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VALIDATING THE RELATIONSHIP BETWEEN LEAN DIMENSIONS AND WASTES: A PILOT STUDY OF MALAYSIAN INDUSTRIES

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ABSTRACT

Lean production or lean manufacturing has become one of the most well-known paradigms for the elimination of waste in the manufacturing industries. Past research in lean shows that there are some set of techniques, tools and practices which have been applied to certain levels across firms according to the respective understanding of lean production of the persons in charge of lean initiatives. This scenario led to various versions of leanness measurement in the manufacturing industry. This paper describes a pilot test analysis in validating a conceptual framework for measuring leanness in the manufacturing industry. This conceptual framework has been developed based on a new definition of lean in the context of Malaysian industries. The right perception of lean is crucial in order to develop the right measurement of true lean. An in-depth study of literature consisting of books, journals and conference articles contribute to the development of the conceptual framework. There are seven main dimensions in measuring leanness in lean manufacturing practices such as manufacturing process and equipment, manufacturing planning and scheduling, visual information system, supplier relationship, customer relationship, workforce management, and product development & technology. In addition, the framework also shows how lean dimensions in the manufacturing system relate to eight types of wastes. A questionnaire has been developed in this study to collect data from the respondents as part of the framework validation process. Descriptive analysis is used to compute the evaluation of data that have been rated by the respondents by using the five-point Likert scale. Respondents of this study are experts from the domain of lean manufacturing in Malaysia.

KEYWORDS: lean manufacturing, lean production, TPS, leanness, lean indicators, lean assessment, wastes, muda.

1. INTRODUCTION

The term “lean” or “leanness” denotes lean manufacturing or lean production as it practices less of everything compared to mass production. It only consumes half of the human effort in the factory, half of the manufacturing space, half of the investment in tools and half of the engineering hours to develop a new product [1]. Based on the studies conducted by Bayou and de Korvin [2], manufacturing leanness is a strategy to obtain input decline to better achieve the goals of the organization through producing better output, where “input” refers to the physical quantity of sources used and their cost, and “output” refers to the quality and quantity of products sold and issues related to customer service. In another study on lean manufacturing, Narasimhan et al. [3] found that efficient use of resources through the reduction of waste is important in leanness because lean production is aimed at reducing non-value added activities or waste.

The main idea of lean production is essentially to maximize customer value while reducing waste. Among the objectives of implementing lean production operations are to increase productivity, improve quality, shorten lead times, and reduce costs [4]. These factors show the performance of a lean production system. Some claim that the techniques of lean production were first identified as the reason for of the success enjoyed by Japan. This contention is based on the fact that the lean management model was first developed at Toyota Motor

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Company by the Japanese after World War II as part of their efforts to reduce costs. Therefore, the introduction of lean has evolved in the market, where its first appearance was in the car industry development that has been pioneered by the Toyota production system (TPS). The success of the TPS shows that the lean techniques are prevailing and significant. The tremendously positive outcome has led other companies from various industries such as electrical and electronics [5-7], automotive [2, 8], auto and machinery [9], wood [10], ceramics [11], industrial machine tools [12] and others to implement lean in their manufacturing process.

However, most companies have implemented lean and lean practices are assessed in their own unique way. The reason for this scenario lies in their internal issues such as lack of knowledge and understanding of lean, culture, skills and so on. Other factors such as the age [13] and size [7, 9, 13] of the company are also found to contribute to the level of use of lean tools or techniques in one company. Therefore, these situations have widespread implications on companies by restricting the measurement or comparing their performance throughout the company and the industry. Some companies have given up practicing lean due to the above mentioned factors. Therefore, a study should be undertaken to identify and define the determinant or indicator to assess the leanness in manufacturing companies. The objective of this article is to gather preliminary views from experts leaning toward a framework concept for leanness in the context of the manufacturing industry in Malaysia.

