

# Less for More: The Structural Effects of Lean Manufacturing Practices on Sustainability of Manufacturing SMEs in Malaysia

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**Abstract** - As one of the important determinants of the health of the global economy, small and medium enterprises (SMEs) are responsible for several environmental degradations. The increase in resource consumption, climate change, biodiversity, water scarcity, and demographic changes and instability triggered society to consider sustainability issues. One of the operational initiatives related to sustainability is lean manufacturing (LM), which has become an imperative factor of organizational excellence in today's volatile competitive market. However, it remains a critical question, does it positively affect corporate sustainability? This quantitative cross-sectional study examined the impact of LM on the triple bottom line (3BL) dimensions. A total of 159 manufacturing SMEs in Malaysia participated in this study. The analysis using the structural equation modeling (SEM) approach evidenced that the holistic implementation of LM practices contributes positively to all dimensions of 3BL. It implied that in order to enhance sustainability performance, SMEs should adopt the LM concepts holistically. This paper extends the boundary of knowledge by lessening the existing gaps in the literature to support the notion of potential implications LM on sustainability. Practitioners could grab benefits by understanding the critical initiatives and strategies towards the future sustainability of their businesses.

**Keywords**-Lean manufacturing; sustainability; triple bottom line; economic performance; environmental performance; social performance; manufacturing SMEs

## 1. Introduction

Sustainable development should be considered as an ultimate goal for all organizations. In the current industrial volatile situation with serious resource crises, business players are inspired to apply approaches to sustain their businesses while targeting competitive advantage. As the world population increases significantly and with the expectation up to 9 billion people by 2050, and non-renewable natural resources are becoming exhaustible,

scarce, challenging, and difficult to acquire; organizations should embrace sustainability issues as a top priority [1]. Even though some corporations have documented that no business can be established on a dead planet, some of them still perceived that protecting the environment and considering the social effects of their operations may sacrifice profitability and operational performance [2]. Specifically, the mechanism of how a business achieves its profitability and operational performance while considering environmental and social aspects appears unclear.

Recently, the increase in resource consumption, climate change, biodiversity, water scarcity, and demographic changes and instability triggered the society to consider sustainability issues by taking the triple bottom line dimensions (or otherwise noted as 3BL) [3] into organizational activities. The 3BL framework encompasses an inter-related combination of environmental, economic, and social aspects. This framework suggested that organizations must obligate to focus on social and environmental dimensions of their undertakings just as they do on economic aspects. The economic performance focuses on maximization of financial benefits through gaining various kind of wealth, such as profit, sales, revenue, return on investment, etc. [4], whereas the social aspect focuses on maximizing the human well-being that covers social value, social identifies, social relationship and social institution, and the environmental sustainability concerns on avoiding negative effects of organizational activities on environment as the consequences of the consumption of energy and natural resources [5]. In other words, besides focusing on profit, the companies must also consider the effects of their operations on the people and planet. Therefore, multidimensional aspects must be integrated beyond the traditional indices, such as profit, market share, and sales. Organizations should also embrace environmental and social characteristics. In order to leverage its operational achievement, a company should consider to apply an integrated operational enhancement initiative along with the sustainability practices.

One of the initiatives that appear to have a link to sustainability is lean manufacturing (LM). In order to leverage companies' sustainability, some literature [1, 6, 7] highlighted that companies have to eradicate all non-value added activities along the supply chain networks. Ohno [8] defined waste as "anything other than the minimum amount of equipment, materials, parts, and working time which is absolutely essential to add value to the product or service." While products may significantly vary between organizations, the typical wastes existed in any organization are relatively similar, which are transportation, excess inventory, unnecessary motion (of operators, machines/equipment, materials), waiting (of operators, machines/equipment, materials), over-processing, overproduction, defects (including scraps), and under-utilized skills. LM has been deeply rooted in literature as one of the common approaches focusing on waste elimination. The majority of the empirical research [9-11] focused on the positive contributions of LM implementation on operational and economic performance (e.g., profitability, quality, cost, flexibility, inventory, etc.). Nevertheless, there is a necessity to deliberate performance from a multidimensional perspective looking at environmental and social implications. It becomes more important as the studies on the implications of LM on these aspects still lack consensus and the issues tended to be neglected in the current literature [1, 2]. Therefore, the implications of LM on long-term sustainability (in terms of the three pillars of 3BL) still needs further exploration. By understanding such implications, economic, environmental, and social performance dimensions can be integrated [12].

Previous studies, such as Siegel, et al. [13], Thanki and Thakkar [14], and Caldera, et al. [15] noted that, to a great extent, SMEs are responsible for several environmental degradations (e.g., air and water pollutions, waste production, etc.). While LM was gradually deliberated and used as a catalyst for better performance [9, 10, 13, 16], the implementation of LM in several organizations (including SMEs) is difficult due to various operational issues as well as an insufficient understanding on its practices and significant benefits towards organizational performance and sustainability [17], besides some limitations in terms of resources availability and various barriers. This situation implied that SMEs need references to guide them in applying LM practices along with implications, benefits, and challenges/barriers to leveraging organizational performance. However, the research data shows that most of the existing literature on LM has been focusing in the context of large organizations. The discussion relating LM and sustainability issues among manufacturing SMEs is still limited and deserves attention [13]. Consequently, the presented results and suggestions from the studies may not be applicable for the SMEs context [18-20]. The results may not be consistent with the reality of SMEs [21]. Given the importance and pivotal role of SMEs in the global economy because of their essential roles as important engines of economic growth and innovation by serving small markets, the identifications of critical practices of LM and predicting their contributions on sustainability performance must be studied. The investigation on this issue is critical because globalization, immediate technological changes, and augmented competitive pressure have a crucial effect on manufacturing SMEs all over the world [12]. SMEs should

leverage their management approaches to advance economic, social and environmental performance without large expenditure or considerable changes. This study focuses on scrutinizing the potential contributions of LM towards the sustainability of SMEs in Malaysia, which contribute to total GDP of the nation up at 38.3% in 2018 [22]. In addition, this study is hoped can support the sustainable development goals of Malaysia targeting protection of the planet, while ensuring prosperity for all.

This paper begins with the introduction section. Following this section, the results of the literature review and research hypotheses will be presented. The next sections will elaborate on the research design and data analysis results. This paper ends with some research implications and suggestions for further studies.

