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ORIGINAL ARTICLE

The Significant of Lean Practice on the Sustainability Performance in Automotive Manufacturing Industry

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ABSTRACT – This study attempts to evaluate the significant of lean practices on the sustainability performance in automotive manufacturing industry. Lean practices are typically used to eliminate waste that are produced by defects, waiting time, overproduction, extra motion, extra processing, excess inventory and unnecessary transportation. Meanwhile, sustainability performance is defined as the alignment of financial, environmental, and social objectives in the conduct of fundamental business operations with the goal of maximizing value. The study was conducted in the form of a questionnaire survey and the statistical analysis was carried out based on collected data. This study only focuses on automotive manufacturing industry in the area of peninsula Malaysia. Statistical Package for Social Sciences (SPSS) is applied to answer the research objectives and to test the hypotheses. The results show the high levels of Cronbach's Alpha indicate that the questionnaire data are valid and dependable. All the companies have significant gain more in terms of environment sustainability performance by adopting lean techniques. The study also indicates the most tools that had been implementing among the four companies are 5S, kaizen, kanban, employee commitment and teamwork. Through the multiple regression analysis, the result indicates that the lean practices have significant and positive effect on sustainability performance in automotive manufacturing industry. The current study also benefits manufacturer by providing information on the extent of lean manufacturing practices and their impact on three bottom lines (TBL) sustainability performance, allowing helping their company achieve long-term economic, environmental, and social improvements.

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INTRODUCTION

For over the last four decades, lean has been regarded as a strategic method to constantly improve processes, goods, services, and organizations [1]. Derived from Toyota Production System (TPS) in the 1990s, Lean increases employee involvement via daily problem-solving activities that aim to reduce waste and improve the efficiency of the value flow. Lean Manufacturing (LM) helps minimize wastes from the manufacturing process and enhance the bottom line process by minimizing cycle time and eliminating non-value-added operations through their tools and techniques [2]. Nowadays, hundreds of manufacturing businesses already use the lean manufacturing philosophy to eliminate waste and enhance their overall operations. By eliminating waste, the quality product or services is improved, while manufacturing time and expenses are reduced [3].

In point of fact, lean approach also facilitates sustainability benefits because lean also appears to have significant impacts on reducing environmental impacts, such as air, water and soil emissions, as well as water and energy consumption efficiency [4]. Sustainability performance is defined as to the pursuit of social, economic, and environmental objectives within the operations of a certain firm and operational links that extend beyond the firm to encompass supply chain and communities [5]. On the other hand, the sustainability strategy also focuses on reducing environmental effect and producing environmentally friendly goods and processes [6].

Besides, lean also promises tremendous benefits regarding competitive advantage and sustainability performance towards the automotive industry cultures. The automotive industry was formerly seen as the 'industry of industries,' with the capacity to propel industrialization forward due to its interconnections and spill-over effects on other manufacturing industries in the pre-globalization era of economic growth [7]. Due to that, for the time being, the automotive sectors have a high level of competition among each other by facing the challenges to reduce the costs and at the same time to maintain and increase their service quality and meet the customer's requirement. In addition, there are several factors influence the manufacturing process in automotive industry, including machine failures that cause unwelcomed stoppages, unskilled human resources that cause longer production times and workplace accidents, and inefficient layouts that cause long delays in the exchange of semi-products between machines [8]. To overcome, automotive manufacturing industry attempt to employ tools (Lean Practices) in the framework of continuous improvement in their production processes in order to stay competitive.

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This study is being conducted with the goal of determining the lean practice and sustainability performance elements in term of their significant in automotive manufacturing as well as analyzing the performance of lean implementation on the three primary sustainability measurements of social, economic, and environmental. The achievement of lean practice on the sustainability performance can be evaluated through the assessments. Consequently, the significant of lean practice on the sustainability performance in automotive manufacturing industry will be assessed. Therefore, the aims of this study are:

1. To identify lean practice and sustainability performance elements in term of their significant in automotive manufacturing industry through the literature review.
2. To develop structured questionnaires survey to measure lean practice on the sustainability performance.
3. To identify the significant lean practice on the sustainability performance in automotive manufacturing industry from the result of the questionnaires survey.