2. MATERIALS AND METHODS

This study has improved the previous conceptual framework by Amelia Natasya et al. [14] specifically on the relationships among dimensions in the transformation stage, and the types of wastes that could be eliminated towards true lean. Comprehensive literature review on lean manufacturing (LM), lean production (LP), Toyota Production System (TPS), wastes, leanness, and lean assessment have been conducted in order to achieve the objectives of this research. The current existing framework [9, 15,16,17,18]) or model [4, 19, 20, 21] of leanness is identified and studied. The key area or dimension of lean implementation and leanness variables in these framework/model have been studied and compared. "Variable "in this study refers to an element such as practice, technique, tool, or principle that had been mentioned interchangeably in the previous studies to measure leanness. The comparative analysis identified the total number of existing variables in a framework/model which range from three to sixty-five. However, a few frameworks/models share similar variables, i.e.: continuous improvement is being widely used by a majority of leanness framework/model. The numerous leanness variables have led to the development of a different version of leanness measure due to the different understanding, interpretation, and perception of the leanness concept among the researchers. This phenomenon brings implications to the lean research and society especially in determining the level of success of lean implementation in the organisation. The prerequisite of lean development or transition cannot be discussed [22] and the performance of two companies cannot be rated or compared towards leanness achievement [2, 23]. As mentioned by Amelia Natasya et al. [14], seven dimensions are found to be crucial towards ensuring the success of lean implementation or true leanness measure. The seven dimensions resulted from the frequency analysis on the most common practice, technique or tool in implementing or measuring leanness that has been mentioned in the previous study. According to Kuruppalil [24], the most common indicator indicates the key indicator in lean implementation. In order to get an initial view on the validation of this conceptual framework, a pilot test has been conducted. The respondents in the study were asked to perform the content analysis by checking the structure of the sentences, comprehensibility, and the possibility of data errors in the instrument. All respondents were requested to answer the questionnaire as a pilot test. Three respondents were involved in this study. Two of them are academicians who are experts and actively doing research in the field of lean manufacturing (P1 and P2) and one industry expert with over 20 years' experience in lean (P3). According to Shafinah [25], a pilot study requires at least three people with the same background characteristics and between fifteen to twenty-five people with different background characteristics. A descriptive analysis is carried out to evaluate the respondents' responses in the pilot test.

3. DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

Generally, the manufacturing system is an input-output model. The system receives the input elements and later undergoes a few processes in the transformation stage. Finally, the desired product is produced in the output stage. The quality and cost of the final output depend heavily on the factors that affect or control the system during the transformation process. The goal is to produce the right product at the right time with the right cost, in order to gain profitability and stay competitive by maintaining sales growth. Figure 1 shows that there are seven main elements in the boxes, which are the *supplier relationship*, *workforce management*, *manufacturing process and equipment*, *manufacturing planning and scheduling*, *visual information system*, *product development and technology* and *customer relationship.*

The italicised text in Figure 1 represents waste whilst the text in the boxes represents lean dimension in manufacturing. Womack and Jones [26] define waste as any human activity which absorbs resources but creates no value. 'Muda' is the Japanese word for waste and Ohno [27] has identified seven types of waste which are also known as Ohno's seven muda. They are: overproduction (O), waiting (W), transportation (T), motion (M), extra processing (E) and defect (D). Waste is always linked to lean. But later, the eighth waste was added to Ohno's original list by other authors, namely "underutilized people". However, Liker [16] adopts a different term for the same type of waste, which is "unused employee creativity".

The description of the eight types of waste has been discussed and agreed to by many scholars. Figure 1 also shows the relationship between lean dimensions and waste, for instance, *supplier relationship* dimension may involve a relationship with four types of waste which are inventory (I), underutilized people (U), defect (D) and waiting (W).