## 2. Literature Review and Hypotheses Development

LM was originally invented by the Toyota Manufacturing Corporation in the 1950s through its extraordinary manufacturing system, which was familiar with the Toyota Production System (TPS). In its development, the principles of TPS were then actively adopted by the US and European manufacturers under the name of "lean". Lean means "less" and at the same time "more" [23]. Less is in terms of non-value-added activities, costs, defects, lead time, space, number of employees, number of suppliers, and inventory. On the other hand, it can also mean more in terms of quality, productivity, sales, customer satisfaction, profitability, and sustainability. Due to its superior contributions, numerous corporations all over the globe endeavor to adopt the LM principles to increase their performance. Nowadays, the adoption of LM practices has been going far beyond its origin (i.e., automaker industry), expanded not only in large companies but also SMEs.

In order to achieve the targeted performance, LM practices must be in place. However, the literature review indicated that different research works have proposed different sets of practices. The practices diverse depending on the researchers' backgrounds. It may cause the mixed findings in the previous studies. Some studies, such as Nawanir, et al. [24], Phan, et al. [25], and Wickramasinghe and Wickramasinghe [26], suggested that the implementation of LM positively affects companies' performance. Differently, other investigations reported that some organizations experienced limited success in the implementation of LM. Kinney and Wempe [27] provided evidence that the enhancement of profitability was concentrated among the earliest LM adopters since the companies that have implemented LM longer (e.g., five and six years) are no longer unveiled higher profitability. Furthermore, Balakrishnan, et al. [28], Ahmad, et al. [29], and Maalouf and Gammelgaard [30] revealed that LM implementation does not necessarily enhance financial performance. Hence, the implications of LM implementation on organizational performance were mixed in the current literature. In order to deal with this issue, this present study compiled common practices of LM in the literature to provide a more comprehensive set of LM practices. Table 1 shows the practices of LM, definitions, and supporting literature.

**Table 1.** Practices of LM

Practices	Definition	Literature
Uniform Production Level	Uniform production aims to diminish the variability of customer demands, which includes some activities, such as uniform workload, repetitive schedule, and daily schedule adherence.	Nawanir, et al. [11], Phan, et al. [25], Belekoukias, et al. [31]
Flexible Resources	Flexible resources are aimed at achieving flexibility of production system including machine, employee, volume, product mix, routing, and supply. These flexibilities could be achieved from several activities such as employee involvement, multifunctional workers, multifunctional machines/equipment, and cross-training for workers to be able to perform multiple tasks.	Nawanir, et al. [11], Khanchanapong, et al. [32], Belekoukias, et al. [31]
Cellular Layouts	Cellular layouts group different types of machines and equipment into cells to process products with comparable requirements. In this layout, process layout and product layout are combined to enhance flexibility and efficiency.	Metternich, et al. [33], Sundar, et al. [34], Marodin and Saurin [35]
Small Lots Production	Small lots production aims at producing a smaller quantity of product at a period of time. In other words, the flow of materials should be in the smallest lot sizes as possible (i.e., one-piece flow). The smaller the lot sizes, the higher the ability of the production line to produce as per the customers requested.	Nawanir, et al. [11], Phan, et al. [25], Jasti and Kodali [36]
Quick setup	Quick setup focuses on reducing setup time from processing one particular product to another. Using the principle of Single-Minute Exchange of Die (SMED), internal setups are converted into external setups to ensure that most of the machine setups are performed while machines are still in operations.	Solke and Singh [37], Phan, et al. [25], dos Santos Bento and Tontini [38]
Total Productive Maintenance (TPM)	TPM combines preventive maintenance with total quality principles to avoid breakdown, achieve zero defects while ensuring availability, effectiveness, efficiency, and optimum conditions of machines and equipment.	Garza-Reyes, et al. [39], dos Santos Bento and Tontini [38]
Quality at the Source	Quality at the source ensures quick and accurate detection of any quality problems. If a quality problem is detected, the machine or production line will automatically stop and the operator can discover the root-cause quickly and solve the problems immediately. This practice guarantees the quality of products and processes.	Zahraee [40], Godinho Filho, et al. [21], Jasti and Kodali [36]
Supplier Networks	Supplier networks aim at ensuring strategic collaboration and partnership between buyers and suppliers for mutual benefits. This practice ensures continuous improvement, information sharing, and performance excellence of buyers and suppliers.	Nawanir, et al. [41], Godinho Filho, et al. [21], Khanchanapong, et al. [32]
Pull System/ <i>Kanban</i>	The pull system is the main principle of LM to ensure production or material movement is performed just as it is needed. <i>Kanban</i> is a work signaling system to trigger and authorize the production and material movement; thus, it controls the pull system to be applied appropriately.	dos Santos Bento and Tontini [38], Al-Zu'bi [42], Zahraee [40]

Several studies suggested that LM practices should be implemented holistically because of the collaborative nature among the practices [11, 32, 43]. Specifically, the implementation of each practice is interdependent with others. Therefore, partial adoption of LM or practicing them in isolation is not advisable because the implementation of one should be supported by other practices, which is consistent with the complementarity theory invented by Edgeworth [44] and popularized by Milgrom and Roberts [45], Milgrom and Roberts [46]. This concept was widely adopted in prior studies on LM, such as Nawanir, et al. [47], Khanchanapong, et al. [32], and Furlan, et al. [48] to highlight the complementarity nature among the LM practices. In addition, the study by Nawanir, et al. [11] set LM as a second-order construct with nine first-order constructs because of the practices are strongly related and tend to be adopted concurrently without putting any practices aside. Hence, this research hypothesized:

**Hypothesis 1:** LM practices are strongly interrelated and complement each other.

Yet several investigations scrutinized the effect of LM on environmental performance [49, 50] and financial performance [51, 52], the simultaneous effects of LM on the sustainable performance of manufacturing SMEs received fewer attentions [53]. More attention to the sustainable effects from the implementation of LM should be given as sustainability is considered as one of the main pre-requisites for competitive advantages. In this perspective, in order to realize sustainability, SMEs should deliberate economic, environmental and social aspects by LM initiatives [13]. This is in line with the idea from Elkington and Rowlands [3] who

highlighted that the company must be managed in a way that not only profit-oriented but which also improves people's lives while sustaining the planet.

