A Critical Assessment of Prevailing Models for Measuring Lean Manufacturing

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Abstract - Lean Manufacturing (LM) is a thought developed in Toyota, thus, there is lack of studies investigated whether the implementation of LM is appropriate for different enterprises' or not because of different organizational and social culture of enterprises and labor. This paper critically analyzes eleven prevailing models for LM in an attempt to find a unified model that can be applied inside enterprises. In the literature several models have a tendency to focus only on a few single components. However, different enterprises use diverse dimensions and models for measuring LM. It aims to review the various LM models prevailing in the contemporary research papers along with presentation of an in-depth analysis exploring the similar and dissimilar aspects. The dimensions of the LM models adopted by different enterprises are quite diverse as revealed through this investigation. The contribution of this review is twofold: various models for LM are critically analyzed followed by a comparative evaluation with a vision to propose a potential model for LM that is applicable for manufacturing enterprises. Results show that the unified model comprises of 11 components for LM initiated from the principles of Toyota Production System (TPS).

Keywords- Lean; Toyota; Prevailing; Model; Assessment; Unified

1. INTRODUCTION

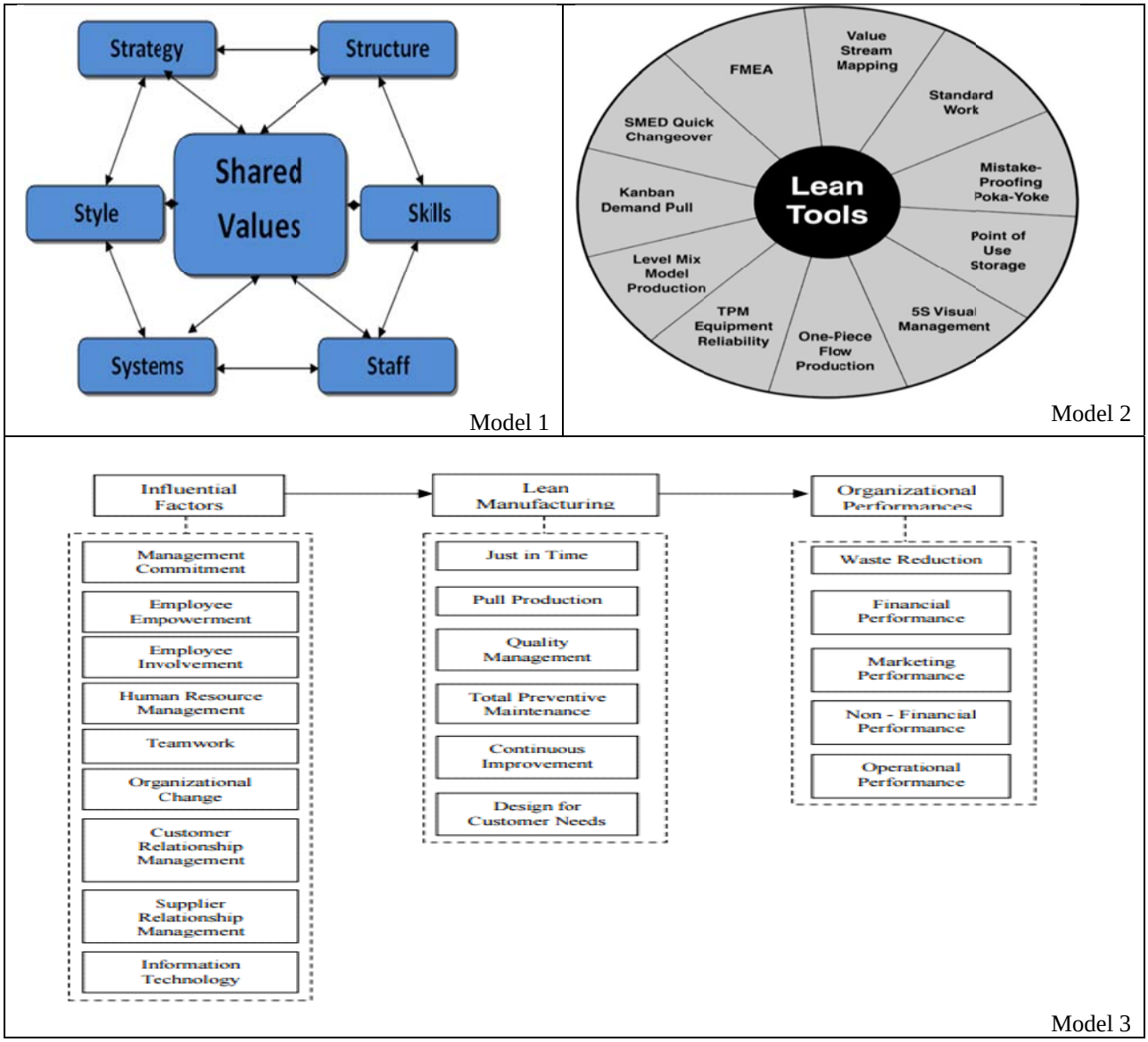
In the past decades, several models have been presented as approaches to improve customer satisfaction, production and operations performance. In addition, based on a review of the literature it can be pointed out that various models for improving productivity have been developed through years [5]. Among these models, there is Total Quality Management (TQM) and, more recently, Six Sigma programs, Lean Production, Agile Manufacturing and World Class Manufacturing (WCM). These models are based on the concepts and techniques of improvement and change. However, literature did not show an attempt to review and compare different LM models to customize a prospective generalized model that can be suitable to be implemented by the different enterprises. Upon carrying out a critical evaluation of the contemporary models found in the literature, a general multidimensional approach for LM is to be introduced. The ultimate purpose of this paper is to review the different contemporary models for LM and to propose a generalized model for LM. This paper starts with introducing different 11 LM models, followed by an explanation of the similarities and dissimilates aspects and finally proposing a model with the significant concerns or dimensions.