The same rule applies to the other dimensions. The emphasis on the relationship may be important as it would help the practitioners in identifying the right tools or techniques to solve problems according to their goal. On the other hand, the arrow shows the direction of contribution in the system. In the input phase for example, the *supplier relationship* and *workforce management* dimensions may contribute to the next phase of the system, also known as the transformation process. The dimensions, relationships, and the type of waste that have been proposed in the previous conceptual framework [14] has been revised, especially the transformation stage. The transformation stage of the new proposed conceptual framework consists of three dimensions instead of four [14] such as the *manufacturing process and equipment, manufacturing planning and scheduling* and *product development and technology.* The new framework propositioned the *visual information system* dimension outside the transformation stage box. Furthermore, the *visual information system* that has been proposed in the transformation stage [14] is more practical and desirable in a wider context of the supply chain in order to increase the quality of data and efficiency during the information sharing across the multi-dimension of the organisation. The accuracy of the information is important in order to make the right decision on production, problem-solving, and continuous improvement activity. A feedback loop function as shown in Figure 1 plays an important role in gaining feedback or information from *customer relationship* in the output phase to the manufacturing system. This loop function helps the organisation to produce the right product which is valued by the customers. By-product output will go to the scrap system. On the other hand, the type of waste along the supply chain (Table 1) and environmental waste factor have also been considered in the new proposed conceptual framework. *Environmental waste* is another type of waste which comes from the use of raw materials, air pollution and water pollution from reduced manufacturing by-products and lowered carbon emission from the energy used.

According to Moreira et al. [28], a study on the relationship between leanness and environmental performance has been carried out by several researchers and organizations as early as 1993, one year after the introduction of the concept of eco-efficiency. This suggests that the earlier studies have tried to link the firm with an environmental impact. Naturally, the process of production also produces another type of waste apart from the eight types of manufacturing waste. Energy consumption and excess material, the release of contaminants into the air, water, and land are the implications of poor product production process [28] which can bring major implications for human health and the environment. One major contributor to the successful implementation of lean is the alignment between stakeholders in the supply chain and the focal organization, seeing that organizations often have difficulties aligning internal processes with customers and suppliers [29]. Therefore, the urgent need to implement effective lean manufacturing is in order to integrate the activities in the transformation of the input and output of an organization's production system through lean thinking.

Table 1. Types of Waste

Dimension	Types of Waste
Manufacturing Process and Equipment	Waiting, Defect, Overproduction, Transportation, Motion, Inventory, Extra Processing.
Manufacturing Planning and Scheduling	Waiting, Defect, Overproduction, Transportation, Motion, Inventory, Extra Processing.
Visual Information System	Waiting, Defect, Overproduction, Inventory, Transportation, Motion, Extra Processing.
Product Development And Technology	Waiting, Defect, Overproduction, Inventory, Transportation, Motion, Extra Processing.
Workforce Management	Waiting, Motion, Underutilized People.
Supplier Relationship	Waiting, Defect, Inventory, Underutilized People.
Customer Relationship	Waiting, Defect, Inventory.

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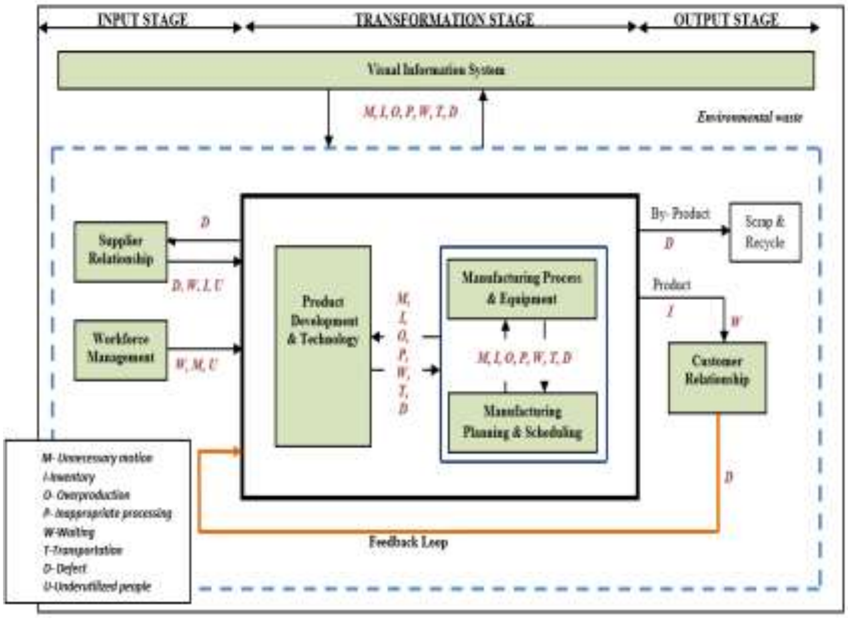

