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The Integration of Lean and Green Manufacturing for Malaysian Manufacturers: A Literature Review to Explore the Synergies between Lean and Green Model

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Abstract. In general, profitability and efficiency have been the main interest for organization. However, the increasing concerns for the environment from government, regulators, customers and other stakeholders has forced companies to seek for alternatives to achieve green objectives. The difficulties faced by organizations are lack of awareness and guideline in implementing green practices in their daily operation. Under constrained resources, employers are reluctant to spend money on something unclear. During the last decade, lean manufacturing seems to be visible trend in most of the manufacturing industries in Malaysia. As lean tends to emphasize on waste reduction, it provides similarity between lean and green. Therefore, it is a better atmosphere to deploy green practices and tools under existing lean manufacturing. The purpose of this paper is to present a review on the synergies between green and lean and identifying the determinants that affecting both lean and green manufacturing for Malaysian manufacturers. The determinant obtained are financial benefit, incentive, legislation, stakeholder, management commitment, technology, environmental awareness and brand image or competitiveness. Besides, the authors identified and suggested future research directions on developing an integrated lean-green model for daily operation. This study aims to assist researchers to identify the opportunities and challenges on lean-green model and this review is useful for manufacturers and government in developing manufacturing policies and guideline.

1. Introduction

The manufacturing sector is a major growth driver of Malaysia's economy. In Eleventh Malaysia Plan (2016-2020), the manufacturing sector is expected to grow at 5.1% per annum, contributing 22.1% to GDP and 18.2% of the total employment by 2020. It contributed about RM232.9 billion or 23% of GDP in 2014, making it the second largest contributor after the services sector. However, Malaysian industrial sector consumes around 45% of electricity generated. Manufacturing sector have recorded a 46% increase in greenhouse gas (GHG) emissions between 2000 and 2011 as reported in the Malaysia 2016 Biennial Update Report (BUR). Due to drastic climate change and rise of the environmental concerns from around the world, companies are urged by regulators, customers and other stakeholders to look into green manufacturing. Green performances in manufacturing industry has become an important criterion to enhance company's reputation especially dealing with multinational companies which will directly lead to better business revenue. Malaysian government has initiated various



programs to encourage green practices among all industries in order to minimize the severe environmental degradation [1]. Besides, Malaysia's National Green Technology Policy had been enforced since 2009 with the objectives to develop, strengthen, enhance, formulate and promote green technology in energy, transport, building, waste management and water management sector. However, most of the manufacturers have insufficient knowledge about environmental management. Therefore, it is very difficult for manufacturer to see the benefits of implementing environmental management [2]. On the other hand, lean manufacturing is still very famous even among small and medium enterprise in Malaysia with the core principal on cutting wastage [3]. The concept of wastage in lean covers wastage of energy and natural resources which create the possibilities to synergies lean and green manufacturing together [4]. With the high implementational cost of green manufacturing, it is logical to consider the lean-green approach and identify the overlapping determinants between lean and green manufacturing and further integrate them into daily operation. The extension from existing lean manufacturing into lean-green manufacturing could be a cost-effective way to start green practices and improve daily operation.

Green studies in Malaysia cover Islamic food companies [5], automobile manufacturers [6], SMEs manufacturing sector [7], electrical and electronics manufacturing [8], furniture sector [9] and others. Unfortunately, most of the international and local studies remain on preliminary stage and lack of empirical results to provide Malaysian manufacturers a clear and step by step implementational model on environmental based manufacturing. Furthermore, finding from Fernando and Wah [10] regarding the impact of eco-innovation drivers based on organisational processes in Malaysian green tech sector shows 79% of the firms did not involve in green practices. The idea of integrated lean-green model is still new especially in Malaysia and lack of relevant studies to fill the research gaps on how to implement green into existing lean manufacturing. Hence, the aim of this study is to provide manufacturers, scholars, regulators and government a clear list of determinants that complementing and affecting lean and green model for manufacturing sector. Besides, the research gaps for future lean-green studies are highly desirable. In order to achieve the mentioned aims, journals related to lean and green are studied thoroughly to identify the determinants that govern the lean and green thinking and group them into organized categories. Followed by, challenges and opportunities of lean and green model were identified to point out the rarely explored lean-green topics.

2. Literature review

2.1. *Lean manufacturing*

A book named "The Machine That Changed the World" makes lean thinking popular around the globe [11]. Toyota implemented lean thinking into their production line and achieved "zero waste to landfill" status in the world [12]. The main idea of lean is to cut any waste in order to speed up the productions or services without compromise the quality and cost. [13]. Besides, lean manufacturing focus on eliminating waste in every stages of the production line [14]. Lean is said to improve the efficiency, profitability and flexibility of an organization [15]. Seven wastes or "muda" found in lean thinking are over-production, defects, unnecessary inventory, inappropriate processing, excessive transportation, waiting, and unnecessary movement [16]. Ultimately, lean waste refers to activities that does not contributes value especially for customer. Lean manufacturing is considered the most influential manufacturing paradigm today [17] and this phenomenon happened in Malaysia for the last decades.

2.2. *Green manufacturing*

Green is an initiative focus on pollution prevention and waste control [18]. Green manufacturing eliminates environmental wastes to reduces environmental impacts and improves ecological efficiency [19]. The eight environmental or green wastes are greenhouse gases, eutrophication, excessive resource usage, excessive power usage, pollution, rubbish, excessive water usage, and poor health and

safety [20]. In general, green waste refers as the consumption of water, energy and resources. According to the Green Technology Master Plan (GTMP) of Malaysia (2017-2030), green thinking should be made as the core of a business strategy, shifting the manufacturing value chain towards green energy, green products and green processes. Unfortunately, environmental impact caused by manufacturing are often compromised in developing countries [21]. Many manufacturers still consider environmental issues as a constraint instead of opportunities to progress [22].