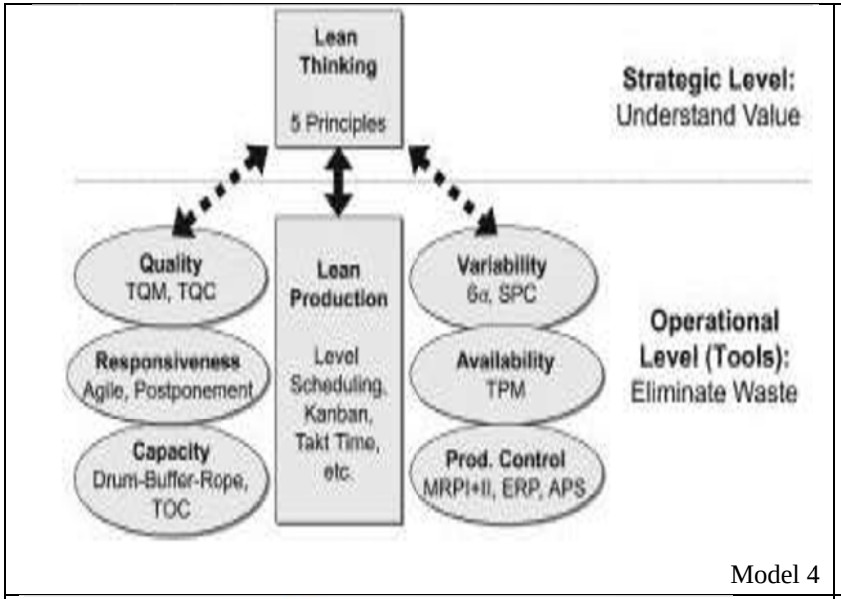
2. LITERATURE REVIEW

LM principles and practices have been considered by different scholars from different perspectives as LM is a growing concept [9] and considers the expenditures of resources for any goal other **than** the creation of value for the end customer [3]. It is obvious that there is disagreement among researchers regarding the descriptions and the practices of LM [2]. Furthermore, according to Shah et al. (2008), LM concept can be classified in the literature into three categories: a philosophy, a set of principles and bundles of practices. Literature on LM was reviewed in order to establish legitimacy of the research design concerned with the different LM models.