LITERATURE REVIEW

Lean Manufacturing Concept

Over the last 30 years, Lean Manufacturing (LM) also known as lean production (LP), or lean, is a manufacturing technique and philosophy established by Toyota Production System (TPS) in Japan, has outlined some of the most widely used and effective methods for achieving operational excellence and currently extensively used by many firms worldwide. Besides, LM focuses on getting the correct goods at the right place, at the right time, and in the right amount to achieve ideal workflow while minimizing waste and being flexible and adaptable.

Waste has always been associated with lean. According to Womack and Jones, waste is any human action that consumes resources but produces no value. 'Muda', one of the three enemies that developed by TPS, is the Japanese term for garbage, and Ohno recognized seven distinct sorts of rubbish, called Ohno's seven Muda. The seven wastes are excessive production, waiting time, transportation, unnecessary motion, inefficient processing, inventory and product defect [9]. Moreover, another two enemies by TPS that must be removed from the production system to accomplish the two central concepts, which are design that overburden (Muri) and reduce inconsistency (Mura). Mura is a Japanese word that signifies unevenness, non-uniformity, or irregularity. Mura is the reason for any of the seven wastes to exist. Mura, in other terms, is the one who drives and leads Muda. Meanwhile, Muri translates as "overburden," "beyond one's capacity," "excessiveness," "impossibility," or "irresponsibility." Muri can occur as a result of Mura or, in some situations, as a result of excessive removal of Muda (waste) throughout the process.

In addition, a lean manufacturing system is built on two pillars: the first is 'Jidoka' (stopping and notifying of irregularities, segregating human and machine labour), and the second is 'just-in-time' (continuous flow, tact time, and pull system). In particular, "Jidoka" (loosely translated as "automation with a human touch"), in which equipment shuts down immediately when a problem occurs, preventing the production of defective products, meanwhile the "Just-in-Time" concept, wherein every process produces on what it is necessary for the following procedure in a continuous flow. These two pillars primary goal is to produce higher-quality products at the lowest possible cost and by minimizing waste in the shortest possible time frame [10].

Lean Tools and Techniques

According to recent surveys, more than 50 lean tools and approaches are extensively employed, based on the scale of the industries. In Malaysia, several studies have been discovered to be connected to adopting and applying lean manufacturing tools and techniques, particularly in the automotive, electrical and electronic, and food and beverage sectors, to enhance performance. Based on the pilot study, it had been identified there are over hundreds of lean tools that can be implemented but the main lean tools and techniques, including (1) 5S (Housekeeping), (2) Poka-Yoke (Mistake Proofing), (3) Kanban, (4) Total Productive Maintenance (TPM), (5) Kaizen (Continuous Improvement), (6) Cellular Manufacturing (CM) (7) Standardized Work (SW), (8) Value Stream Mapping (VSM), (9) Jidoka, and (10) Plan-Do-Check-Act (PDCA) [11]. Figure 1 shows example of lean manufacturing techniques and tools.

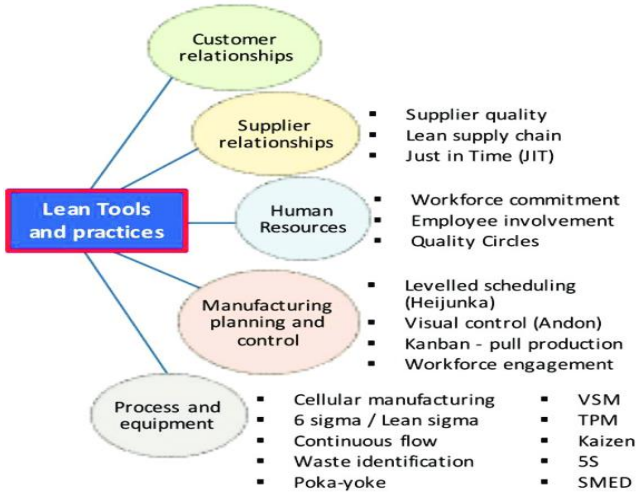

Figure 1. LM Techniques and Tools

Sustainable Manufacturing

Currently, sustainable manufacturing (SM) has become a critical concern for manufacturing organizations worldwide. Sustainability has been identified as a crucial necessity due to declining government rules, nongovernmental pressure on social and environmental issues, and growing customer desire for green products [12]. SM is defined as a manufacturing process that reduces negative environmental consequences, conserves energy and natural resources, is safe for organization workers, community, and consumers, and is commercially successful. The goal of SM is to reduce the amount of energy, materials used and emissions and the development of undesirable by-products or processes while maintaining the product's value to the community and the organization [13]. Moreover, it should be emphasized that SM used three primary indicators known as Triple Bottom Line (TBL) indicators (economic, social, and environmental). As a consequence, only those TBL indicators should be used to assess the manufacturing process's long-term sustainability.