Figure 1. A conceptual framework of lean production dimensions and its relation to waste.

4. RESULTS AND DISCUSSION

The five-point Likert scale is used by the respondents to rate their answers, ranging from '1-Not Important', '2-Less Important', '3-Uncertain', '4-Important' and '5-Very Important'. The mean and standard deviation were computed to measure their evaluation of the proposed framework. Respondents were asked to evaluate the items related to lean dimensions (6 items), the relationship among dimensions (18 items), and the relationship between dimension and waste (38 items).

The first series of questions in Part C of the questionnaire concern expert's opinion related to the importance of each dimension in measuring lean practice or leanness. Table 2 sets out the analysis of the seven lean dimensions (CO1 to CO7) that have been evaluated by the experts (P1, P2 and P3). From Table 2, the *workforce management* dimension recorded the highest score of mean value which is 4.76. According to Expert P3, the focus on managing employees is to make employees adhere to Standard Operation Procedures (SOPs) and to develop training for both middle managers and employees to enhance their capability and skills to perform continuous improvement activities like Kaizen or simple projects on their own. In addition, the most recent issue in *workforce management* is managing foreign workers who have limited language skills, making it difficult for them to understand instructions. This problem may increase the risk of defective products and cause a slowdown in meeting production target.

This finding is supported by Machado and Pereira [21] who highlighted the concept of lean as being mainly related to people, especially in terms of improving working conditions, finding better ways of doing things and increasing productivity. Besides, all the mean values in Table 2 were reported to be at least 4.00, which indicates a high degree of emphasis on the proposed dimensions. Thus, all the other dimensions, being *manufacturing processes and equipment*, *manufacturing planning and scheduling*, *product development and technology,* and *visual information systems* were accepted for testing at the actual phase of study.

The qualitative technique has been successful in gathering feedback from the respondents. One of the respondents (P3) agreed with the proposed dimensions but she thought that both *manufacturing planning and scheduling* and *product development and technology* dimensions were external factors which most of the time were uncontrollable by the manufacturing plant. Quality and schedules were claimed to be highly dependent on market demand or forecast provided by customers. Sometimes, orders are made by forecast basis but then the order is suddenly cancelled by the customer. This situation causes the stock to become inventory waste that could expire, become obsolete and become scrap. These inventory waste may consume warehouse space and incur a rental cost. In the context of product design, manufacturing plant is actually at the receiving end even though the relationship or communication with product design is important. The operational factors such as optimum resources, equipment up-time, and internal quality performance in manufacturing plant significantly contribute to the leanness status of the manufacturing plant. The manufacturing process must be designed to the minimum waste. The possibility of human error, delay or bottleneck between processes must be eliminated. In addition, equipment must be designed in order to add value to the process of transforming raw materials to final products, not just limited to functions as conveyor or transporter of materials. *Customer relationship* is important in gaining direct feedback on quality performance. Thus, a proper mechanism is needed so that customers could give feedback on a defect or product improvement. Besides, corrective action can be done by manufacturing plant. Expert P3 added that *Supplier relationship* function place more emphasis on the supplier quality management and *visual information system* is claimed to be to be the key thing in lean. However, the application of information technology in manufacturing is not necessarily visual.

