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Defining and Developing Measures of Lean Sustainability for Manufacturing Sector

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Abstract. Toyota Manufacturing Company revival after World War II and its survival during 1973 global oil crisis had inspired many manufacturing organisations around the world to initiate lean transformation. However, due to lack of clear understanding of the lean sustainability concept, many manufacturers are unable to fully transform into a true lean organisation like Toyota. In fact, without a proper measurement, the organisation's transformation progress will be unknown and the specific gains made from lean improvement cannot be monitored. Hence, it will result in wrong strategy deployment in the lean transformation program. This paper therefore aims to theoretically define Lean Transformation Sustainability and propose set of indicators for measuring this concept. A myriad of literature related to theory and practices of lean manufacturing was studied to better understand this concept. The methodology adopted to better understand Lean Transformation Sustainability concept was based on steps to success in writing literature review by Machi and McEvoy. Apparently, Lean Transformation Sustainability can be measured in three dimensions; (1) lean elements momentum, (2) lean culture adaptation, and (3) enduring success. At the end of this article, the authors recommend several opportunities for future research that can be used for adding literature to lean body of knowledge.

1. Introduction

Lean Manufacturing (LM) is an improvement strategy which originated from Toyota Production System (TPS). Toyota Motor Company sustainable success in facing 1973 global oil crisis had inspired manufacturing organisations around the globe to convert from traditional mass and batch production to LM system. The conversion from traditional mass and batch production to LM system is called “lean transformation” [1-3]. The term “Lean Transformation” describes necessary changes made to acquire desirable gains associated with lean practices. The term transformation suggests a magnitude, wholeness, and depth of change needed in organisations to fully embrace lean thinking as a new operational philosophy replacing profit-based mind set [2, 3].

However, organisations that have successfully initiate lean transformation may experience difficulties and challenges to sustain this initiative in the long run [4-6]. Rationally, no organisation would engage in a change initiative with the intention to fail. Despite abundant studies and works that demonstrate LM has significant and positive effect on various performance measures [7-9], this field has struggled with the lack of clarity on how to continuously achieve such performance from lean transformation and what indicators should be considered to measure it. This missing piece of knowledge in LM literature needs urgent attention by lean scholars and researchers [4, 10].

Therefore, objectives of this paper are as follows. First, authors attempt to resolve the lexical confusion surrounding “lean sustainability” and explain the different views in defining this term.



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Second, in authors' pursuit of a clear and consensus definition of lean sustainability, we propose an operational definition that encompasses its underlying multidimensional concept. Finally, based on an extensive literature study, the present review proposed set of 34 indicators to measure lean transformation sustainability concept.

2. Methodology

This literature study was carried out based on the framework of six steps to success in writing literature review proposed by Machi and McEvoy [11]. Machi and McEvoy defined a literature review as a written document that presents a logical argued issue established on a comprehensive understanding about the current state of knowledge regarding a topic of interest. The six steps to success in the literature review writing are including; (1) select a topic (specifies and frames), (2) search the literature (explores and catalogues), (3) develop the argument (organises and forms), (4) survey the literature (documents and discovers), (5) critique the literature (advocates and defines), and (6) write the review (addresses the topic).

To enable a broad outreach, Google Scholar is used to find related articles regarding the topic [12]. Starting with keywords like "lean sustainability", "sustainable lean", "sustaining lean", and "lean maturity" related articles were retrieved. As a result, 38 publications were downloaded and studied. These publications encompassed indexed journal, peer-review journals, and grey literatures. Grey literature refers to any material not easily identifiable by traditional bibliographic index or database, such as reports, working papers, dissertations, thesis trade and industry magazines [13, 14]. Inclusion of grey literatures makes a literature review study more rigorous and comprehensive [15].

Lastly, some more significant studies were found through the cross-references as well as forward and backward searches. Forward search means reviewing additional sources that have cited the retrieved articles, while backward search refers to reviewing the literature cited in the articles yielded from the keyword search [14, 16].

3. Defining lean sustainability

The term "Lean Sustainability" is often interpreted as leveraging LM for reducing waste from raw materials and energy consumption for the sake of future growth and prosperity (i.e. triple bottom line – social, economy, and environmental) [6, 17-20]. Whereas, this review intends to refer Lean Sustainability as maintaining momentum of lean implementation once initial pilot and blitz are completed, following Jørgensen et al [6]. This notion translates "sustainability" as the synonym of ongoing, prolong, endurance, continual, longevity, tenability, viability or maintainability.

