

# Relationships of Lean, Green Manufacturing and Sustainable Performance: Assessing the Applicability of the Proposed Model

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**Abstract -** While Lean Manufacturing (LM) focuses on minimization of wastes, Green Manufacturing (GM) emphasizes on achieving zero emissions. Little is known about the linkage between these two initiatives and their integration. Furthermore, it is also not clear whether these two initiatives can coexist in the same organization or not. To address the gaps, this paper highlights the potential synergic effect and proposes a multi-dimensional model based on assumptions (1) GM is represented by the soft aspects of Environmental Management System (EMS), (2) the EMS is the possible mediator in the relationship between LM and Sustainable Performance (SP), and (3) the mediating model can be examined using bootstrapping technique within Structural Equation Modeling (SEM). The contributions of this paper are theoretical in nature which include (i) proposal of a conceptual approach comprising of three integrated models (ii) introduction of the lean manufacturing with four bundles namely, problem solving, process, philosophy and people (LM 4P). Four hypotheses were postulated for the research. The preliminary results indicate that the model is validated by conducting semi structured interviews in few industries in Malaysia. The future direction of this paper is to empirically investigate the model for hypotheses testing through the techniques employed in SEM.

**Keywords-** *Lean; Green; Sustainable; Mediation; Interview.*

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## 1. INTRODUCTION

Lean Manufacturing (LM) can reduce waste without additional requirements of resources which enable organizations starting to implement LM that resulted in a plethora of LM definitions, objectives, performance indicators, tools/techniques/methodologies, and concepts/elements [7]. EMS has become one of the main tools used by companies to handle the environmental aspects and the impacts that their activities have on the environment [10]. ISO 14001 certification is excellent for industries to embrace toward sustainable environmental management and benchmarking [4]. Scholars [36] stated that it is important for manufacturing companies to implement LM practices with environmental management as a means of obtaining eco-advantages through improvements in environmental performance. This paper focus on the mediation concept for the following reasons: (1) mediation is a very popular topic (2) mediation analysis tend to be more powerful than moderation analysis (3) When more causal or structural models are examined, the mediational part of the model is the most interesting part of the model. One of the main reasons for the intense interest in testing using mediation is trying to understand the mechanism through which the causal variable affects the outcome [27].

In this paper the research gap can be viewed from three different perspectives. These gaps together form the problem identified in this paper with reference to operations management literature concerned with interrelatedness between LM, EMS and sustainability issues and will be solved in later stages. These are described as follows:

*First Gap:* Even though there are numerous potential benefits of EMS, there is criticism about the implementation of EMS. Researchers [16] argued that it is still unclear whether ISO 14001 adoption enhances financial performance of firms or it is merely a placebo for firm managers who want to obtain membership in the green club. Reference [31] concluded that the relationship between EMS and firm performance yielded inconclusive results. Researchers [17] argued that presently there is no widely agreed methodology or system for evaluating the EMS's effectiveness. Reference [6] claimed that there is still lack of in-depth investigation of internal dynamics in maintaining ISO 14001 EMS. Reference [19] Claimed that little empirical information exists on the critical success factors of environmental management (i.e. ISO14001 EMS implementation).

*Second Gap:* There is a lack of standard LM implementation process/framework [14] additionally there is a lack of suitable theoretical frameworks to establish the concept of lean service and probe its impact on performance [15]. Furthermore there is a lack of studies that addressed the impact of LM on the sustainable performance [35] And last but not least, there is no clear definition of lean management philosophy [2]. Scholars [3] argued that the empirical validity of the effect of LM practices on firm performance in literature is in its infancy, and moving it forward requires the attention of academics and scholars.

*Third Gap:* [24] claimed that there is no integration and combination between LM principles and EMS. In the literature, there is a lack of sustainability metrics and adaptation of improvement methods to push companies' operational performance [21].

This paper attempts to propose a conceptual model that integrates a philosophy (LM) and a management standard (EMS ISO 14001) with sustainable perspective. Thus, the proposed questions in this paper are characterized as follows:

*RQ1: What is the model that integrates the three constructs namely LM4P, Soft EMS and SP?*

This question will be answered in this paper after reviewing the relevant literature concerned with LM, EMS practices and the sustainability. The next questions RQ2, RQ3 and RQ4 will be among the future directions of this paper.