Table 2. The lean dimensions (n=3)

Item	P1	P2	P3	Mean	SD
C01	5	4	4	4.33	0.58
C02	5	4	4	4.67	0.58
C03	3	4	5	4.00	1.00
C04	5	4	3	4.00	1.00
C05	5	4	3	4.00	1.00
C06	5	4	4	4.33	0.58
C07	5	4	3	4.00	1.00

C01=Supplier Relationship; C05=Product Development & Technology
C02=Workforce Management; C06=Customer Relationship
C03=Manufacturing Process & Equipment; C07= Visual Information System
C04= Manufacturing Planning & Scheduling;

The series of questions in Part D of the questionnaire concern experts' opinion on the importance of the order of these dimension relationships among the dimensions to provide valid representations of the leanness measurement conceptual framework. The arrows in Figure 1 and Figure 2 represent the relationship among dimensions and the results for these relationships are shown in Table 3. Items DI1 to DI5 in the questionnaire represent the relationship between dimensions in the input phase and transformation phase. As shown in both figures, some of the relationships are only single way such as relationship from *workforce management* dimension to the transformation process. This relationship is tested by item DI3 (4.67). However, the relationship between the *supplier relationship* dimension and transformation process is tested on a two-ways basis. Item DI1 (4.33) is the relationship from *supplier relationship* to the transformation process, while DI2 (3.67) is vice versa. According to expert P3, the transformation process may contribute to *supplier relationship* (DI2) only if manufacturing plants buy materials as needed (just in time or pull system) instead of buying just-in-case/big lots size. In conventional ways, suppliers are the ones who contribute to transformation (DI1). The lower rank supplier will only be visited for the purpose of improving their performance. However, expert P3 also claimed that not every company applies this and for this reason, the supplier is the one who needs to catch up. Meanwhile, the relationship between *visual information system* dimension and both *supplier relationship* dimension and *workforce management* dimension are represented as DI4 (4.00) and DI5 (4.00) respectively. The qualitative data in this study also indicated that *visual information system* will only contribute to *supplier relationship* if visual pull card/Kanban system were used in ordering materials. Besides, Kanban cards are nowadays electronic based and can be sent by fax, email or etc. Expert P2 and P3 thought that the relationship between *workforce management* and *visual information system* is not so strong. Expert P3 claimed that a *visual information system* is merely a tool that can be used to share key information. On the other hand, it is the workforce who should be responsible for applying and updating the *visual information system* properly in order to successfully utilize its function.

The relationship between dimensions in the transformation phase is represented by items DT1 to DT7. Item DT1 (5.00) refers to the relationship from transformation process to *customer relationship* in the output phase. Both items DT2 (4.67) and DT3 (3.67) represent the two-way relationship between *product development and technology* and manufacturing activities at shop floor. The mean score for DT3 is only 3.67 since, as highlighted by expert P3 earlier, *manufacturing process and equipment* is just at the receiving end. Even though communication between product development and the shop floor is important in the ideal situation of the lean environment, it is hard to be done practically in Malaysia. The rapid progress of *product development and technology* in Malaysia has caused the *manufacturing process and equipment* to fully accept the final design and then try their best to fit it in with the process in order to produce the product. Meanwhile, the relationship between *manufacturing process and equipment* and *manufacturing planning and scheduling* is represented by items DT4

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(4.33) and DT5 (5.00). According to expert P3, the good performance of both equipment and process in shop floor will contribute to smooth planning and scheduling. Both items DT6 (4.67) and DT7 (3.67) represent the two-way relationship between *visual information systems* and transformation process. As reported in Table 3, the mean score for DT7 is only 3.67. This is because expert P3 has claimed that the relationship is only true if the *visual information system* is applied to the system. As she mentioned before, the application of information technology in manufacturing does not necessarily have to be visual.