2.3. Synergies of lean and green manufacturing

Cost no doubt is the main concern for any business organizations especially for SMEs. Although employers are urged to realize their responsibility on environmental issues and find ways to achieve green objectives from stakeholders, high investment cost for green is always one of the top barriers around the world including Malaysia [7]. Due to the similarities on “cutting waste” between lean and green, lean manufacturing could be a pre-requisite step for implementing green. It is easier to start a long-term green investment after employer manage to secure a better operational return from lean. Therefore, the authors further investigate the similarities between lean and green in this study. Synergies between lean and green mainly focus on the usage of energy, resources and reduction of wastes [23]. Study shows lean is beneficial for green while green shows positive impact on existing business operations. Lean emphasizes on cutting any non-value added waste and green focuses on reduction of environmental waste, “waste reduction” is the key similarity between them. The concept of waste and waste reduction techniques are well complementing lean and green [23-26]. Therefore, the alignment between lean and green paradigm in term of methods and tools become natural. Extension to green manufacturing is natural and more studies indicates implementation of integrated environmental and operations management unleash greater advantages for businesses [27-28].

3. Complementary determinants for lean and green

From a bigger picture, deterioration of environment and ecology in the earth due to exploitation of human is an undeniable fact. Environmental responsibility starts to fall on every industry including manufacturing industry. Malaysia’s government sets target to achieve 17,000 of green manufacturing by 2030 according to GTMP Malaysia as compared to 3,400 established green manufacturers recorded on 2015. This will eventually lead to tougher legislation enforcement. Consequently, adoption of green practices in manufacturing industry is inevitable. Similarity between lean and green is a break through point and it will be easier to adopt green practices into existing lean manufacturing since lean is a popular trend in Malaysia for past decades. Rather than kick start everything from scratch, it is more affordable to expand green practices from existing lean manufacturing. Implementing green practices into existing lean manufacturing could be a win-win approach to achieve greater profit and better environmental performance.

A summary of green determinants that complement lean manufacturing is identified after thorough journals studies and shown in Table 1. Although this is a preliminary study but the identified determinants that complementing green thinking into lean are valuable in the sense of manufacturers could focus on determinates that governs lean-green manufacturing and start to reconsider and initiate upcoming green developments. Besides, the identified determinants could be further analysed by obtaining the precedence relationship between the key determinants using statistical tools like Interpretive Structural Analysis.

Table 1. Complementary of green into lean.

Determinants	References
Financial benefit	A study of an automotive firm showed that tailored lean and green model managed to reduce approximately 10.8% of the production costs [29]. Bergmiller and McCright identified that implementation of green into lean companies achieve better lean results. The researchers further confirm that green manufacturing drives lean results and improved cost performance [28].
Incentive	Financial incentives encouraged the adoption of green in SMEs [30-31] and this is not contradicting with lean thinking where continuous improvement is crucial.
Legislation	SMEs should comply with the existing environmental legislation and develop earlier planning for future legislation through hard and software upgradation [32]. Besides, governments should provide roadmap of future law enforcement with achievable targets to organization [33].
Stakeholder	Green supply chain is still in infancy stage in Malaysia because many local suppliers do not conform to any environmental certification yet. However, some global suppliers are certified with ISO14001 [6]. On the other hand, customers are aware of the environment degradation and they demand for environmental friendly products [34].
Management commitment	Commitment of top management is the most critical factor in successful implementation of lean and green for both SMEs and large firms [21]. Top management always have the final say in decision making processes [32].
Technology	Information technology (IT) provides reliable aids in implementing green practices and managing material flow efficiently [35]. Shift of technology from manual labour to automated production is an encouraging approach to go greener [36].
Environmental awareness	Environmental awareness, education and training are green driver for both SME and large industries [21] because high level of environmental awareness is a pre-requisite for implementing lean and green manufacturing [37].
Brand image/competitiveness	Environmental stance not only increased revenue but improved brand image [25,38]. Besides, green practices help manufacturers improve their competitiveness in the local and global markets [39].

4. Challenges and research gaps

Research shows the investment in environmental certification and management can reap earnings in the long term [7] but employers still conclude that the implementation of green will incur high cost [39] with unclear return. Introduction of cost effective lean-green models for manufacturing industry and educates employers the long-term green benefits would be highly desirable. Secondly, standardizations are needed on current performance metrics for lean and green because lean and green performances are examined by researchers individually [40] and this might lead to contradiction between findings from different researchers. Besides, employers are demanding a standardized step by step procedures to ease the green implementation processes. Lastly, health and safety in the context of green are still rarely explored by researchers.

5. Conclusion

In this study, the authors have identified the determinants that complement green into lean and drive the implementation of lean-green model in daily operation especially in Malaysia. The authors have compiled eight determinants from a comprehensive literature review. Besides, the authors have highlighted the challenges and research gaps in the lean-green model. Although the presented results are still in the preliminary stage but it provides an overview direction on the complementation of green into existing lean manufacturing and lean could be a pre-requisite step for implementing green. The authors intended to further the study by obtaining opinions from government and industrial experts and this will provide a holistic view on implementing lean-green manufacturing in Malaysia.

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