2.1 CONTEMPORARY MODELS FOR LM

The 11 models proposed in recent literatures to illustrate the main pillars of LM are briefly discussed in Fig.1





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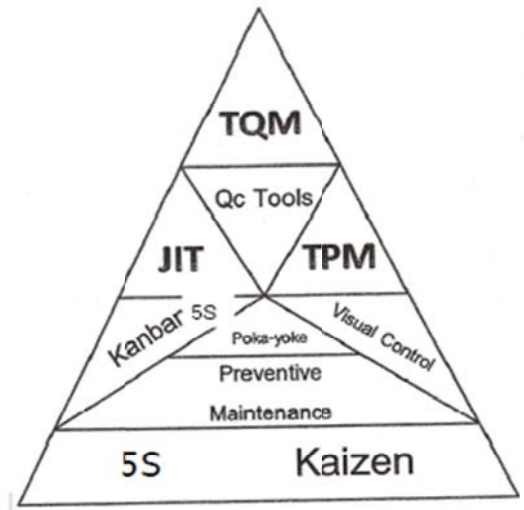

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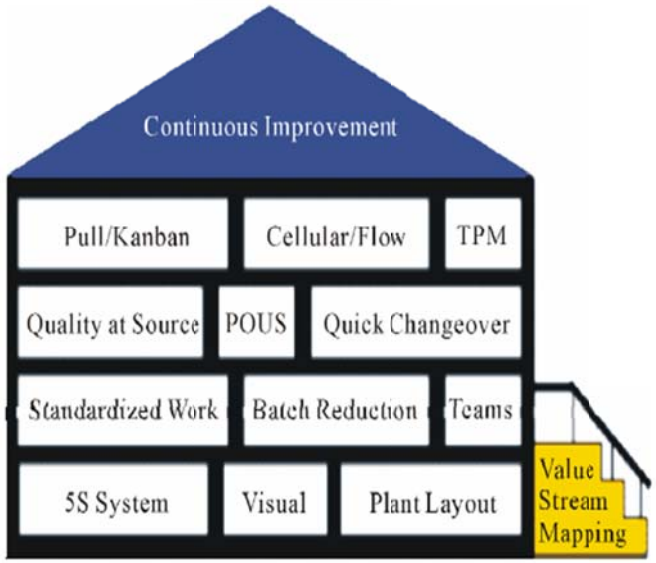

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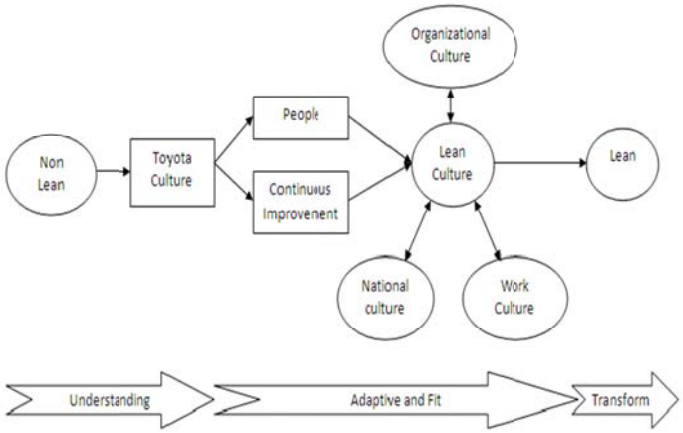

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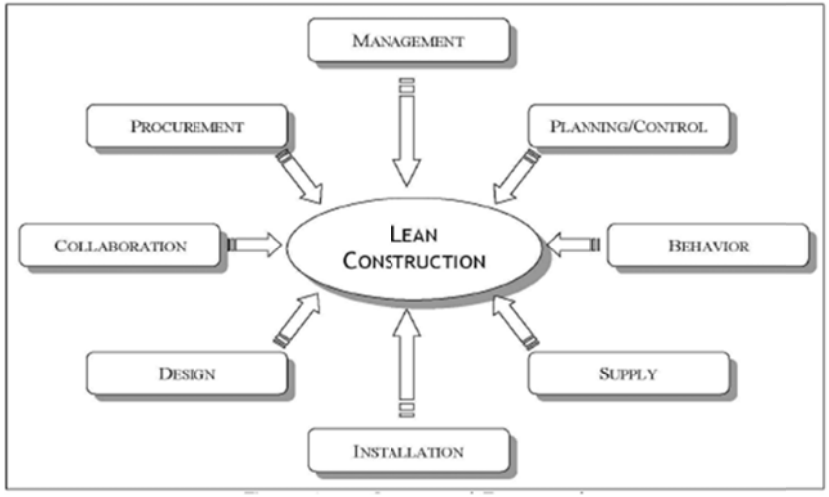