The relationship between the dimensions in the output phase is represented by items D01 to D06. Both items DO1 (4.00) and D02 (4.00) represent the two-way relations between *visual information system* and *customer relationship*. On the other hand, item D03 (4.67) represents the feedback loop from the *customer relationship* to the transformation phase of manufacturing plant. Outputs of the system which are made up of product and by-product are represented as D04 (4.33). The relationship from product to the customer in the output phase is represented by D05 (4.67). In addition, the relationship from by-product to scraps, recycling, and environmental waste are represented by D06 (5.00). The highest value of mean score in Table 3 shows items DT1, DT5 and D06 with a value of 5.00 (very important). Meanwhile the lowest mean score is 3.67, which is given by items DI2, DT3 and DT7. Thus, all items of the mean score are higher than the uncertain level. All these items are retained to be validated in the actual study.

Table 3. The relationships among lean dimensions (n=3)

Item	P2	P3	P4	Mean	SD
DI1	5	4	4	4.33	0.58
DI2	5	4	2	3.67	1.53
DI3	4	5	5	4.67	0.58
DI4	4	4	4	4.00	0.00
DI5	5	4	3	4.00	1.00
DT1	5	5	5	5.00	0.00
DT2	5	4	5	4.67	0.58
DT3	4	4	3	3.67	0.58
DT4	4	5	4	4.33	0.58
DT5	5	5	5	5.00	0.00
DT6	4	5	5	4.67	0.58
DT7	5	3	3	3.67	1.15
D01	5	4	3	4.00	1.00
D02	5	3	4	4.00	1.00
D03	5	4	5	4.67	0.58
D04	4	4	5	4.33	0.58
D05	4	5	5	4.67	0.58
D06	5	5	5	5.00	0.00

Set out below is another point of view from expert P3 regarding the relationship of lean dimensions:

... 'In the context of relationship perspective, it is quite sporadic to distinguish that *visual information system* to be designed on the outside of the main system. This situation shows that *visual information system* is an important element. It could be true because lean itself is making things 'visual'. Simply, there must be a justification for this situation because of its difference from others' leanness framework/model. Normally, the *visual information system* is observed as a tool or practice and not as a relationship '...

The series of questions in part E are concerned with experts' opinion regarding the importance of a relationship between lean dimension and types of waste in manufacturing. Both Table 4 and Table 5 report the results of the relationships between lean dimension and waste. Items IS01 to IS04 involve the relationship between the dimension of *supplier relationship* with the waste of inventory (4.67), defect (4.67), waiting (4.67) and underutilized people (4.00). However, the experts had suggested adding other related types of waste like extra processing (E) and transportation (T) to this dimension. In addition, the respondents had proposed some important characteristics like Vendor Development Program and SAP-ERP to this dimension. In the context of waste in *workforce management*, the relationship is associated with motion (4.00), waiting (4.00), and underutilized people (4.67). Besides, defect waste has been found to be relevant in *workforce management* by the respondents. Items TP01 until TP07 represent the relationship between the dimension of *manufacturing process and equipment* with the waste of motion (5.00), inventory (4.67), overproduction (4.00), defect (4.67), transportation (5.00), waiting (4.67) and extra processing (4.67). Respondents of this study also suggested waste of underutilized people to represent issues such as improper distribution of work or imbalance between processes. Besides, some of the employees who do not have much loads can contribute more by doing important activities. Elements like procurement and e-procurement were also recommended by the respondents.