Similar to Jørgensen et al [6], Murti [1] perceived Lean Sustainability as how to maintain the momentum of lean change within practising organisations. Murti [1] elaborated the term "lean change" as the conversion from traditional manufacturing system (i.e. mass, batch or queue system) adoption to LM system adoption. However, Roth [3] denoted that lean managers and consultants often used the term "lean transformation" instead of "lean change" to address this conversion. This is because, the term "lean transformation" suggests a magnitude, wholeness, and depth of change needed in organisations to fully implement and gain improvements associated with LM [3].

Hence, the present review proposed the term "Lean Transformation Sustainability" to describe organisation's effort in maintaining the momentum of conversion from traditional manufacturing system to LM system. This new term is also hoped to resolve confusion and any ambiguity between leveraging LM system for achieving triple bottom line (i.e. Lean Sustainability) and the effort to maintain momentum of LM implementation (i.e. Lean Transformation Sustainability). Thus, the first objective of this paper have been fulfilled.

Further, in order to propose a comprehensive operational definition for describing Lean Transformation Sustainability concept, several issues need to be addressed. Firstly, previous studies expressed the effort to maintain momentum of LM implementation in varying terms including; "sustaining lean culture" [2], "sustaining lean improvements", "sustaining lean transition", or "sustaining lean success". However, none of these studies provided clear and detailed definitions on

these terms. The use of varying terms without detail definitions in previous studies are implying that this concept and its measurement is still vague and ambiguous. The concept of sustainable improvement programmes like LM and Total Quality Management (TQM) are indeed ambiguous and lead to considerable confusion. Hence, they were suggesting that a detail and comprehensive definition of this concept is in need.

Nevertheless, there are few scholars attempted to define this concept. For instance, sustaining lean as obtaining enduring success with lean deployment. In contrast, Mohd Yusof and Aoki [4] perceived sustaining lean as a state where adopting practices of costs reduction through waste elimination is the way of life. On the other hand, other researcher describe sustainable lean in more detailed by describing a sustainable lean organisation as companies that have made to the highest level of lean maturity and advancing at a strong but cautious pace. These companies are marked by their strong, steady value margin across a wide range of conditions. Yet, all three definitions are not really consistent to one another.

Alukal's definition was focussing on sustaining success in lean transformation effort. Meanwhile, Mohd Yusof and Aoki's definition emphasised on treating lean transformation as "the way of life" (i.e. culture) which in-line with studies of [2]. Whereas, Ruffa's definition highlighted lean maturity level as the essence of lean transformation sustainability. Lean maturity level refers to the degree to which an organisation is adopting lean elements. Thus, the present review believes that Lean Transformation Sustainability can be defined as a multidimensional concept featuring; (1) acquisition of enduring success, (2) continuous adaptation of lean culture, and (3) consistent momentum of lean elements adoption.

Sustainable organisational change as the process through which new working methods, performance goals, and improvement trajectories are maintained for a period appropriate to a given context. In other words, sustainable change centres on three facets which include; (1) the stability of work methods, (2) the persistent achievement of performance goals, and (3) the consistent direction towards continuous improvement. Definition and facets of Sustainable Change underpinned authors' definition of Lean Transformation Sustainability (see table 1).

Table 1. Similarities between Sustainable Change and Lean Transformation Sustainability concepts.

Sustainable Organisational Change	Lean Transformation Sustainability
Stability of work methods	Momentum of lean elements adoption
Persistent achievement of performance goals	Enduring success
Consistent direction towards continuous improvement	Adaptation to Lean culture

Another ambiguous issue related to Lean Transformation Sustainability concept is the time period of sustaining phase begins and ends. There is indeed a considerable confusion to determine when does the sustaining phase begins. In TQM context, the sustaining phase started when the pilot phase is completed. The pilot phase involves the process of installing various quality management practices and tools into the organisation system is done. Once the pilot phase is over, the sustaining phase starts to commence. Thus, the same logic can be applied to LM, as both TQM and LM are regarded as continuous improvement methodologies for improving manufacturing operations.

A pilot Lean Project can be completed and started to show visible improvements within 6 months. On the other hand, the period of sustaining phase as undefined duration towards the future. A new working methods, performance goals, and continuous improvement culture which occur during sustaining phase are expected to last for a period appropriate to a given context. Hence, there is no ending period for sustaining phase as long as the organisation desire and intend to continue such effort.

Therefore, this paper operationally defines Lean Transformation Sustainability as maintaining the momentum of lean elements adoption, while achieving persistent performance goals, and having consistent direction towards continuous improvement once the lean pilot project is completed until a

certain period appropriates to the setting. Lean pilot project refers to the process of installing basic lean elements into the manufacturing system of an organisation. Basic lean elements are referring to lean practices, tools or techniques that require less investment, feasible to implement and deem applicable to SMEs. Multi-skilled employees, 5S, visual control and display, standardisation of operation, cross-functional teamwork are among basic lean elements. Hence, the second objective of this paper is accomplished.