Economic sustainability performance deals with economic values generated by an organization after deducting the costs of all resources. This performance measure focuses on various capitals, such as man-made, human, natural, and social that should be sustained. It reflects the financial organization that mostly related to industrial costs. One of the central views of LM is minimizing all types of waste, which consume resources but do not contribute to the value creation of products and processes. In line with this logic, there is extensive evidence saying that LM positively affects the economic performance of an organization, especially through the achievement in operational performance measures [2, 41, 52], such as quality, flexibility, inventory minimization, costs reduction, and productivity. Hofer, et al. [54] highlighted the importance of inventory leanness through LM implementation towards financial performance. Interestingly, Leon and Calvo-Amodio [2] elaborated on how LM can improve economic performance. The study highlighted that economic performance could be enhanced through operational costs reduction, better yields, higher flexibility, and better environmental performance. In short, as LM targets to enhance value-added activities while reducing all wastages, LM potentially assists companies to create higher income and profitability through the elimination of costs. Therefore, it leads to the following hypothesis:

**Hypothesis 2:** The holistic implementation of LM practices improves economic sustainability performance.

Today's environment is suffering due to some ecological issues like global warming, acid rain, air and water pollutions, waste disposal, ozone layer exhaustion, climate change, and many more. These issues subsequently can give major negative impacts on human lives, animals, plants, and nations on the planet. Abdul-Rashid, et al. [55] stated that environmental performance depends on the use of cleaner sustainable resources. To overcome the environmental challenges, exploring the opportunities and developing better strategies (e.g., LM implementation) to encounter sustainability requirements. In this perspective, several studies have conceptually elaborated on the potential of LM practices, methods, and tools in securing the environment. For instance, Garza-Reyes [56] highlighted that as LM, which focuses on waste elimination, provides better pre-condition to diminish environmental waste, such as exaggerated consumption of natural resources. In line with Garza-Reyes [56], Mollenkopf, et al. [57] suggested lean manufacturers are more likely to accept environmental innovations.

More importantly, Garza-Reyes [56], Garza-Reyes, et al. [39], and Farias, et al. [9] revealed the alignment between the main objectives of LM and good environmental objectives. LM emphasizes the elimination of eight common waste. The eliminations in over-production, over-processing, excessive transportation, and defects (including scraps, non-workable products, warranty claim, product return, etc.) do not only enhance organizational performance through cost reduction but also reduce the consumption of resources, eliminate air and water pollutions, waste disposal, etc. Minimization of inventory may reduce the use of space/storage, electricity, and other resources. In some cases, certain inventory items need heating and chilling, which thus consumes energy and give negative effects on the environment. Hajmohammad, et al. [58] empirically investigated how LM can improve the firm's environmental performance. The study highlighted that the use of flexible resources (i.e., flexible machines and workers) is favorable to enhance the effectiveness of production processes, which indeed supports sustainable environment initiatives. Similarly, Chiarini [59] studied how LM practices and tools contributed towards a sustainable environment among the European motorcycle component manufacturers. The study reported that value stream mapping helps to identify environmental issues caused by manufacturing processes, 5S improves waste management, and cellular manufacturing reduces energy consumptions. In addition, TPM eliminates oil leakages, dusts emissions and chemical fumes into the atmosphere. Therefore, the following is hypothesized.

**Hypothesis 3:** The holistic implementation of LM practices improves environmental sustainability performance.

Besides targeting their economic and environmental performance, manufacturing industries should ensure that their industrial operations and activities do not cause social damage. Sroufe and Gopalakrishna-Remani [60] defined social sustainability performance as the ability of an organization to reduce the negative social impacts of its operations, besides achieving a variety of its social goals. In other words, the social aspect of sustainability reflects how socially responsible a company throughout its operations. The social sustainability performance helps to maintain the cohesion between an organization and its society [4]. Even

though the implications of LM implementation on economic and environmental performance have been addressed repeatedly in previous studies, Cherrafi, et al. [12] and Leon and Calvo-Amodio [2] noted that social implications of LM adoption have not been fully explored and discussed in academic research. Even though the limited investigations on the social implications of LM implementation, LM is believed to have a positive effect on social sustainability performance [13] through ensuring that the industrial operations do not cause negative social implications while maintaining human life quality [61]. However, review on the literature leads to the hypotheses that LM potentially improves social performance through the creation of cleaner production, less stress of workers, and better/safer workplace [2], higher participation of workers and more variety of works [47], better working condition and more job satisfaction [62], increasing morale of workers [63], enhancement in skills of workers [23, 31], better productivity [11], etc. As such, this evidence provides strong support to the following hypothesis:  
**Hypothesis 4:** The holistic implementation of LM practices improves social sustainability performance.

### 3. Methodology

To predict the structural effects of LM on sustainability performance measures, a survey questionnaire with ordered options was designed as a tool for data collection. The questionnaire consists of three sections. Section 1 encompassed general information about respondents and their companies, whereas section 2 emphasized the implementation of all the LM practices. The questions were adopted from the validated LM constructs by Nawanir, et al. [47]. Section 3 assessed sustainability performance measures looking at the achievement of the companies during the past five years. The measurements were adapted from several sources, such as Sajan, et al. [64], Nawanir, et al. [24], and Abdul-Rashid, et al. [55]. In both of the sections (2 and 3), the respondents answered the questions based on the five-point interval scale from 1 (strongly disagree) to 5 (strongly agree). The data collection instrument was pre-tested through an extensive focus group discussion (FGD) with experts consisting of two manufacturing managers and four academicians to ensure its content and face validity. Finally, the instrument was improved based on the results of the FGD. To ensure the fitness of the questionnaire with the nature of research context, some of the measurement items were modified, added, and discarded.

The samples were designated based on the directory published by SME Corporation Malaysia [65] recording a total of 7,988 manufacturing SMEs from eight industries (i.e., electronics and electrical, automotive, machinery, textiles, fabricated metal, rubber and plastic products, furniture, and leather and related products). In the context of Malaysia, a company is categorized small if it has 5 to 74 employees or sales turnover between RM300 thousand to less than RM15 Million. Whereas, a company having 75 and 200 employees or sales turnover above RM15 Million and less than RM50 Million is considered medium. This study was focused on the adoption of LM in companies producing discrete products to avoid bias in relating the findings with literature. By using a proportionate cluster random sampling procedure, the sample members were drawn from the population. A total of 700 manufacturing SMEs were invited to involve in the survey in

order to achieve a satisfactory response rate. The targeted respondents are companies' senior management who manage manufacturing operations. A uniform resource locator (URL) of the online questionnaire was disseminated via email to the targeted respondents. To maximize the response rate, a series of reminders were sent after three weeks of the first attempt.

#### 4. Results

After three months from the first attempt, a total of 171 responses were received. However, 12 responses are unusable due to invalid respondents and blank responses. Therefore, 159 responses were used for the subsequent data analysis, leading to a 22.71% effective response rate. The companies consisted of 17.62% automotive and vehicle, 23.27% electronics, electrical, and instrumentation, 8.81% rubber and plastic products, 12.58% fabricated metal, 10.41% leather and related products, 12.58% furniture, and 15.09% textiles related products. Based on the respondents' positions in their company, the majority of them hold production managers (40.25%), head of production departments (32.70%) and production directors (27.04%). Most of the respondents have been serving in the company for more than 5 years (63%), whereas 37% of them served their organizations between 3 and 5 years. Therefore, the respondents were holding the companies' senior management positions, who were familiar with their manufacturing operations and performance.