The relationship between *manufacturing planning and scheduling* with waste is tested through items TS01 till S06 for motion (4.00), inventory (5.00), overproduction (5.00), defect (4.00), transportation (4.33), waiting (5.00) and extra processing (4.33). Elements like MRP, MRPII and maintenance of equipment are proposed by experts P1 and P2. The relationship between *product development and technology* dimension and waste are represented by items TT01 to TT07, being waste of motion (4.00), inventory (4.00), overproduction (3.67), defect (4.00), transportation (3.67), waiting (3.33) and extra processing (4.0). Items TV01 to TV07 represent the relationship between the *visual information system* dimension with the waste of motion (4.33), inventory (4.33), overproduction (4.33), defect (4.33), transportation (3.33), waiting (3.67) and extra processing (3.67). On the other hand, OC01 to OC03 represents the relationship between *customer relationship* dimension and the waste of inventory (4.33), defect (3.00) and waiting (3.67). As shown in Table 4, the mean value for OCO2 is 3.00. As stated by expert P3, it is too late to improve the quality level at the output stage because the product has already been distributed to the customer. This situation is known as lagging and relates to market quality. She also claimed that it would be good if there is a leading indicator such as supplier quality and internal quality instead of this lagging indicator at the transformation phase. In addition, the root cause for the measurement of rework needs to be investigated and remedied. As shown in Table 4, the lowest level of the mean score is 3.00 or uncertain, thus, all items tested in this section are maintained to be validated in the actual study.

Table 4. The relationships between dimensions and waste (n=3)

Item	P1	P2	P3	Mean	SD
IS01	5	4	5	4.67	0.58
IS02	5	4	5	4.67	0.58
IS03	5	4	5	4.67	0.58
IS04	5	4	3	4.00	1.00
IW01	4	4	4	4.00	0.00
IW02	4	4	4	4.00	0.00
IW03	5	4	5	4.67	0.58
TP01	5	5	5	5.00	0.00
TP02	5	4	5	4.67	0.58
TP03	5	2	5	4.00	1.73
TP04	5	4	5	4.67	0.58
TP05	5	5	5	5.00	0.00
TP06	5	4	5	4.67	0.58
TP07	5	4	5	4.67	0.58
TS01	4	4	4	4.00	0.00
TS02	5	5	5	5.00	0.00
TS03	5	5	5	5.00	0.00
TS04	4	3	5	4.00	1.00
TS05	5	3	5	4.33	1.15
TS06	5	5	5	5.00	0.00
TS07	4	4	5	4.33	0.58
TT01	4	4	4	4.00	0.00
TT02	4	4	4	4.00	0.00
TT03	4	3	4	3.67	0.58
TT04	4	4	4	4.00	0.00
TT05	4	4	3	3.67	0.58
TT06	4	3	3	3.33	0.58
TT07	5	3	4	4.00	1.00

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OC01	5	4	4	4.33	1.73
OC02	4	4	1	3.00	0.58
OC03	4	3	4	3.67	0.58
TV01	5	4	3	4.33	0.58
TV02	4	5	4	4.33	1.15
TV03	5	5	3	4.33	1.15
TV04	4	5	4	4.33	0.58
TV05	4	3	3	3.33	0.58
TV06	4	4	3	3.67	0.58
TV07	4	4	3	3.67	0.58

The results of the pilot test in Table 4 and Table 5 show a total of fifteen items (23.8%) which recorded 0.00 as their result for the value of standard deviation. These items are DI4, DT1, DT5, D06, W01, IW02, P01, TP05, TS01, TS02, S03, S06, T01, T02 and TT04. This value indicates that all respondents provided the same data or consent to the study item. The majority of the items recorded a value of standard deviation which is equal to or not more than 1.00 (49.2%). According to Brinkman [30], a low value of standard deviation indicates a high level of agreement among raters. Ten items (15.9%) recorded a standard deviation of at least 1:00 for items C03, C04, C05, CO7, DI5, D01, D02, IS04, and TT07. Meanwhile, seven items of the study (11.1%) which are DI2, DT7, TP03, TS05, OC01, TV02 and TV03 each showed a value of standard deviation which is greater than 1.00. A high score indicates that the amount of variation for the item is greater than its mean value in the agreement among the evaluators [31]. Outliers data may also increase the value of standard deviation dramatically.