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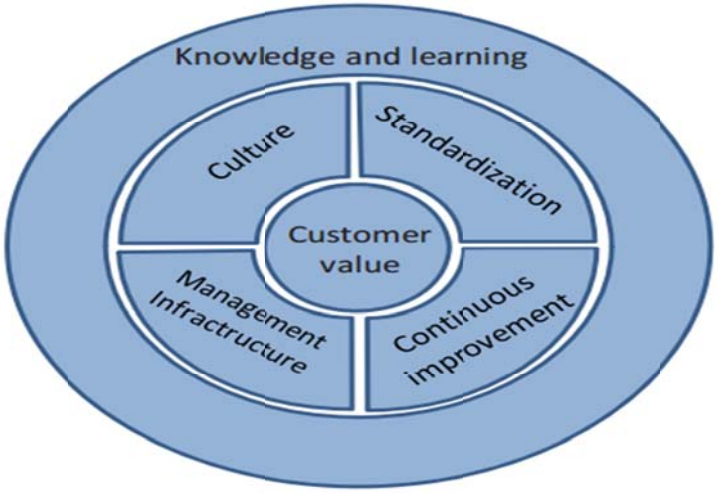

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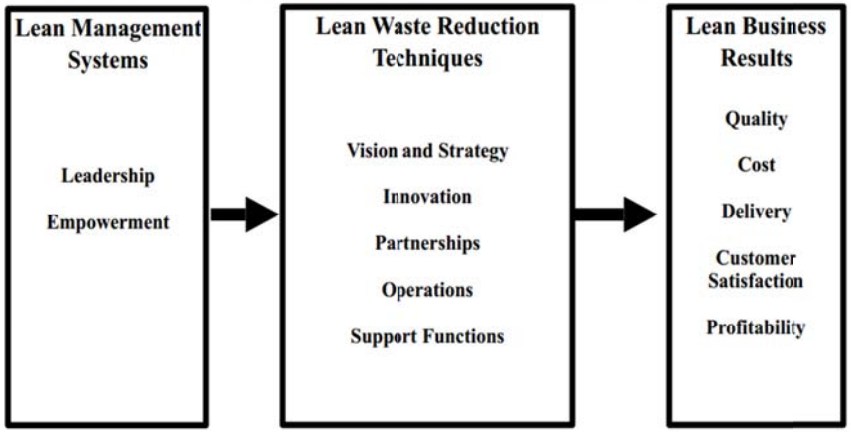
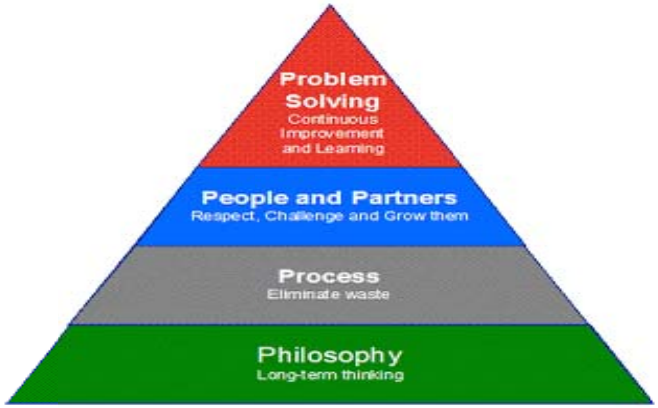


Model 10



Model:11

Fig.1. LM models

Description of these 11 models as follows:

Model 1 describes LM in terms of the 7S structure. These are interrelated components have an effect on each other. The main value and strength of this model is the shared values components have to make the enterprises more powerful and met the expectations of the customers. [13] described these 7 factors as follows:

(1) Strategy: the plan devised to maintain and build competitive advantage over the competition.
(2) Structure: the way the organization is structured and who reports to whom.
(3) Systems: the daily activities and procedures that staff members engage in to get the job done.
(4) Shared Values: these are the core values of the company that are evidenced in the corporate culture and the general work ethic.
(5) Style: the style of leadership adopted.
(6) Staff: the employees and their general capabilities.
(7) Skills: the actual skills and competencies of the employees working for the company

Model 2 describes the different tools for LM. The focus here in the hard aspects of LM where this model comprises of 11 tools and techniques including Kaizen, 5S, and others. It looks as a circle integrating all the tools in one model together to support and improves the nature of the enterprises towards minimization of the production costs.

Model 3 is depicted for Malaysian enterprises and comprises of six different vital components such as the continuous improvement, Total Productive Maintenance (TPM). However, this model is designed for the automotive industry only.

Model 4 describes LM from two different aspects namely, the strategic level and operational level. This can supports the strategies of enterprises through utilizing of the LM waste reduction from the production process. Each level has different tools and both are indirectly related to each other to be consistent with LM different principles

Model 5 This model describes LM as triangular interaction of the different tools. It was reexamined by using Analytic Hierarchy Process (AHP) technique to ensure the correctness of the model. The goal of AHP process was the success of JIT, TQM, and TPM application. The criteria are 1) Lead time of JIT, TQM, and TPM application, 2) Performance efficiency,3) Defects and product quality and 4) Machine breakdown. The alternatives were 5S, Kaizen, preventive maintenance, Kanban, visual control, Poka-Yoke, and QC tools

Model 6 shows LM as a house. The stairs for the house are Value Stream Mapping (VSM) since VSM is considered an important entity in LM system. This house consists of 14 different tools including the continuous improvement.

Model 7 focuses in achieving LM inside enterprises through three different stages as sequential steps. The first stage is called understanding which shows that at the beginning any enterprise will be not implementing LM tools and techniques. However, upon starting the application of LM, the principles will be originated from Toyota production system (TPS). Where TPS is larger than LM. The second stage focuses on the soft LM aspects concerned with people initiatives and the continuous improvement since LM a philosophy for the continuous improvement. Furthermore, lean culture is offered in this stage. Culture is characterized by three different initiatives namely, (i) national culture, (ii) work culture and (iii) the organizational culture. This third stage implies the direct transformation of an enterprise to be LM environment. Thus, it changed from the non-lean enterprise into LM enterprise that uses the different tools in professional way.

Model 8 focuses on the construction industries and includes different techniques that fit the construction industry. It shows the contribution of eight categories that contribute together to LM including supply, design, planning, installation, procurement, behavior, collaboration, and finally soft aspects of LM which is management support

Model 9 proposes that defining customer value is a key in any LM system effort; it is the core of the model. This knowledge based LM model comprises of six core components with different sub characteristics. It represents a

suitable compromise between being specific and generic at the same time, aiming to keep an overall system perspective with minimum interdependencies between the different components.

Model 10 shown in Figure 1 distills the essence of the theories of Womack and Jones, the SAE, and Liker into one coherent model. The Shingo Prize has a unique database of Lean companies' performance to these criteria based on a panel of expert examiners, which is a credible basis for comparing Green system performance [4].

Model 11 is called LM4P model which includes all 12 LM principles as proposed by [12]. It shapes as a pyramid that comprises of four layers. These layers are integrated to each other such that the final layer is concerned with problem solving issues. Generally 1P is related to philosophy, 2P is focused on process, 3P is related to people and partners and 4P is concerned with problem solving. The reference for these models is depicted as shown in Table 1.