Triple Bottom Line

Traditionally, performance measurement in manufacturing operations has been done from an operational perspective. However, since the turn of the century, pressure from various stakeholders has grown for non-economic outcomes to be tracked and improved (social and environmental). This three-pronged approach to sustainable performance has been known as the Triple Bottom Line (TBL) as shown in Figure 2. Moreover, John Elkington articulated the TBL for the first time in his 1999 book, "Cannibals with Forks: The Triple Bottom Line in Twenty-First Century Business". The TBL approach encourages firms to strike a balance between the economic, environmental, and social principles of sustainability. This differs from traditional reporting frameworks in that it includes ecological (or environmental) and social variables for which appropriate measurement methods may be tough to obtain by. The TBL dimensions are made up of the three Ps: people, the planet, and profits [14]. Table 1 shows Analysis of Literature Review of Impact Lean Practices on Sustainability Performance.

Figure 2. TBL Approach

METHODOLOGY

The study starts by reviewing the journal's literature to extract evidence that may be utilized to support the research findings in automotive manufacturing. Then, the structured questionnaires are developed and validated by industrial expert and academician to ensure that the questions proposed are relevant and meet the study requirements. Four automotive manufacturing industries in Malaysia will be selected to conduct this study toward the impact of lean practice on sustainability performance. The questionnaires will be distributed via online platform which are through email or WhatsApp or combination of the both platform to the Top management (Manager, Head of Department), executive (Engineer, Supervisor), and shop floor (Operator, Technician) workers.

The survey questionnaires are divided into three sections; Section A (Respondent Background), Section B (Identification of Level of Lean Practices Implemented in the Company) and Section C (Impact of Lean Practices on the Sustainability Performance). The respondents are asked to score the given tools and aspects in terms of their effectiveness in implementing the concept of LM practices with the scale of (1) disagree, (2) neutral, and (3) agree. The company's implementation of lean tools can be classified as not implemented (1), intermediate level of implementation (2), high level of implementation (3). A larger score indicates a greater degree of agreement with the questioned statement, or vice versa. A three-point Likert Scale is used to answer all questions so that the scale created can be easily measured and perform statistical analysis.

The statistical analysis will be performed using Statistical Package for the Social Sciences (SPSS) software to analyses the level of lean and its significant on the sustainability performance of the companies. The data is analyzed using the Cronbach's Alpha, Levene's test, ANOVA, and t-Test.

RESULT AND DISCUSSION

Cronbach's Alpha

Table 1 shows the Cronbach's Alpha value for Section B and Section C. Cronbach's alpha value for Section B, hard lean practices/ tools is indicated as good reliability since the value is 0.809. Meanwhile, for soft lean practices/ tools, it is indicating outstanding reliability since the value is 0.903. Besides, the Cronbach's alpha for Section C is considered as acceptable internal consistency because the value is ≥ 0.7. Cronbach's alphas scores for both the implementation of lean tools and sustainability performance revealed that the score is dependable, and the elements are directly correlated as a group.

Table 1. Cronbach's Alpha for Section B and Section C

Section B (Implementation of Lean Practices in the Company)	**Cronbach 's Alpha**
Hard Lean Tools/Practices	0.809
Soft Lean Tools/Practices	0.903
Section C (Sustainability Performance Resulting from Implemented Lean Practices)	**Cronbach 's Alpha**
Social Sustainability Performance	0.704
Environmental Sustainability Performance	0.713
Economic/Operational Sustainability Performance	0.715

Levene Test

Figure 3 depicts the outcomes of the Levene's Test for lean tools implementation for Company A, Company B, Company C and Company D. Levene's Test has a P-value of 0.791, which is larger than 0.05. As a result, the null hypothesis Ho is accepted. High P-values suggest that no difference exists between the variances. As a result, there is not enough evidence to reject the null hypothesis and accept the claim. Thus, a one-way ANOVA test with equal variance will be performed.