Data were analyzed using Structural Equation Modeling (SEM) approach. This approach allows the simultaneous assessments of the structural relationships among multiple variables. Thus, measurement errors are well controlled. In addition, SEM provides a more complete analysis of the inter-relationship among the variables. The SmartPLS 3.2.9 software [66] was chosen as a data analysis tool because this research is exploratory in nature, besides it makes a minimum demand on the data distribution and sample size. A two-step approach involving measurement model and structural model assessments was applied in the analysis stage.

##### 4.1. Measurement Model Assessment

Since this study had reflective and formative measures, the construct validity of the reflective model was first assessed to indicate how well the measurement items assigned to a construct are truly measuring it. For this purpose, the convergent and discriminant validity was used as the criteria. Convergent validity measures the degree to which the measurement items of a construct converge together, which reflects the correlations among the items measuring the construct. Convergent validity was specified by outer loadings, average variance extracted (AVE), and composite reliability (CR). The outputs of the convergent validity assessment are shown in Table 2. Based on the table, some of the measurement items were deleted because the outer loadings are below the critical value of 0.4 [67]. In addition, AVE and CR values show the adequate convergent validity for all constructs as all values exceed 0.5 and 0.7, respectively [68]. By using the repeated indicator approach, a second-order construct of LM was subsequently assessed. Table 2 shows that the outer loadings of first-order constructs are greater than or equal to 0.4. Therefore, convergent validity was confirmed for both first and second-order constructs.

Subsequently, to ensure the uniqueness of the constructs, a discriminant validity assessment was performed by comparing the square root of AVE value of a construct with the correlation coefficients of that construct with other constructs [69]. Table 3 shows that all reflective measurement models have adequate discriminant validity as the square root of AVE values of all construct are higher than the correlations with any other constructs. In a nutshell, all constructs distinct from each other.

To validate the formative constructs, this study conducted a redundancy analysis to determine "whether, jointly, the formative indicators represent the construct of interest adequately" [70]. For this purpose, this study opted for a global single-item as a criterion variable [67]. For the economic performance, this study involved asking for respondents' agreement on "The overall economic performance of our company during the past five years has been outstanding" for its global item. A similar question was also asked for both environmental and social performances. Table 4 summarizes the construct validity of formative constructs. Specifically, the standardized beta value for the relationship between the formative construct economic performance and its global item is 0.840. Alike, the beta values for environmental and social performance are 0.831 and 0.867, respectively. Therefore, the redundancy analysis specified that the formative indicators represent the construct adequately as all the values of standardized beta are higher than 0.8, which supports the global single item's convergent validity [67, 70]. The next assessment on the formative construct was the outer variance inflation factor (VIF) to ensure the absence of multicollinearity between the formative indicators. The results proofed that all the indicators of economic, environmental, and social performance yield VIF values lower than the threshold of 3.3 [71]. Therefore, VIF values did not indicate any redundancy between the formative indicators. Subsequently, indicator weight significance was assessed. Ten indicator weights were found to be insignificant (i.e., ECSP1, ECSP3, ECSP5, ECSP6, ECSP7, ENSP1, ENSP2, ENSP3, ENSP5, and SSP3). However, they should not be interpreted as a poor measurement model quality. Following Hair, et al. [67] and Cheah, et al. [70], the indicators outer loadings of the insignificant weights should be assessed. The result showed that one indicator (i.e., ENSP2) has high outer loading ( $> 0.5$ ); thus, the item should be interpreted as absolutely important and would be retained. The remaining nine items were examined its theoretical relevance and potential content overlap with other items of the same construct [67]. Finally, three items were decided to be deleted (i.e., ECSP3, ECSP5, and SSP3) as the theory-driven conceptualization does not strongly support the indicators inclusion. Based on the result of the measurement model assessment for both reflective and formative constructs, it can be concluded that construct validity is satisfactory.

Subsequently, to test the first hypothesis stating the inter-relationships among the LM practices, loadings of first-order constructs and correlation coefficients among the practices were considered. Table 2 shows that the outer loadings range between 0.400 and 0.854, with 50.70% AVE of the second-order construct LM. Although the outer loading of SN is slightly low, it is still considered sufficient. Besides,

the correlations coefficients between LM practices range between 0.165 and 0.712 (see Table 3). Based on the rule of thumb [72], the majority of the correlation coefficients (28 out of 36) range between medium (from 0.30 and 0.49) and strong

correlation (0.50 and above). Therefore, the first hypothesis stating the complementarity nature of the relationship between the LM constructs can be supported.