*RQ2. What is the relationship between LM4P and SP?*

*RQ3. What is the relationship between Soft EMS aspects and SP?*

*RQ3. How does Soft EMS mediate the relationship between LM 4P and SP?*

The next sections in this paper review the literature concerned with LM, EMS and SP. It describes the relevant findings of previous studies focusing on the organizational performance. This is followed by the methodology phases that contributed to the proposed study model. Finally, preliminary results were introduced. The paper ends with showing the main contributions, limitations and future research agenda.

## 2.0 LITERATURE REVIEW

In this paper the literature is divided into four sections namely lean and organizational performance linkage, EMS and organizational performance linkage, the linkage between LM and EMS, and finally the sustainable performance.

### 2.1 LM AND ORGANIZATIONAL PERFORMANCE LINKAGE

The novelty of this paper comes from the fact that LM comprises of four integrated bundles as few studies investigated the impact of these bundles on the organizational performance. In the literature this linkage is not clear and several researchers use different measures to measure both LM and the performance of the enterprises. Thus, further research is necessary to understand the nature of this complex relationship between LM and organizational performance. For instance, scholars [22] argued that it is important to develop an understanding of the factors that are critical to the successful implementation of lean principles and practices. In addition, [7] examined seven lean implementation frameworks and found that there is no standard LM implementation framework and the crux of this is the lack of dedicated LM implementation tools, techniques, or methodologies. They emphasized that all the reported tools used in LM implementation are stand-alone matured tools like 5S, six sigma, TPM, CMS, JIT, VSM, kaizen, etc. Furthermore, [23] reviewed LM literature and categorized the literature into four areas of internal aspects (shop floor), value chain, work organization, and impact of geographical context. [9] in their study of 228 manufacturing companies in Ireland found that internal lean practices are positively associated with the multiple operational performance in terms of quality, delivery, flexibility and cost. In addition, industry clock speed moderates the relationship between internal lean practices and quality, delivery, and flexibility.

It is vital to understand that the four bundles of LM are aligned with LM principles; these principles commonly considered as the main priorities for LM, these are:

1. Base your management decisions on a long term philosophy, even at the expense of short-term financial goals
2. Create continuous process flow to bring problems to the surface
3. Use “pull” systems to avoid overproduction
4. Level out the workload
5. Build a culture of stopping to fix problems, to get quality right the first time
6. Standardized tasks are the foundations for continuous improvement and employee empowerment
7. Use visual control so no problems are hidden
8. Use only reliable, thoroughly tested technology that serves your people and processes
9. Grow leaders who thoroughly understand the work. Live the philosophy and teach it to others
10. Develop exceptional people and teams who follow your company’s philosophy
11. Respect your extended network of partners and suppliers by challenging them and helping them improve
12. Go and see for yourself to thoroughly understand the situation
13. Make decisions slowly by consensus, thoroughly considering all options and implement decisions rapidly
14. Become a learning organization through relentless reflection.

## 2.2 EMS AND ORGANIZATIONAL PERFORMANCE LINKAGE

The relationship between ISO 14001 certification and corporate environmental performance has become an important research topic in recent years [26]. Currently there are many environmental management tools employed to manage environmental performance, such as environmental impact assessments; environmental auditing; substance flow analysis; life cycle assessments; and EMS [34]. Review of literature has identified a mix of empirical evidence on the relationship between ISO 14001 EMS implementation and firm’s performance [32]. In their study conducted in Malaysia [32] found that EMS implementation has a positive and significant relationship with SMEs performance (i.e. operation performance and business performance).

## 2.3 LM AND EMS LINKAGE

The relationship between LM and Environmental Management (EM) has become known as “lean and green” and analyzed by different scholars [36]. According to [12] companies can use lean practices as a catalyst for greening the supply chains because “lean” and “green” have overlapping practices and elements. Researchers [24] proposed a model for lean and ISO 14001 integration which shows that the basic principles and methodology of the EMS and LM do match with each other.

## 2.4 SUSTAINABLE PERFORMANCE (SP)

In the literature, scholars use different terms to define sustainability. For instance, Scholars [5] clarified that the concept of sustainability seems to have endless applications; it has proven difficult to define. Sustainability means retain something over time continuously. Sustainable development aims to enhance both the economic and social growth, while minimizing negative environmental impacts [1]. The sustainability in the context of EMS certification is to retain the status of the certified company as environmentally friendly [25]. According to [13] organizations are implementing EMS with the aim to contribute to the ‘environmental pillar’ of sustainability and ultimately to better organizational performance and increased stakeholder satisfaction. The current unpredictable economic context has made the issue of sustainability more crucial for organizations across all sectors [30].