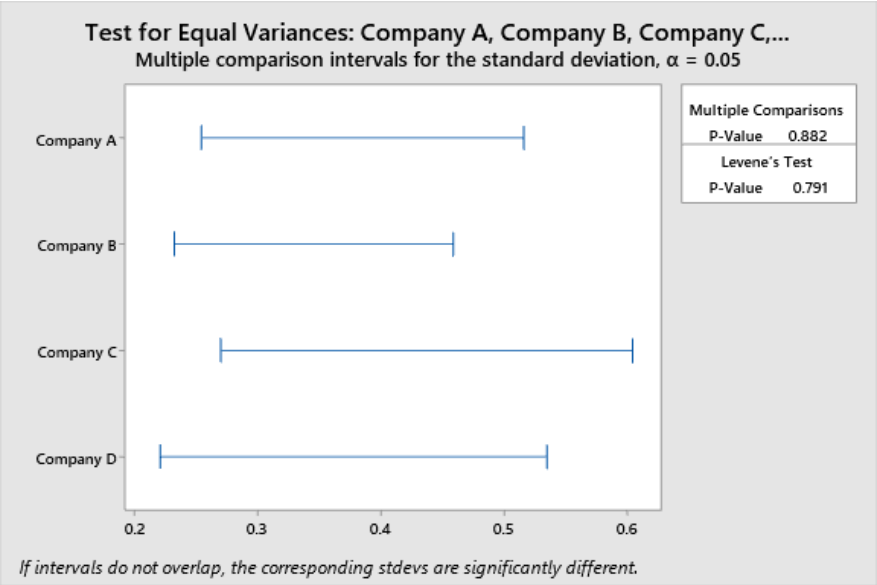

Figure 3. Test for Equal Variance of Lean Tools Implementation between the companies

Figure 4 displays the results of the Levene's Test for the impact of lean practices implementation on sustainability performance among the companies A, B, C, and D. The P-value for Levene's Test is 0.682, which is greater than 0.05. The null hypothesis Ho is therefore accepted. High P-values indicate that there is no difference between the variances. Therefore, insufficient evidence exists to reject the null hypothesis and accept the claim. Consequently, a one-way ANOVA with equal variance will be conducted.

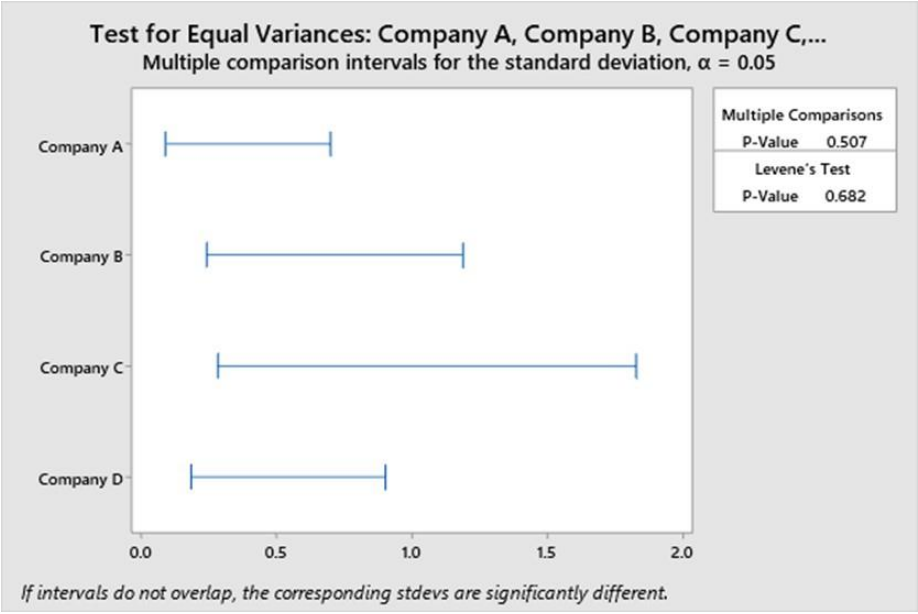

Figure 4. Test for Equal Variance of Sustainability Performance between the companies experiment

Analysis of Variance (ANOVA)

Table 2 shows the comparison on lean tools and sustainability performance among the four companies (Company A, Company B, Company C and Company D). If the P-value of one-way ANOVA is less than $\alpha = 0.05$, the alternative hypothesis, Ha is accepted. In this case, the P-value of the lean tools and sustainability performance among four automotive industries are lies under $\alpha = 0.05$. Thus, the null hypothesis, Ho is rejected and the claim is accepted that there is difference between the means and groups.