**Table 2.** Convergent Validity of Reflective Constructs

Construct	Item Code	Item	Outer Loading	AVE	CR
<b>First Order Constructs</b>					
CL	CL1	The machines are in close proximity to each other.	0.696	0.543	0.826
	CL2	Production facilities are arranged in relation to each other, so that material handling is minimized.	0.775		
CL3*	CL3*	The machines can be easily moved from one workstation to another	-	0.751	
	CL4	We group dissimilar equipment into a workstation to process a family of parts with similar requirements (such as shapes, processing or routing requirements).			
	CL5	Families of products determine our factory layout.	0.723		
	FR	FR1*	If a particular workstation has no demand, the production workers can go elsewhere in the manufacturing facility to operate a workstation that has demand.		
FR	FR2	If one production worker is absent, another production worker can perform the same responsibilities.	0.747	0.827	
	FR3	We use general-purpose machines, which can perform several basic functions.			
	FR4	When one machine is broken down, a different type of machine can be used to perform the same jobs.	0.746		
	PSK	PSK1*	To authorize orders to suppliers, we use supplier <i>Kanban</i> that rotates between factories and suppliers.		
PSK	PSK2	We use a <i>kanban</i> system to authorize material movements.	0.594	0.818	
	PSK3	We use the pull system (producing in response to demand from the next stage of the production process) to control our production rather than schedule prepared in advance.			
	QAS	QAS1	We use visual control systems (such as <i>andon</i> /line-stop alarm light, level indicator, warning signal, signboard, etc.) as a mechanism to make the problems visible.		
QAS	QAS2*	Quality problems can be traced to the source easily.	-	0.823	
	QAS3*	We have the quality-focused teams that meet regularly to discuss quality issues.			
	QAS4	The production workers are authorized to stop production if serious quality problems occurred			
	QS	QS1	The production workers perform their own machines' setups.		
QS	QS2*	We are aggressively working on reducing machines' setup time.	-	0.746	
	QS3	We emphasize to pull all the tools in the normal storage location.			
	QS4	The production workers are trained on machines' setup activities	0.739		
	SLP	SLP1	We produce in more frequent but smaller lot size.		
SLP	SLP2*	We receive products from suppliers in small lot sizes with frequent deliveries.	-	0.715	
	SLP3	We are aggressively working on reducing production lot sizes.			
	SLP4	We emphasize producing a small number of items together in a batch.	0.726		
	SLP5	We produce only in necessary quantities, no more and no less.	0.793		
SN	SN1	Our suppliers deliver materials to us just as it is needed (on a just-in-time basis)	0.804	0.675	0.806
	SN2*	We strive to establish long-term relationships with suppliers.	-	0.838	
	SN3	We emphasize to work together with the suppliers for mutual benefits.			
TPM	TPM1	We ensure that the machines are in a high state of readiness for production at all the time.	0.780	0.639	0.841
	TPM2*	We dedicate periodic inspection to keep machines in operation.	-	0.788	
	TPM3*	We have a sound system of daily maintenance to prevent the machine breakdown from occurring.			
	TPM4	We have time reserved each day for maintenance activities.	0.830		
	TPM5	We emphasize a good maintenance system as a strategy for achieving quality compliance.			
UPL	UPL1	We produce more than one product model from day to day (mixed model production).	0.643		
UPL	UPL2	We emphasize a more accurate forecast to reduce variability.	0.759	0.745	
	UPL3*	We emphasize to equate workloads in each production process.			
	UPL4	Each product is produced in a relatively fixed quantity per production period.			
	UPL5	We always have some quantity of every product model to respond to variation in customer demand.	0.674		
<b>Second-Order Construct</b>					
LM	CL	Cellular Layouts	0.826	0.507	0.898
	FR	Flexible Resources	0.761		
	PSK	Pull System/ <i>Kanban</i>	0.452		
	QAS	Quality at the Source	0.625		
	QS	Quick Setups	0.854		
	SLP	Small Lots Production	0.734		
	SN	Supplier Networks	0.400		
	TPM	Total Productive Maintenance	0.827		
	UPL	Uniform Production Level	0.769		

**Note:** \*The items are removed due to low outer loading.

**Table 3.** Discriminant Validity: Fornell and Larcker Criterion

	CL	ECSP	ENSP	FR	PSK	QAS	QS	SLP	SN	SSP	TPM	UPL
CL	<b>0.737</b>											
ECSP	0.221	<b>N/A</b>										
ENSP	0.270	0.637	<b>N/A</b>									
FR	0.637	0.330	0.286	<b>0.774</b>								
PSK	0.215	0.546	0.483	0.297	<b>0.715</b>							
QAS	0.400	0.210	0.315	0.380	0.336	<b>0.839</b>						
QS	0.690	0.288	0.315	0.562	0.277	0.554	<b>0.788</b>					
SLP	0.670	0.184	0.217	0.606	0.172	0.317	0.546	<b>0.772</b>				
SN	0.215	0.421	0.351	0.322	0.334	0.165	0.321	0.185	<b>0.821</b>			
SSP	0.243	0.524	0.587	0.334	0.375	0.326	0.372	0.237	0.454	<b>N/A</b>		
TPM	0.572	0.371	0.353	0.528	0.424	0.575	0.712	0.470	0.248	0.403	<b>0.799</b>	
UPL	0.524	0.446	0.421	0.482	0.421	0.439	0.590	0.443	0.344	0.488	0.616	<b>0.707</b>

**Note:** The diagonal values (bolded) are the square root of AVEs, and off-diagonal values are correlation coefficients. N/A (not applicable) for formative constructs.

**Table 4.** Construct Validity of Formative Constructs

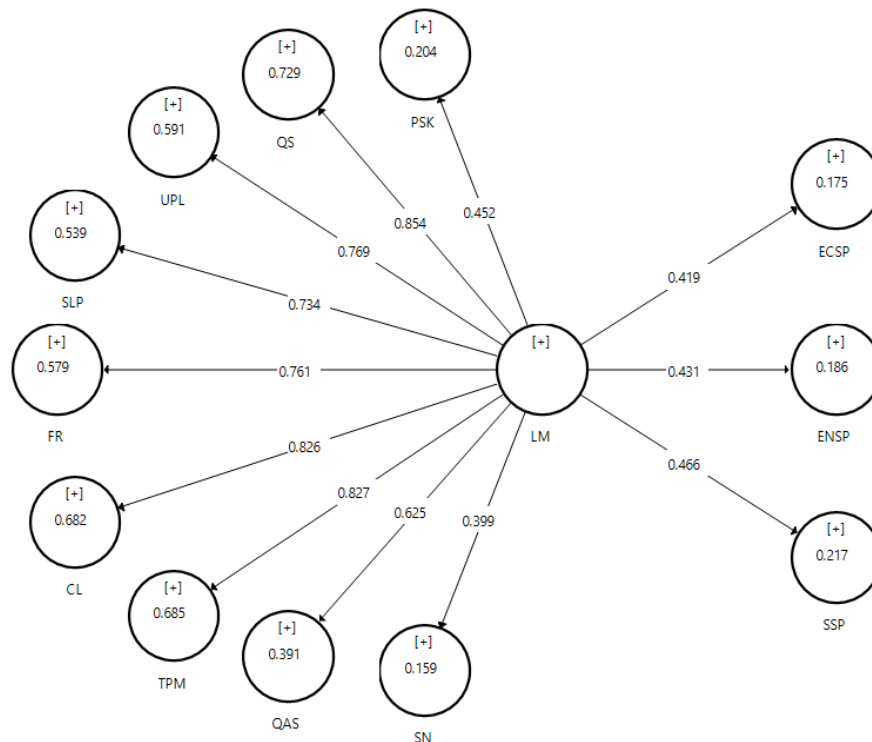
Construct	Item Code	Item	Std Beta*	Outer Weight	VIF	t	p
ECSP	ECSP1	We have improved market share.	0.840	0.084	1.187	0.331	0.370
	ECSP2	We have improved our company's image (i.e., our company is seen as a green company).		0.312	1.509	2.029	0.021
	ECSP3**	We have decreased waste treatment fees.		0.069	1.288	0.312	0.378
	ECSP4	We have increased profitability.		0.320	1.258	1.953	0.026
	ECSP5**	We have reduced environmental accident fees.		0.199	1.649	1.395	0.082
	ECSP6	We have reduced manufacturing costs.		0.206	1.133	1.251	0.106
	ECSP7	We have improved product quality.		0.150	1.446	0.675	0.250
	ECSP8	We have improved order delivery and flexibility.		0.493	1.578	2.919	0.002
ENSP	ENSP1	We have reduced wastewater.	0.831	0.175	1.256	0.872	0.192
	ENSP2	We have reduced solid waste.		0.168	1.414	1.112	0.133
	ENSP3	We have reduced energy consumption.		0.115	1.146	0.636	0.262
	ENSP4	We have decreased the production of toxic/harmful/hazardous/flammable substances.		0.439	1.141	2.227	0.013
	ENSP5	We have decreased material usage.		0.214	1.272	1.301	0.097
	ENSP6	We have improved compliance with environmental standards.		0.662	1.392	2.920	0.002
SSP	SSP1	We have improved relationship with the community and stakeholder.	0.867	0.447	1.034	4.317	0.000
	SSP2	We have improved workplace safety and health.		0.693	1.136	6.178	0.000
	SSP3**	We have improved the work environment.		0.221	1.056	1.247	0.106
	SSP4	We have improved the living quality of the surrounding community.		0.357	1.113	2.493	0.006