## 2.5 UNDERPINNING THEORIES

According to [18] a model is a representation of a theory. Thus, a model should not be developed without some underlying theory. Three theories are depicted in order to develop the model as a basis for this paper.

*First: Theory of Constraints (TOC).* TOC provides a specific methodology for identifying and eliminating constraints, referred to as the Five Focusing Steps. The TOC can serve as a highly effective mechanism for prioritizing improvement projects, while LM can provide a rich toolbox of improvement techniques. LM tools and techniques are primarily applied to the constraint, they can also be applied to equipment that is subordinated to the constraint (e.g. to equipment that starves or blocks the constraint; to post-constraint equipment that causes quality losses).

*Second: Resource based View (RBV) Theory.* RBV argues that organizational capabilities are a source for competitive advantage [33]. Scholars considered that resource based rationales apply well to EMS ISO 14001 implementation for several reasons including the implementation of proactive environmental strategies have been shown to affect the environmental performance [11].

*Third: Action theory and conceptual theory.* According to [30] the effect of the antecedent variable on the mediator variable is called the action theory because a manipulation is introduced to change the mediator. The effect of the mediator variable on the outcome variable is called the conceptual theory because the mediator is not directly manipulated but is theorized to affect the outcome. It is clear the Action theory can be described among LM 4P and Soft EMS practices. On the other hand, the conceptual theory is shown in the synergy of Soft EMS and SP.

### 3.0 THE PROPOSED CONCEPTUAL MODEL

The proposed conceptual model is comprised of three integrated models; this can explain the synergy among the latent constructs in a better way. Fig.1 explains this synergy

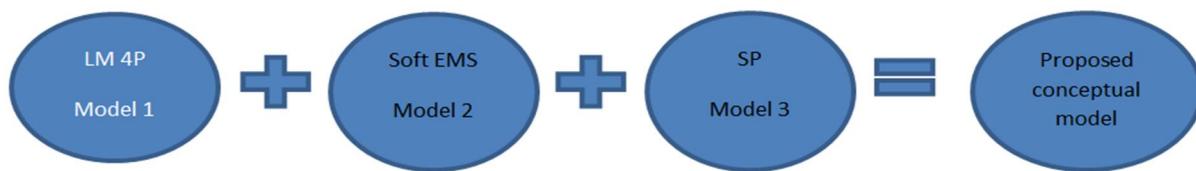
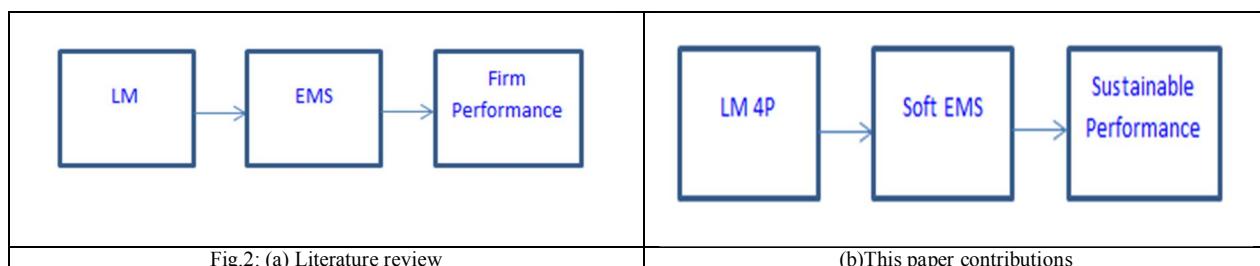


Fig. 1: proposed synergy among three models. Source: proposed by Authors

These three models are LM 4P model, Soft EMS model and SP. To understand the interrelationships among these constructs, the conceptual model is developed as shown in Fig. 1. The components of the conceptual model are: (1) LM 4P as the exogenous construct, (2) Soft EMS as the mediator, and (3) SP is the endogenous construct. Fig. 2 illustrates the main contributions of this paper compared to the literature review where it explains the new concepts presented.



It is proposed that LM4P is the model that considers the four bundles namely, problem solving, process, philosophy, and people aspects. In general, Liker (2004) described the fourteen principles of Toyota production system in terms of the LM 4P; principle 1 is classified as 1P (philosophy). Principles 2 through 8 are classified under 2P (process), while principles 9, 10 and 11 are classified into 3P (people). Finally principles 12 through 14 are clustered into 4P (problem solving) as it shown in Fig.3.