Table 1: Support for LM Models

Model	Reference
1	Mckinsey consulting. On line : http://www.educational-business-articles.com/7s-model.html
2	Business Excellence http://www.bexcellence.org/Lean-manufacturing.html
3	Roslin et al.(2014) [14]
4	Hines et al.(2004) [7]
5	Teeravarapruq et al.(2011) [17]
6	Chen and Cox(2012) [6]
7	Ahmad and Azuan (2013) [1]
8	Johansen & Walter (2007) [8]
9	Welo et al. (2013) [18]
10	(Bergmiller and McCright, 2009) [4]
11	Liker (2004) [12]

3. METHODOLOGY

The methodology in this paper focused on three main stages as it shown in Fig. 2

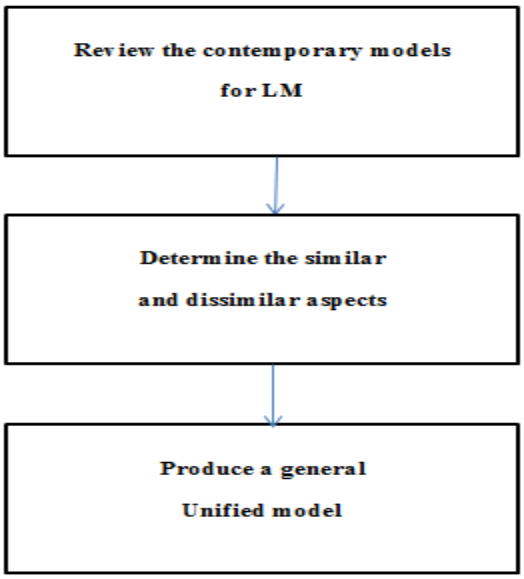


Fig.2: Methodology of this research. Source: developed by authors

The first phase of the methodology adopted in this paper includes reviewing the different contemporary models available in LM. This implies models related to Malaysian environment and other countries either developed or developing. In operations management literature there are variety of LM models utilized by different scholars and this depends on different factors including the complexity of operations inside the same enterprise, the nature of work of each enterprise.

The second phase is about analyzing these models in order to show the main similar and dissimilar aspects that facing these LM models. Since there are different resources utilized by different enterprises, it is expected there are different perspectives for the common similar and dissimilar aspects.

The third phase in the methodology of this paper is dependent on both first and second phases conducted which are producing a general perspective model for LM. It is proposed that this model can be applied to different enterprises and utilized by managers to enhance their operations and minimize the production costs in the manufacturing process.

4. RESULTS

4.1 COMPARATIVE EVALUATION OF THE MODELS

Table 2 depicts the main similarities and dissimilarities aspects; it shows a comparative view of the main common points and the differences among the models.

Table2: Similar and dissimilar aspects between LM models

Similarities aspects among the models	**Dissimilarities aspects among the models**
❖ All models presented have theoretical basis	✓ The interaction process(mechanism) is different
❖ Collaboration between the main components	✓ Number of components is different between models
❖ Focus on integration principle between the different vital elements	✓ Strategies are different among the LM models
❖ Accommodate LM using multi-dimensional approaches	✓ Shape and style of LM models are different
❖ Can be applied to different sectors	✓ Some of LM models focuses on quality culture
❖ All models have theoretical basis	✓ LM models can introduce the transformation from non LM to lean thru different environments
❖ Continuous improvement and 5S are the most common factors available in the models	✓ The utilization of hard LM aspects or Soft LM aspects
❖ 5 models focused on Kaizen and continuous improvement. These are models 3, 5, 7, 9 and 11.	
❖ Three models namely 10, 11 and 4 focused on minimization of wastes	

4.2 A PROSPECTIVE GENERALIZED MODEL

Based on the analysis shown in Table 1, it is obvious that different enterprises utilize different models for LM. Furthermore, these models are different from small to medium and large enterprises, either manufacturing or service. The proposed model in this paper comprises of the most common components for LM as it depicted in Figure3. It is apparent that LM is not focused only in manufacturing enterprises, however, it can be applied through the service organizations, this is due to the main broad principles for LM which is originated from TPS, and thus, it is universally applicable (Sousa and Voss, 2001). The model proposed in this paper can easily be implemented by the enterprises since it originated from TPS. Our proposed model provides a solution that allows us to deal with the

gaps and limitations introduced above in this paper. We expect that this model will be a useful reference for enterprises that seeks a general model to fit its operations and processes. However, it needs support from top management while embarking on the implementation phase.