**Note:**  $p < 0.05$  (one-tailed test). \*Standardized beta of the relationship between formative construct and its global item, indicating convergent validity. \*\*The items were removed from the formative measurement model due to insignificant outer weight, low outer loading, and lack of theory-driven conceptualization.

#### 4.2. Structural Model Assessment

In this stage, a bias-corrected bootstrapping procedure was applied. According to Ringle, et al. [66], the use of 5,000 bootstrap samples can guarantee the stability of the results. A one-tailed test with a 0.05 significance level was set. Figure 1 and Table 5 exhibit the results of the structural model assessment. These show that LM positively related to all measures of sustainability performance. Specifically, the second-order construct of LM positively affects economic sustainability performance (ECSP,  $\beta = 0.419$ ,  $t = 2.424$ ), environmental sustainability performance (ENSP,  $\beta = 0.431$ ,  $t = 4.107$ ) and social sustainability performance (SSP,  $\beta = 0.466$ ,  $t = 4.111$ ). Hair, et al. [73] recommended looking at the confidence interval in order to provide extra information concerning the degree to which the population parameter falls at a certain confidence level. As shown in Table 5, all confidence intervals do not contain zero. Consequently, the null hypotheses asserting that the  $\beta$ -values equal to zero are rejected. Therefore, H2, H3, and H4 were strongly supported.

Next, the coefficient of determination ( $R^2$ ) and predictive relevance ( $Q^2$ ) were assessed [74]. The  $R^2$  specifies the total variance in an endogenous variable, which is explained by the exogenous variable(s). In other words, the  $R^2$  signifies the exogenous variables' shared effects on an endogenous variable. Following the rule of thumb from Hair, et al. [67], the  $R^2$  values of 0.75, 0.50, and 0.25 respectively reflect substantial, moderate, and small variance in the endogenous variable predicted from the exogenous variable(s). Table 5 shows that a total of 18.60% variance in ENSP is explained by LM, and LM explains 17.50% variance in ECSP and 21.70% variance in SSP. These figures demonstrate a reasonable and substantial explanatory power of LM on ENSP, ECSP, and SSP. Subsequently, the predictive relevance ( $Q^2$ ) of the structural model was tested by using a blindfolding procedure with an omission distance of 7. The  $Q^2$  predicts the accuracy of  $R^2$ . Table 5 shows that all  $Q^2$  values are higher than 0. Therefore, the model has a significant predictive capability [67].



**Figure 1.** Results of Structural Model Assessment ( $p \leq 0.05$  (one-tailed test))

**Table 5.** Summary of Hypotheses Testing

Hypothesis	Path	Std. Beta	Std. Error	t-Value	Bias	Confidence Interval		R <sup>2</sup>	Q <sup>2</sup>	Decision
						5.00%	95.00%			
H2	LM→ECSP	0.419	0.173	2.424	0.043	0.153	0.666	0.175	0.023	Supported
H3	LM→ENSP	0.431	0.105	4.107	0.045	0.254	0.582	0.186	0.029	Supported
H4	LM→SSP	0.466	0.113	4.111	0.006	0.277	0.649	0.217	0.077	Supported

**Note:**  $p \leq 0.05$  (one-tailed test)

## 5. Discussion

This research was aimed at examining the structural effects of LM adoption on corporate sustainability triple bottom line measures (i.e., economics, environmental, and social). To achieve the objective, four hypotheses were tested. The result from the first hypothesis testing revealed that LM practices are interdependent with each other. The structural effects of LM were tested with three hypotheses relating to LM with all the measures of sustainability performance. The study found that LM positively affects all measures of sustainability performance. Therefore, in order to leverage the sustainability of SMEs, one of the important approaches is through embracing the LM practices in a holistic manner within their daily activities. Below, the results of the hypotheses testing will be discussed.

### 5.1. The interrelationship between LM practices.

The interrelationship among the LM practices is proven in this study. It implies that LM practices should be adopted holistically. In other words, all the practices should be adopted simultaneously, without putting any of the practices in isolation. This study confirmed the previous studies by Shah and Ward [75], Dal Pont, et al. [76], Furlan, et al. [77], Bortolotti, et al. [78], Čiarnienė and Vienažindienė [79], and

Nawanir, et al. [47]. Even though the studies were conducted in several different contexts, they agreed that the LM practices should not be applied in a piecemeal approach; selecting some practices, while leaving some others a side. The paper by Sahoo and Yadav [80] established that LM bundles significantly improve business performance as compared to standalone practices. In a similar vein, according to Dombrowski, et al. [81], western enterprises has failed to achieve the expected performance due to the implementation isolated principles of LM and failed to adopt in an integrated system.

This finding supports the complementarity theory by Edgeworth [44] which emphasizes the synergistic effects of combined practices. According to the theory, the total effects of combined practices tend to be more significant than the total effects of their isolated practices. Yet, although this study adopted the validated instrument for LM practices from Nawanir, et al. [47], the different contexts of study influenced the results. In the present study, some of the adopted items had to be discarded due to low outer loadings, which indicates that the implementation of LM in large manufacturers are slightly different from the SMEs. The present study shows that some of the important LM activities might be neglected by the SMEs, such as the utilization of movable facilities, multi-skilled workers, supplier *kanban*, traceable quality



problems, quality circle, frequent delivery with small quantities from suppliers, long-term relationship/agreement with suppliers, supplier development programs, and uniform workload. This study, consequently, suggests that SMEs should invest in and apply all the LM activities and practices at the same time, rather than picking them up one over the other. Partial adoption may cause the unsuccessful implementation of LM, which leads to unsatisfactory performance achievement [77].