4. Lean transformation sustainability measures

Based on the proposed definition in the previous section, the present study proposed three features for measuring Lean Transformation Sustainability namely; (1) momentum of lean elements, (2) enduring success, and (3) adaptability to lean culture.

4.1 Momentum of Lean Elements

Lean Elements refer to lean tools, techniques, practices or procedures. Momentum of Lean Elements adoption are matched with the stability of work methods. Stability of work methods translate the situation where the new ways of working become the norm, integrated or mainstream way of working rather than something added on. In the long term, the work methods are expected to remain intact and not reverted to the old ways. Moreover, these work methods might evolve alongside other changes in the setting and probably continue to improve over time.

While there are numerous Lean Elements can be identified in the literatures, the present study only selected several Lean Elements that are classified as Lean Building Blocks for measuring the momentum of adoption. Lean Building Blocks is a set of lean tools and techniques which can be used by practitioners to introduce, improve, and sustain the lean transformation in their organisation. 15 Lean Building Blocks have been derived as the following:

- (1) Cross-functional teams
- (2) Batch size reduction (small lot production)
- (3) Work cells (cellular manufacturing)
- (4) Quick changeover (setup time reduction)
- (5) Pull system (kanban system)
- (6) Total Productive Maintenance (TPM)
- (7) Workplace organisation (5S)
- (8) Visual management (visual control)
- (9) Andon
- (10) Standard work (standardisation of operations)
- (11) Quality at the source
- (12) Autonomation (jidoka)
- (13) Error proofing (poka yoke)
- (14) Levelling (heijunka)
- (15) Value Stream Mapping (VSM)

Concisely, this study operationally defines Momentum of Lean Elements feature as the level of Lean Elements adoption are instilled in organisation's manufacturing system as the mainstream way of working. Hence, the present study proposed the following measurement items:

- (1) Lean Elements adoption become the norm (typical practice) in manufacturing operations.
- (2) Lean Elements adoption are well-integrated with manufacturing staffs' daily work.
- (3) Every adopted Lean Element is remained intact (no backsliding).
- (4) Lean Elements are continuously used in an effective manner.
- (5) The effectiveness of every adopted Lean Element is constantly improving.
- (6) New/additional Lean Elements are introduced for adoption from time to time.

4.2 *Enduring success*

Enduring success implies that performance levels and goals achievement persist for a period appropriate to the setting. Achieving enduring success works as a constant stimulus which prove that the efforts of making improvement are paying off. Improvement programs like LM or TQM would be in vain if success yielded from the programs are not held or endured. When implemented successfully, LM not only allows for cost reduction while improving quality, but it can also position a company to achieve tremendous growth (e.g. productivity enhancement, competitive advantage, market share expansion) [3].

An improvement program is successful if objectives are accomplished and the targeted problems are resolved. LM objectives are including; productivity improvement, manufacturing costs reduction, increased competitiveness, market share improvement, and improved delivery records. Meanwhile, targeted problems in LM program centres on waste elimination and reduction of non-value adding activities along the manufacturing or production timeline.

In sum, this study operationally defines Enduring Success as the ability to persistently achieve targeted goals and desired performance level from Lean Transformation efforts as soon as the sustaining phase begins (i.e. the process of installing basic Lean Elements into the manufacturing system is done). Rooted in common success indicators identified in several previous studies, this feature is measured as the following:

- (1) By the nature of our work, workers motion to move parts is a regular practice in our plant
- (2) Minimising overproduction in our plant leads to preventing accumulation of units within the store
- (3) When we minimise the excess inventory through working, our production defective units are less
- (4) Workers and machines waiting minimization facilitate the monitoring of product quality
- (5) Over-processing minimization leads to a better use of time and efforts
- (6) Defects minimization reduces re-manufacturing the same products
- (7) Materials/products transportation minimization in our plant reduces the risk of damaged units or defects
- (8) Since our plant implementing LM, we gain a better competitive position (competitive advantage)
- (9) Since our plant implementing LM, the market share of products are expanding
- (10) Since our plant implementing LM, the overall business performance (e.g. ROS, ROI, and ROA) are improving
- (11) Since our plant implementing LM, the overall productivity (e.g. machine productivity, labour productivity, etc.) are increasing
- (12) Since our plant implementing LM, the overall production costs (e.g. operating costs, labour costs, inventory cost, etc.) are decreasing
- (13) Since our plant implementing LM, our on-time delivery record is getting better

4.3 *Adaptability to lean culture*

Lean culture is the culture of eliminating waste and problem solving which rooted in the concept of continuous improvement [1]. It is a complex process of cultural change which contingent on learning and knowledge sharing [6]. The lean culture also can be viewed as an organizational culture where employees are aware and actually implementing lean practices [8]. Thus, some scholars addressed the lean culture as soft lean practices. In fact, success in creating a lean culture depends on employees getting actively involved and being allowed to practice the lean elements in frequent trainings and their every-day tasks [7].