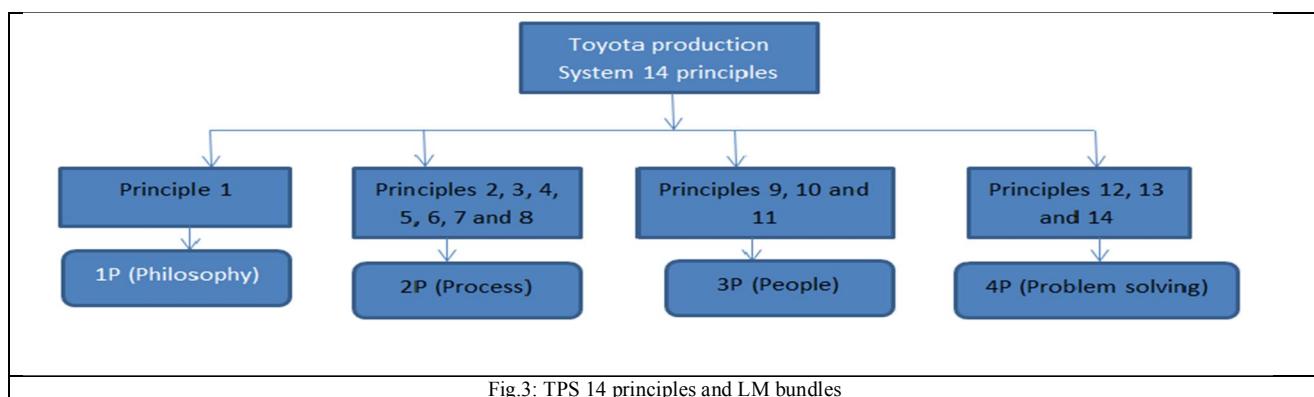
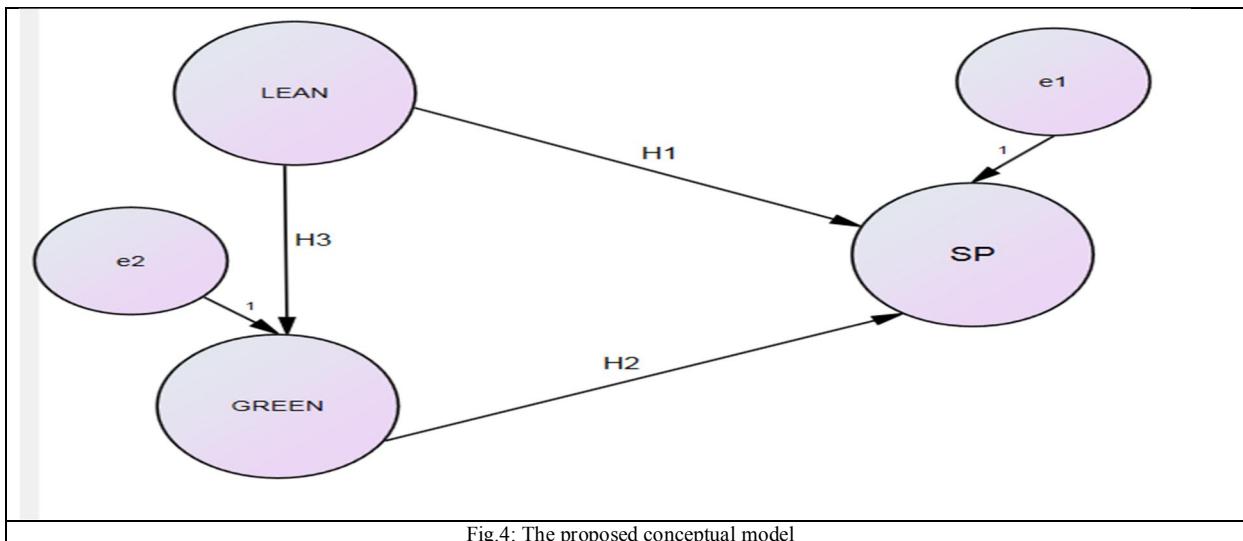


Fig.3: TPS 14 principles and LM bundles

The model proposed in this paper is based on the theories derived from the literature review as it depicted in Fig.4. The main cause and effect relationships in figure 4 introduce the direct and indirect effects among the main constructs in the model. The main claim of this paper is that LM4P has direct effects on the SP on the companies. SP can be measured using the dimensions of financial, environmental and social. Furthermore, the indirect effect between the two nodes (i.e., constructs) is called as the mediating. GM represented by the soft dimension of EMS is the possible mediator variable. This implies that LM4P has indirect effect on SP through its direct effect on EMS.