Even though previous studies provided strong support on the application of lean bundles, it might be contingent on several aspects. A longitudinal study from Hallavo, et al. [82] advised that the holistic implementation of LM practices is effective. However, the study also highlighted the role of some contextual factors that may affect the extensiveness of the implementation, such as the company's ownership, business cycle, and maturity issues which are related to the age of the company and the duration of LM adoption in the company. Henao, et al. [1] also stated that the effectiveness of LM implementation is contingent on the degree of balance between the practices. On top of that, Nawanir, et al. [47] elaborated that the comprehensive adoption of LM is largely depending on business nature-related factors, such as type of products, production process, and technology. Some internal characteristics, such as organizational structure, business complexity, size, and so forth may influence the implementation [83]. In short, the LM practices to be implemented in the company should fit the contexts and natures of the company.

### 5.2. *The effects of LM on economic performance.*

Previous studies highlighted this relationship extensively. Some of the literature such as Nawanir, et al. [41], and Chavez, et al. [84], looked into the economic performance in two different levels (i.e., operational and business levels), which is similar with Fullerton and Wempe [52] who looked into non-financial and financial performance. In the manufacturing operations settings, business performance is the result of the achievement in operational performance [41, 52, 85]. The higher the operational performance (e.g., quality, flexibility, inventory, productivity, lead time, etc.) will result in the higher the business performance. Thus, in this study, operational and business performance are considered as subsets of the overall economic performance.

In line with previous studies, this study revealed that the more extensive the implementation of LM, the higher the overall economic performance. Generally, in several different scenarios, previous studies tended to support the view that LM enhances economic performance. This finding is backed by a number of studies, such as Furlan, et al. [48], Belekoukias, et al. [31], Nawanir, et al. [24], Valente, et al. [86], Marodin, et al. [87], and Sahoo and Yadav [88]. Nawanir, et al. [24] emphasized the significant contribution of holistic LM implementation on profitability up to 36%. The study by Sahoo and Yadav [88] among manufacturing SMEs in India highlighted that operations performance can be improved by up to 30.41% by the implementation of process improvement related activities, 22.75% and 29.70% through the implementation of flow management, and waste minimization activities, respectively. More interestingly, a recent study [83] reported that the holistic implementation of

LM potentially improved the operational performance of Indian SMEs up to 80.40%. Besides the integrated approach in the implementation, such enhancement could be due to several factors, such as change initiatives and innovations [83], the nature of LM that focuses on waste elimination while improving efficiency [47, 48], and top management support [31, 83], and fitness between LM practices and business nature of the companies.

In spite of the positive contributions of LM economically, several studies [79, 89] have noted differently, which revealed other weakening elements of that relationship. Interestingly, Henao, et al. [1] suggested looking at the contingency perspectives, in which each company may have different approaches to achieve their own goals. In addition, some organizations or staff failed to understand LM as a continuous improvement process [79]. LM practices will not be able to achieve the targeted performance without every day, everywhere, and everyone improvements.

### 5.3. *The effects of LM on environmental performance.*

Testing on the third hypothesis pointed to the positive implication of LM on environmental performance. The more extensive the implementation of LM, the better the impact on the environment. In other words, LM implementation has a considerable potential to improve environmental conservation. In line with this finding, several studies suggested similar results. For instance, the studies by Resta, et al. [90], Piercy and Rich [91], Vinodh, et al. [92], and Verrier, et al. [93] noted that LM contributes significantly in reducing resource consumption. Resta, et al. [90], Pagell and Shevchenko [94], Piercy and Rich [91], and Verrier, et al. [93] documented that LM contributes to the environmental performance as it is able to control pollution caused by companies' operations. More importantly, the implementation of LM can increase energy efficiency [90, 93-95], and environmental awareness [91, 96], besides promoting recycling [96, 97]. All these findings are logical as LM emphasizes waste reduction, leading to energy and resource-saving while controlling pollutions caused by the companies' operations and activities. Specifically, LM may directly help the companies to conserve the environment in several different ways, as below:

- The application of the pull system that will produce when requested by customers can result in less work and more efficient usage of machines.
- The utilization of multi-functional machines and equipment may help to decrease the number of machines for production. Therefore, it reduces energy usage and encourages the optimum deployment of resources [98].
- Cellular layouts with close proximity between the facilities and changeable layouts diminish conveyance, material handling, inventory, and space [99, 100]. This leads to less energy consumption.
- Producing only in necessary quantity based on the quantity of customer demand can avoid overproduction. Therefore, there will be fewer works to handle excessive products.
- Small lot production can improve quality because quality issues can be detected easily, and operators have a low tendency to let defects pass. This also minimizes the inventory level because it depends on the quantity produced in a batch. Finally, it saves energy and resources for handling inventory and defective products.

- Quick setups with the single minutes' exchange of dies (SMED) principles help to make setup process efficient and effective. Thus, it requires fewer resources and energy.
- Uniform production level (*heijunka*) promotes uniform workload through line balancing, repetitive production, level schedule, steady cycle rate, and market pace final production rate [101]. This eliminates overburden to workers and machines as well as unevenness in the operations schedule [89]. Therefore, manufacturing processes run steadily with the same workloads, besides helping in minimizing inventory.
- Quality at the source ensures the production of good quality of products. This practice makes any quality problems noticeable and traceable, therefore, if an abnormality is detected, operations will be automatically stopped. This reduces the risks of producing defects in large quantities and avoids damage to machines, tools, and equipment. This also conserves energy and resources to handle product defects and machine damages.
- TPM promotes a sound maintenance system of facilities. It ensures machines, tools, and equipment are in a high state of readiness at all the time while preventing breakdowns from occurring. On top of that, the plants rigorously clean workstations to make unusual incidences visible. Therefore, immediate actions can be taken to prevent worse incidents and contaminations.
- LM demands just-in-time delivery from suppliers, in which parts and materials should be delivered on a just-in-time basis. In addition to it, supplier development programs and synchronization with suppliers avoid waste of inventory, overproductions, and transportations [1, 91].