Table 5. Response for dimension and waste** (**n=3)

Item	Comments
IS01-IS04 (Supplier Relationship)	• The Vendor Development Program (VDP). • ERP-SAP. • Waste of transportation exists when the location is far from each other. • The waste processing system is more applicable when booking or internal planning system is not prepared properly, causing orders to suppliers being made immediately.
IW01-IW03 (Workforce Management)	Waste defects occur when workers are not given the training should be relevant SOP.
TP01-TP07 (Manufacturing Process & Equipment)	• Wastage of unused labor occurs when a task is not distributed properly and imbalance between the process, causing some workers to have less work while they may contribute to other important activities. • Procurement and e-procurement.
TS01-TS07 (Manufacturing Planning & Scheduling)	• MRP, MRP II • Maintenance is more focused on equipment
TT01-TT07 (Product Development & Technology)	• Manpower unused: product design lead to workers performing routine tasks in the manufacture of manuals. • Tasks that can be done through automation so that labor can be utilized better elsewhere.
TV01-TV07 (Customer Relationship)	• The visual information is an important tool for sharing information related to the process and equipment. Do not directly impact on the elimination of waste or waste identification. • Bullwhip Effect, real-time data collection
OC01-0C03 (Visual Information System)	• CRM • Labelling scale three as less important is certainly better than nothing.

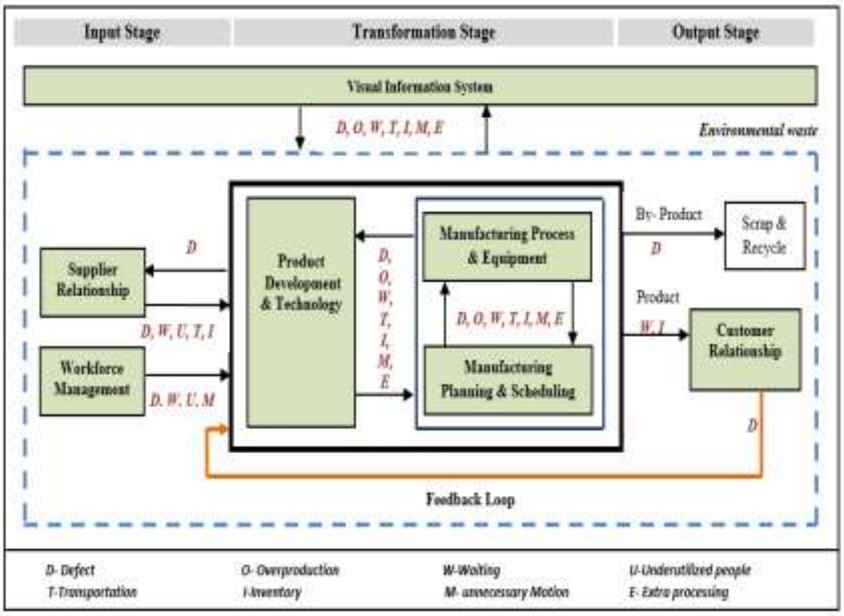

Figure 2. A revised conceptual framework of lean production dimensions and its relation to waste.

5. CONCLUSION

This study was undertaken to get a preliminary view of the validation of conceptual framework for lean manufacturing measurement in the manufacturing industry. An earlier study has identified the factors or determinants that contribute to the measurement of lean practices. Similar practices/tools/techniques with the same characteristics are grouped into the same dimension. As a result, seven main dimensions have been identified to be significant and contribute to leanness measurement in manufacturing. The findings of this study will be brought forward and utilized in the next stage of validating the framework by using the Delphi Method. Further work needs to be done to establish whether the relationships between the dimensions and waste are true by conducting the Delphi method approach. The conceptual framework can also be modelled into a diagnostic model for leanness measurement in future work. Practitioners and scholars may benefit from this study as it will contribute towards improving the general effectiveness of the strategic manufacturing performance.

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