### 3.1 DEVELOPMENT OF THE HYPOTHESES

In guiding the direction of the analysis, and to clarify the controversial comments on LM 4P, soft EMS, and SP four hypotheses were developed from the theoretical model. These categories include many main research hypotheses postulated for this study, which reflect the findings of the earlier literature and theoretical background, and will be empirically examined in the Malaysian Manufacturing context using the structured questionnaire that will be developed and analyzed using AMOS software for SEM technique. The gaps presented at the beginning of this paper facilitated the formation of the main aim: *To develop the conceptual model and to investigate the interrelationships among the latent constructs in a sample of Malaysian Manufacturing certified industries.* Thus, the following hypotheses are proposed to be examined:

#### Hypothesis One:

***There is a positive and significant relationship between LM4P and SP***

The first hypothesis describes the causal effect between the LM4P as the exogenous latent construct and the SP as the endogenous latent construct. It is proposed that the different bundles for LM will have a positive impact of the SP.

#### Hypothesis Two:

***There is a positive and significant relationship between soft EMS aspects and SP***

The second hypothesis also discusses the direct relationship between the Soft EMS aspects and the elements of SP. This paper proposes that there EMS has a positive impact when it is applied correctly inside the organizations.

#### Hypothesis Three:

***There is a positive and significant relationship between LM4P and Soft EMS aspects***

The third hypothesis presents the synergy among two wide concepts represented by a philosophy (as LM) and a standard as (EMS).

#### Hypothesis Four: The mediating effects of soft EMS

In studying the dimensions of EMS namely soft and hard, [19] considered that hard EMS mediates the relationship between Soft EMS and the firm performance. [26] found that the internalization process of ISO 14001 serves an important role in mediating the relationship between ISO14001 certification and environmental performance. Based on these reflections, the hypothesis is proposed as:

***Soft EMS mediates the relationship between LM4P and SP***

#### 4.0 METHODOLOGY

The design of this paper is based on two phases; namely the semi structured interview in the first phase. And the second phase which includes the empirical investigation of the model and testing the hypotheses through the techniques employed from Structural Equation Modeling (SEM). This phase is among the future direction of this paper.

##### 4.1 SEMI STRUCTURED INTERVIEW

The interview is a form of data collection in which questions are asked orally and subjects' responses are recorded, either verbatim or summarized [29]. The interview with firms will be a great help in order to understand the nature of indicators in practice and compare it with theories which comes from literature review. In this paper, the purpose of the interview is to assess the applicability of the conceptual model proposed in this study, such that results will be utilized in order to design the questionnaire in the actual data collection phase and provide in-depth information regarding the practices used in this study. This approach was conducted by [28] in their study conducted in Lebanese Pharmaceutical Industry to assess the implementation of LM practices. [14] identified three types of interviews; namely (1) structured which uses a structured questionnaire, (2) semi- structured which uses open ended questions and (3) unstructured in which questions based solely on what the interviewee says. In this study, an in-depth semi- structured interview with open- ended questions was conducted which is similar to the study of [20]. Semi structured interviews enable the deep exploration of experiences. Open ended questions are most appropriate for exploratory research. An in-depth interview uses a few open-response, relatively general questions with some probes to obtain more detail. Using open -ended questions, the researcher does not use predetermined categories or scales to collect the data [8]. The interview protocol designed to include a guide about the definition of these practices. The sections of the interview include basic questions about the companies and the interviewee, the opinion of the interviewee about the practices of LM, and EMS and their understanding of these practices. Final section of the interview concerned with the impact of practices on SP.

##### 4.2 VALIDATION OF THE PROPOSED MODEL

The proposed model in this paper is validated through the in depth interviews conducted with Operations Management managers from different disciplines including quality and environmental managers. In addition, the interview protocol was validated also with experts and academics from International Islamic university Malaysia and other universities in Malaysia to examine the content and face validity. Thus, before holding the interviews these issues were accurately conducted.