Table 2. Comparison on Lean Tools and Sustainability Performance among the Companies

Variables	Mean				P-value
	Comp A	Comp B	Comp C	Comp D	
Hard lean practices	1.546	1.5	1.444	1.422	<0.001
Soft lean practices	1.437	12.00	1.311	1.4	<0.001

Table 3 demonstrate that the P-values for sustainable performance in the social, environmental, and economic dimensions are all less than 0.05. This shows that the means are not within the confidence range of 95 percent, hence Ho is rejected and the claim is accepted. Therefore, it is apparent that the impact of sustainability performance of Company A, Company B, Company C and Company D is different.

Table 3. Comparison on Lean Tools and Sustainability Performance among the Companies

Variables	Mean				P-value
	Company A	Company B	Company C	Company D	
Social sustainability performance	2.667	2.533	2.667	2.773	<0.001
Environmental sustainability performance	2.857	2.933	2.989	2.667	<0.001
Economic sustainability performance	2.76	2.667	2.445	2.467	<0.001

Linear Regresion Analysis

Ho: There is no significantly effect of lean practice on the sustainability performance in automotive manufacturingindustry.

Ha: There is significantly effect of lean practices on the sustainability performance in automotive manufacturingindustry.

Table 4 demonstrates the linear regression analysis between the lean practices and sustainability performancein automotive manufacturing industry. The 10 significant factors that can forecast sustainability performance are 5S, kaizen, kanban, JIT, andon, top management, human resource management, employee commitment, organizational culture and lastly is teamwork. The R-value is 0.709, which almost close to 1, and is therefore a strong and association and also a good prediction value. R square or also called as coefficient of determination is equals 0.503, in which lean practices represents 50.3% of the variability for sustainability performance.

Table 4. Summary of Results for Hypothesis Interpretation

Model Summary				
Model	R	R-Square	Adjusted R-Square	Estimated Standard Error (S)
1	0.709	0.503	0.441	0.105

Based on Table 5, the p-value of independent variable of 10 lean practices has a value of $p < 0.05$ and is significant to the hypothesis Ha. Therefore, the Ho is rejected and the Ha is accepted where there is significant effect of lean practices on the sustainability performance in automotive manufacturing industry.

Table 5. Summary of Coefficient Regression

Variable	P-value
Lean Practices	0.022

CONCLUSION

As a conclusion, the objectives of this study are successfully identified and obtained. Furthermore, in the form of a Likert scale questionnaire, a successful lean practice on sustainability performance evaluation for automotive manufacturing companies was devised and then verified by three industrial experts before the questionnaires form were distributed to the respondents. The level of lean implementation and impact of sustainable performance based on lean practice is then examined when a survey is done. In addition, the high levels of Cronbach's Alpha indicate that the questionnaire data are valid and dependable. The level of implementation had been determined and compared by measure the mean score of scale 3. Besides, through the process of analysis, the findings show all the companies studied have

significant gain more in terms of environment sustainability performance by adopting lean techniques. In addition, this exploratory study also indicates the most tools that had been implementing among the four companies are which are 5S, kaizen, kanban, employee commitment and teamwork. Through the multiple regression analysis, the result indicates that the lean practices have significant and positive effect on sustainability performance in automotive manufacturing industry. This current study also benefits manufacturer by providing information on the extent of lean manufacturing practices and their impact on three bottom lines (TBL) sustainability performance, allowing helping their company achieve long-term economic, environmental, and social improvements. Since the Likert Scale Questionnaire limits the feedback and responses from the respondents, future researchers can expand the project by adding open-ended interviews to the study. It is because the data from likert scale question is limited. In addition, it also recommends that the number of respondents should same for each of the companies or sectors in order to get more precise data and analysis. The future researchers can also look into other sector of the companies such as multinational company. By doing this, they could learn more about lean tools and how well they work in terms of sustainability because the data they get is not limited based on the type of the company.

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