in BP as well as competitive power is due to LM practices. Also, the results in this study agree with Wong *et al.* (2009) who hold that the resultant improvement in profitability and response time of electrical industries in Malaysia is as a result of LM implementation. From Thai manufacturers' perspective, it has been observed that LM practices offer a significant contribution to better customer satisfaction of small, medium and large manufacturers (Rahman *et al.*, 2010). Hence, this study supports the postulation that the application of LM is also evident in the developing countries and not only in the developed countries.

6. Implications of the study

The relationship hypothesized in this study is empirically and theoretically supported. In particular, the study has further confirmed and established the LM practices–BP relationship. The study contributes to the body of knowledge and theories on how BP is influenced by LM. Additionally, this study provides an insight into simultaneous implementation of all the LM practices, which is in line with the complementarity theory. According to Lee *et al.* (2010), companies that gain superior performance and competitive advantage through complementarity of organizational practices (such as LM) are expected to sustain in the competitive advantage over a long period of time.

From the practical perspective, the results offer several suggestions to practitioners. This study avails them with opportunities to expand their knowledge regarding the impact of LM on BP. To survive in today's global competitive business, modern manufacturing companies should increase their organizational performance through the implementation of LM. As LM encourages the company to produce without waste, the production will become more effective and efficient, and subsequently enhance the BP.

The study confirms that the achievement of high BP is dependent upon the implementation of LM practices as a whole, instead of piecemeal. From the context of implementation, to succeed, managers and practitioners should simultaneously implement all the LM practices in a holistic manner. In other words, the potential benefits of its implementation cannot fully be realized until all the practices are integrated. The implementation of isolated practices or piecemeal adoption tends to fail in achieving the desired performance (Alves *et al.*, 2012; Dora *et al.*, 2013) because all the practices are mutually supportive. The implementation of an individual LM practice may also improve the contribution of other existing practices. These arguments are supported by Dombrowski *et al.* (2012) who state that Western companies did not achieve the expected results of LM implementation, because they failed to implement an integrated LM system, whereas they had used isolated practices. Thus, it can be clinched that managers should adopt a simultaneous and holistic approach of LM implementation, rather than applying them in isolation. This can be ensured through operations' standards, in which they describe the current practices and could be used as a basis to ensure that all the operations are performed in the similar way all the time, and is continually improvised (Inamizu *et al.*, 2014). In fact, that standard, which is called standard operating procedures provides all the required details and decision branches required to perform a given practice. They are intended to be followed without deviation. They may contribute significantly to achieve uniformity of LM implementation at any point of time. This hints that to succeed in applying LM, the standard operating procedures must be in place.

7. Limitations and suggestions for future research

As in all survey-based research, a postulation in data collection is that the participants had plentiful knowledge to participate in the present study. The data characterize self-reporting by mainly the middle or top management positions in manufacturing. Although common method variance was absent in this study, as indicated in the results of Harman's single factor test (Podsakoff *et al.*, 2003), future researchers should consider of collecting data from multiple individuals in one company. In addition, it should be noted that this study collects data from nine industries categorized as large companies (i.e. paper products, chemical products, rubber and plastic products, non-metallic mineral products, basic metals and fabricated metal products, industrial machinery, electronic and electrical equipment and components, instrumentation and motor vehicle and accessories). It may not be applicable to other industries or small and medium enterprises (SMEs). Hence, studying LM in other industries and in the SME context could enrich the LM literatures.

8. Conclusion

This study postulates that LM implementation contributes significantly to the enhancement of BP. However, to achieve the desired performance, all the LM practices must be implemented in a holistic manner because of the mutually supportive nature among them. The findings may help to explain the mixed results from prior studies examining performance effects of LM.

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