#### 5.0 RESULTS FOR THE SEMI STRUCTURED INTERVIEW

To validate the proposed conceptual model and to assess its applicability, an in depth personal interviews were conducted with the managers in three manufacturing companies in Malaysia. Each interview continues for period in the range of 20 to 30 minutes. Analysis of the profile of the interviewee managers in the three companies is illustrated in Fig. 5. The interviewee managers were asked about their opinion about these practices and their impact to the sustainable performance. Open ended questions included as: What do you think about the impact of the implementation of these practices on your company's stainable performance? The response from the interviewed managers in explained in Table 2 where the interviewed managers are classified into the three companies. The nature of work of these companies identified as company A in the medical equipment's while company B in plastic products and company C in dairy products.

### 5.1 Profile of the interviewees Managers

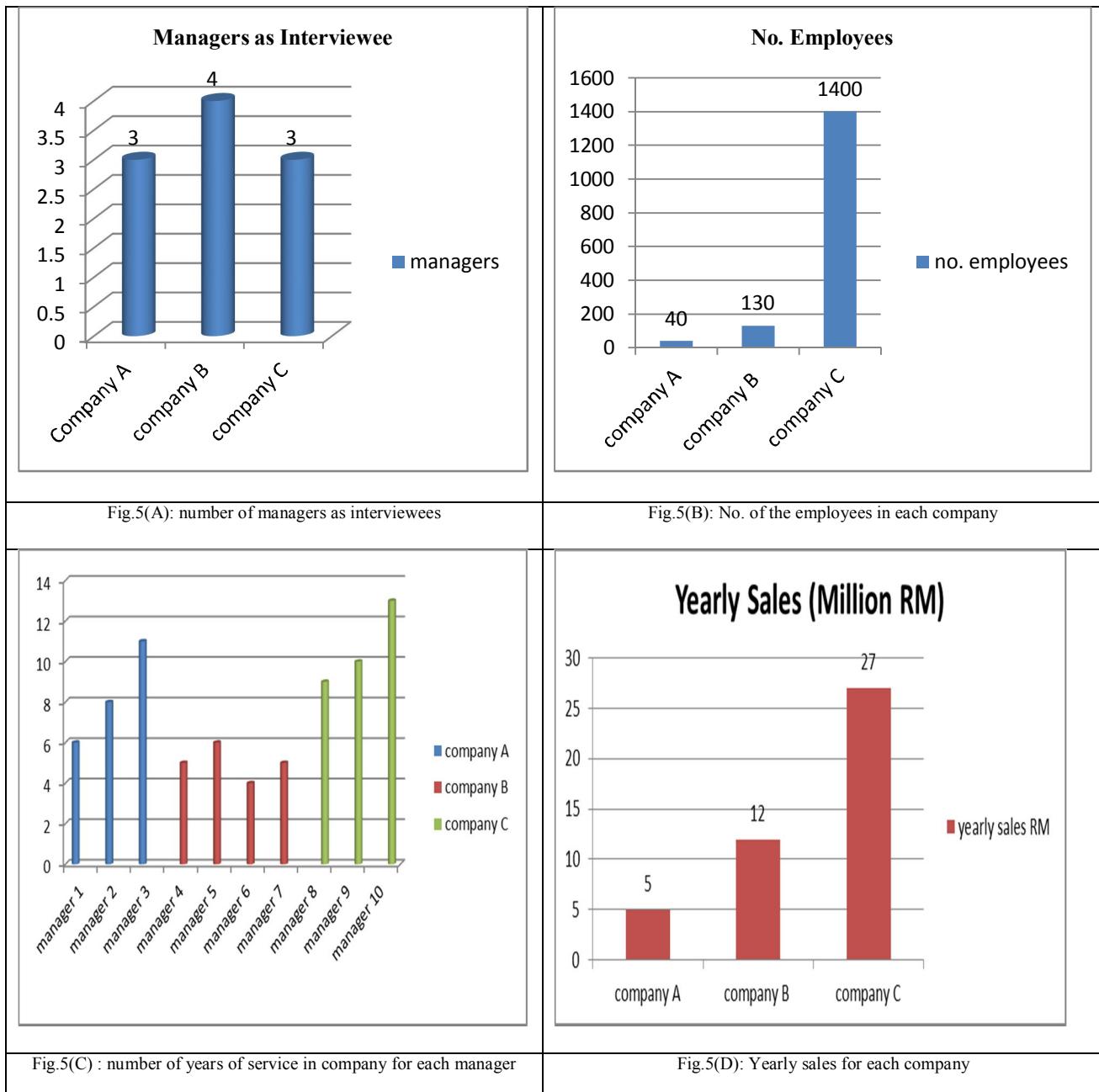


Figure 5 highlights different issues concerned with the interviewed managers in the targeted companies, while a comparison between the three companies namely A, B and C is depicted in Table 1