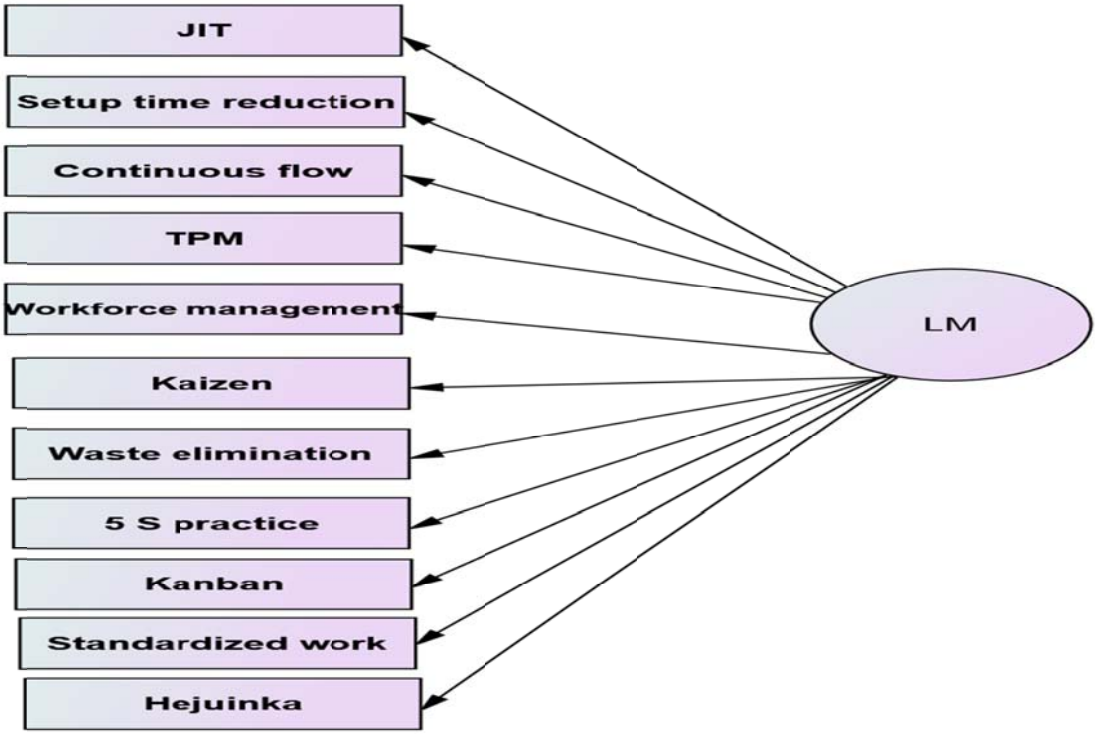


Fig.3: Proposed generalized model for LM

5. Conclusion and future directions

In this paper we discussed important issues of LM models and the corresponding components. These models are applied in different enterprises. Both in the developed or developing countries. However, the generalized model proposed in this paper will be useful for enterprises seeking to implement LM in a proper manner since it focuses on the common LM initiatives, tools and techniques that focus on elimination of wastes from the production process, thus, reducing the associated costs and improving the profit margin. The model proposed in this paper is an initial start off point and considered as a guideline for the possible implementation of LM in enterprises. With reference to the proposed generalized model, managers can utilize the principles aligned to be suitable with the processes of the enterprises. This paper provides essential strategies for managers dealing with operations management inside enterprises. Authors suggest that future direction of this paper can be conducted on evaluating the efficiency of the model based on the major weaknesses and strength initiatives. Furthermore, it is a vital step to explore the prospective model empirically to understand its effectiveness thru the implementation process by enterprises.

5.1 Limitations of the paper:

Similar to other papers in Operations Management, this paper suffers from limitations. Authors identified two limitations as follows: (i) the proposed prospective general model is theoretically proposed in this paper. Further additional efforts needed to empirically understand the model. (ii) The proposed 11 models are also presented theoretically in this paper. An empirical investigation is required to further understand these models in depth.

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BIOGRAPHY

Amjad Khalili is a PhD candidate in the Kulliyyah of Engineering at IIUM. He is researcher in Operations Management, Quality Management and technology. He has strong experience in World Bank and European Commission funded projects for tertiary education. Specialized in Industrial Engineering, Quality Management and Engineering Management. Participated in different Workshops, seminars, lectures and study tours with Ministry of Education and Higher Education in Palestine.

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