Organisation's adaptability to lean culture is matched to the notion of consistent direction towards continuous improvement. Consistent direction towards continuous improvement involves; (1) alteration

of thinking, attitudes, or behaviours (2) transformation into supportive systems surrounding, and (3) ability to withstand challenge and variation.

Alteration in behaviour and attitude towards continuous improvement is visible when improvement procedures crossing a variety of functions are becoming easier or stable industrial relations is achieved. Industrial relations as stable when management are emphasising a sense of teamwork and pulling together employees to have common goals in achieving TQM objectives. Working as part of a team, inter-dependent, and closely linked with other functional areas are behaviours that differentiate between LM system and traditional mass production habit.

Meanwhile, transformation into supportive systems surrounding is evident when a non-blaming, performance oriented, and process-driven organisational atmosphere exists [2]. Employees are not blamed for failures and mistakes. Instead, failures are viewed as opportunities to learn and possibility to improve. In addition, mutual respect and trust exists across functional areas with equitable sharing of benefits from continuous improvement activities.

Finally, organisation's ability to withstand challenge and variation is apparent when conflicts are openly discussed and differing opinions are voiced. Organisation members who well-adapted with lean culture strive to achieve win-win solutions to reach consensus for resolving conflicts. The lean culture also overcome challenge and variation by promoting open and honest feedback between organisation's members. Organisation's members are encouraged to reveal errors, potential risks, and present only true facts, regardless good or bad.

Concisely, this study defines Adaptability to Lean Culture feature as the degree of organisation's members truly embrace the culture of eliminating waste, continuous improvement, and ongoing learning. Based on previous literature [8], indicators for measuring this feature are proposed as the following:

- (1) A non-blaming organisational atmosphere exists (i.e. failure or error not directed to certain group or a person).
- (2) Every manufacturing (production) staff understand how lean transformation relates to their job responsibility
- (3) Every manufacturing (production) staff is well-informed on all lean transformation matters
- (4) Every manufacturing (production) staff applies lean thinking to improve job performance
- (5) Every manufacturing (production) staff is committed to continuously learn on how to eliminate waste
- (6) Every manufacturing (production) staff focuses on eliminating wastes in daily job
- (7) Suggestions (ideas) from any manufacturing (production) staff is highly encouraged
- (8) Senior managers are actively leading the deployment of lean transformation
- (9) Senior managers know when to help and when not to intervene in lean project assignments
- (10) Effective measurements of lean transformation progress (performance) are in place
- (11) Conflicts (problems) are always viewed as opportunities to learn
- (12) Conflicts (problems) are always viewed as opportunities for improvement
- (13) Most problem solving groups in this manufacturing (production) plant feature staffs from a variety of functional areas
- (14) Cross functional team working are effective in fostering lean transformation
- (15) Production work teams' efforts are recognised (rewarded), even if improvements are not fully successful

5. Concluding remarks and future research

The aim of the study was to define and propose indicators (measurement items) that can be used in the evaluation of Lean Transformation Sustainability in the manufacturing sector. This was done, first by resolving the confusions with existing terms and definitions related to lean sustainability or sustainable lean. Secondly, three features of Lean Transformation Sustainability namely; (1) momentum of lean elements adoption, (2) enduring success, and (3) adaptation to lean culture were identified and proposed with reference to literature. The proposed features and indicators in this research study however, is still

a work in progress as is yet to be validated in the real manufacturing environment, hence is termed as a conceptual study. Therefore, an empirical study in the real environment of Malaysian manufacturing sector will be carried out by using the proposed indicators.

For future research, the empirical study may be conducted by collecting quantitative data (survey), qualitative data (case study) or both (mixed-method). The empirical study will help in determining the validity and reliability of this concept, as well as the contributing factors associated with lean transformation sustainability at the manufacturing plant. The use of data collected from the empirical study is to support the theoretical assumptions highlighted earlier in this paper. Results of the future study are estimated to demonstrate indicators of Lean Transformation Sustainability are valid, reliable, and applicable to Malaysian manufacturers. These indicators also serve as the basis for future studies to determine the effect of factors such as Lean Leadership and Organisational Learning on Lean Transformation Sustainability. Since there is still lack of research been carried out in Malaysian manufacturing sector on lean transformation sustainability, the authors will expand the body of knowledge by addressing this issue.

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