Table1: comparison among the respondent companies

Characteristic	Company A	Company B	Company C
Size of the company	Small	Medium	Large
Yearly sales of each company	Lowest	Median	Highest
No. of Interviewed managers	A and C are similar	Highest than (A and C)	C and A are similar

Table2: results of the semi structured interview

Company	Manager	Q1: What do you think about the impact of the implementation of these practices on your company sustainable performance?
A	1	Of course implementing these practices can have a great impact on the company's Operations and processes. I am sure that the cost is minimized which is good for our company.
	2	Actually The implementation of these practice will create a knowledge culture between employees and encourage them to use the best techniques to improve the performance in our company
	3	Of course it will lead to achieve higher levels of quality inside and outside the company. These are universal practices and management standards, thus, it will enable our company to gain the competitive advantage
B	1	In fact, starting from the vision and mission of our company we can observe tangible benefits from implementing these practices. We started in building trust with other markets which enable us to produce more products when we started using some tools for Lean and quality such as 5S
	2	Of course as a manager, I can understand that there are some lessons learnt from practicing these standards and philosophies. Some companies use either qualitative or quantitative techniques to measure the impact. We are happy since there is reduction in the production costs due to implementing these practices.
	3	Of course continuous improvement is shown in the processes. Customer satisfaction level is improved, number of complaints about our services is minimized, and thus, we have better productivity and quality.
	4	Using TQM, lean and the standards can result in improvement in the performance. We have increased the profit, better business practices, more comfortable environment, and more customer satisfied.
C	1	These practices allowed our firm to improve our processes and activities through minimization of the wastes and resources.
	2	Surely I recommend that all companies to start their journey towards achieving lean and TQM in addition to the other standards. Even though it takes time and efforts but potential benefits and impact can be achieved in next stages.
	3	These practices changed the view of the employees since they at the beginning were reluctant to adopt the tools. The impact needs time to be observed. I can say that it creates a quality culture and motivates us to open new markets and businesses with other outside Malaysia.

## 6. CONCLUSIONS AND MAIN IMPLICATIONS

To the knowledge of the authors this study is the first to explore the interrelationships among special model for Lean, entitled LM4P, taking into consideration its effect towards Green management (the combined Lean and green). One of the major contributions for this paper is introducing the mediation concept in terms of the relationship between LM and soft dimension of EMS. Furthermore, it introduces this mechanism using bootstrapping technique for structural equation modeling. Another contribution can be indicated from using the multi-dimensional model for LM which comprises of the four pillars of Toyota Production System (TPS). These pillars are classified under the bundles of problem solving, people, process, and philosophy and considered as the most common bundles for representation of LM. Furthermore, this paper followed the methodological triangulation which consists of two phases in data collection. Results of the semi structured interviews with the managers in the manufacturing industries indicated that the proposed model is validated; hence, it works and can be applied inside the different manufacturing sectors. Authors conclude that model goes in parallel with the ideas generated in this paper. As the main aim of the in depth interviews is to assess the model and ensure its validity, the second phase which is the quantitative phase through developing the questionnaire can be established. Managers should follow these systems and methodologies in order to keep the innovation strategy. It is believed that when these tools and techniques are implemented properly, then it will have a good impact and generate profits to the companies after implementation. Furthermore, it is understood that these systems can be aligned together in the organizations, thus achieving the desired results.

## 7. LIMITATIONS AND FUTURE DIRECTION

Similar to other research in operations management, this study suffers from limitations. The proposed meditational model is theoretically proposed here. Researchers and academics have to continue investigating the interrelationships among the practices described in this paper. Malaysian managers can benefit from this paper by understanding how these practices can affect their organizations towards minimization of the expected wastes from different processes. Another limitation is that this paper is focused on the manufacturing industries. It is expected that the proposed model in this study to be also applicable in different service companies like banks and hospitals “lean health care”. Authors strongly recommend other scholars to investigate the proposed hypotheses in other sectors to develop general criteria for LM-EMS and SP linkages.

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