Even though many of the findings pointed at the positive effects, the lack of consensus on the relationship between LM and environment conservation is found in the literature. Albeit extraordinary operational performance, LM may cause greater harm to the environment. Some of the studies have arisen environmental issues as side effects of LM adoption. Pagell and Shevchenko [94] argued, although LM successfully reduces waste caused by production activities, the LM activities still remain negative environmental footprints with regards to resource consumption and emissions. Henao, et al. [1], Bergenwall, et al. [89], and Leon and Calvo-Amodio [2] also concerned about the pollution as LM requires more frequent transportations and handling due to frequent delivery from suppliers and shipping to customers in multiple small quantities.

Taking these negative findings into consideration, the traditional LM focused on the elimination of cardinal manufacturing wastes, which did not include any considerations on the environmental aspects of companies' operations. Consequently, the practitioners and scholars may have not included environmental elements into the set of LM practices and activities. Interestingly, instead of considering eight waste as proposed by Womack and Jones [102], practitioners should consider to include the ninth waste; environmental waste, referring to "*excessive usage of resources and substances released into the air, water, or onto the land that could harm human health or the environment*" [103]. The inclusion of the ninth waste may give consequences of environmental practices that potentially improved environmental performance. The integration of LM

and green practices [13, 50, 56, 61, 104], and proposing eco-lean practices [105] could be the answer from the mission of eliminating lean *mudas* and green *mudas* simultaneously [1]. On one side, LM practices eliminate transportation, inventory, movement, waiting, overproduction, over-processing, defects, and underutilized skills, while green practices are responsible for the elimination of excessive power usage, greenhouse gases, eutrophication, pollution, excessive resources usage, and poor health and safety.

#### 5.4. The effects of LM practices on social performance.

There is a scarcity of investigations that relates operations management practices with this 3BL outcome. This is due to the complexity of social characteristics, especially when relating manufacturing activities with various interests of all stakeholders. Achieving a balance between economics (i.e., operational) performance and the social outcomes is very challenging as there is no single consensus about a suitable level of social responsibility that an organization should accomplish [1, 106]. It led to the scarcity of established metrics to measure social performance in the current literature.

This study investigated social performance through three validated measures (see Table 4). This study assumed that LM implementation should be able to improve three important factors, which are the relationship between the company and its stakeholders and surrounding community, employees' work safety and health, and the living quality of its community. The statistical test concluded a positive effect of LM implementation on the societal outcomes, with the improvement up to up to 21.70%. The finding is in line with Piercy and Rich [91], who found that extensive training for employees, empowerment, and extensive application of standardized work, and visual management significantly improve the levels of workplace safety and health. The study from Distelhorst, et al. [107] among 300 apparel factories in developing countries noted that LM led to the 15% decrease in non-compliance with labor standards in terms of wage and work hour practices. The study encouraged companies to intervene in the capability building of employees in order to reduce social harm in LM employment. Other studies also noted the positive effect of LM on works safety and health, such as Resta, et al. [90], Silva, et al. [95], and Verrier, et al. [93].

Even though the findings possessed empirical supports from previous studies, Longoni, et al. [108] stated that the effects of LM on work safety and health can be either positive or negative, depending on the set of LM practices implemented in the plants. The positive effects, for example, LM encourages the workers to possess multiple skills and be able to do several activities, which finally will improve workers' productivity. However, it causes fatigue and gives negative impacts in terms of work safety and health. In line with this, Distelhorst, et al. [107] and Longoni, et al. [108] also revealed a non-significant impact of LM on the achievement of health and safety standards. Similarly, Bergenwall, et al. [89] also reported such a negative effect, since one of the LM activities is cross-training to target multi-skilled workers, some of the employees are reluctant to join such training as it negatively affects their job security, and subsequently causes employees' mistrust.

## 6. Implications of the Study

Given the importance of SMEs in the global markets, the adoption of LM that focuses on cost reduction through waste elimination could contribute to the prosperity of the SMEs. This paper subsidizes significantly to the literature by providing a solid foundation for the linkage between LM and business sustainability performance. The study highlighted the importance of the holistic adoption of LM in the manufacturing SMEs context. Piecemeal adoption could not bring significant benefits to the achievement of business sustainability. This study extends the complementarity theory by Edgeworth [44], which is not only appropriate for large manufacturers but also in the context of SMEs. The theory suggested that performance outcomes depend largely on the simultaneous adoption of LM practices. The theory believed that separate practices cannot be self-sufficiently able to achieve targeted performance. Rather, the implementation of one practice will increase the total effect of other practices and *vice-versa*. Interestingly, Lee, et al. [109] emphasized that organizations that attain outstanding performance levels through the adoption of complementarity of organizational practices are able to withstand their competitive advantage over long periods of time. Therefore, considering the complementarities among the practices is significant due to their positive contributions to organizational performance.

Besides suggesting the holistic adoption of LM practices, this study also highlighted the positive significant effects of LM on the 3BL dimensions simultaneously. This evidence suggests that the more extensive the implementation of LM, the better the economic, environmental, and social performance of the SMEs. This implies that manufacturing SMEs should not only focus on economic performance while neglecting the impacts of their business activities on environmental and social dimensions. All the 3BL dimensions should be taken into account in order to be sustainable. The SMEs should make trade-offs between all the dimensions in order to continue making gains in all the dimensions [1]. Focusing only on chasing the economic performance dimension, while neglecting another two dimensions may cause the economic achievements to become expenses to overcome the environmental and social issues caused by the business activities. Here, considering to integrate green concepts into the application of LM could be beneficial in helping manufacturing SMEs to be sustainable [14].

## 7. Limitation and Suggestions for Further Studies

This study is not exempt from its limitations. First, this study is a quantitative cross-sectional in nature. As LM is a long-term initiative, its impact on sustainability performance could not be realized in the short term. Therefore, longitudinal studies are suggested in order to provide a more convincing result. Second, this study was not framed by context-specific circumstances, while the implementation of LM and its performance effects are contexts-dependent. In some cases, a concept is a function of its context. Even though this study focused on manufacturing SMEs in Malaysia, some contextual factors, such as the nature of the business, organizational culture, and leadership issues; may interfere with the relationships between the variables. Third, this study may lack qualitative data to explain and justify the findings. Therefore, future studies are encouraged to consider using a

qualitative method as well as a mixed-method to provide a clearer picture of how LM affects every single sustainability dimension. Forth, besides these methodological issues, this study realized that the investigations on the effects of LM on social aspects of 3BL are still rare in the recent literature, leading to the lack of consensus on how LM can contribute to social performance. Also, there is no agreement on the acceptable measures and dimensions for the social performance in the literature because of the scarcity of research addressing this issue. Therefore, there is a need to investigate its important dimensions of social performance along with the development of their measurement scales. The investigation on the dimensions would shed a light to show the path on how LM practices can contribute to every single aspect of social sustainability performance.

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