Environmental Friendliness in Low Carbon Supply Chain and Operations

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INTRODUCTION

Increasing environmental concerns has compelled manufacturing firms to reconsider their operation strategy. Rethinking of manufacturing firm's operations to meet customer requirements and to achieve performance in operations, economy, social and environment are necessary (Fernando, Jasmi, & Shaharudin, 2019). Nowadays, environmental issue such as climate change due to carbon emissions from manufacturing industry has become a popular topic among firms, customers and society. Evolution of shifting customer requirements from cost reduction to include more product features to product that not harmful to the environment have demand firms to change its operation management. For instance, manufacturing firms have evolved from mass production to mass customization and now towards energy management and environmental principle (Fernando, Shaharudin, Ismail, Yew, & Ganesan, 2018; Fernando, Shaharudin, Haron, Karim, & Ganesan, 2018). These shifting in strategies have seen manufacturing firms practicing just-in-time (JIT) strategy, total quality management (TQM), flexible manufacturing system (FMS), agile manufacturing (AM) strategy, lean production (LP) and supply chain management (SCM) (Gunasekaran & Ngai, 2012). These strategies are practiced by firms to achieve performances such as economic (Schandl et al., 2016), social (Beitzen-Heineke, Balta-Ozkan, & Reefke, 2017), operations (Mirkouei, Mirzaie, Haapala, Sessions, & Murthy, 2016) and environment (Nouira, Frein, & Hadj-Alouane, 2014).

Nowadays, manufacturing firms are expected to reduce environmental impacts in its supply chain and operations (Willersinn, Möbius, Mouron, Lansche, & Mack, 2017). The importance of reducing environmental impacts and threats has been studied across manufacturing sectors such as in food sector (Camanzi, Alikadic, Compagnoni, & Merloni, 2017), medical sector (Unger & Landis, 2016), automotive sector (Bechtsis, Tsolakis, Vlachos, & Iakovou, 2017), aerospace sector (Ruiz-Benitez, López, & Real, 2018), furniture sector (Fernando, Shaharudin, & Wahid, 2016) and energy sector (Fernando & Hor, 2017). These sectors need to address environmental issues especially in regard to carbon emission. Increasing carbon emission from manufacturing firms' supply chain and operations activities are highlighted as critical issue that need attention from every stakeholder (Shaharudin & Fernando, 2015). Thus, manufacturing firms need to adopt environmental friendliness criteria to appease its stakeholders. Environmental friendliness criteria can be defined as firm's operations that will not harm the environment through energy efficient and clean energy (Gunasekaran & Ngai, 2012).

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Nevertheless, literature on environmental management are divisive for supply chain cluster and operations cluster. Most articles in the literature recognized that green supply chain management (GSCM) (Kamal & Fernando, 2015), low carbon supply chain management (LCSCM) (Shaharudin & Fernando, 2017) and sustainable supply chain management (SSCM) (Balaman, Matopoulos, Wright, & Scott, 2017) have acknowledged the importance of environmental friendliness criteria. Yet, operations cluster has fallen behind in recognizing environmental friendliness criteria (Shaharudin, Fernando, Jabbour, Sroufe, & Jasmi, 2019). While Gunasekaran and Ngai (2012) introduced the concept in operations and Balfaqih, Nopiah, Saibani and Al-Nory (2016) highlighted of its importance, an investigation on environmental friendliness criteria is still limited. Furthermore, an in-depth walkthrough of this criteria such as its definition, features and previous studies discussion should be undertaken by scholars.

Since low carbon operations has been sought after by customers (Böttcher & Müller, 2015), manufacturing firms need to ensure it can meet the customer environmental requirements (Fernando, Wah, & Shaharudin, 2016). Environmental friendliness criteria are based on customer requirement for low carbon operations where it is emphasis on energy and green criteria. The reason for environmental friendliness is critical for manufacturing operations because energy is one of the highest contributor to environmental degradation and pollution (Chang, Hu, & Jan, 2016). As recorded, 49 percent of the carbon emissions come from energy and heat production (World Bank, 2014). Furthermore, firms that failed to record its energy use or adopt energy efficient technology will lag behind firms that have energy management practice in reducing carbon emissions and realising environmental friendliness (Fernando & Hor, 2017). A recent life cycle analysis study in China manufacturing industry has found that 37 percent of carbon emissions come from heating process of energy generation (Ma, Du, Zhang, Wang, & Xie, 2017). These statistical numbers show that energy efficient and low energy consumption have greater impact on operations of firms to reduce carbon emissions. Therefore, manufacturing firms should adopt environmental friendliness principles and energy efficient criteria in its operations.

As environmental friendliness is operations performance measure, this study is bound to generate interest for low carbon operations criteria and contributing to the literature. The insight of this study will prompt future studies in developing environmental friendliness, distinguishing environmental friendliness criteria with other performance measure and addressing literature gaps in regard to understanding the concept of environmental friendliness criteria. Thus, research questions for this study:

1. What is the current knowledge of environmental friendliness from the perspective of supply chain and operations?
2. What is environmental friendliness performance indicator?

BACKGROUND

Environmental Friendliness can be defined as operational performance without harming the environment using less energy consumption, clean energy, has green value and use life cycle assessment to support environmental friendliness principles. This definition is established through understanding several underlying concepts of environmental friendliness by scholars as shown in Table 1.

Features of environmental friendliness for operations in manufacturing industry are shown in Table 2. In regard to environmental friendliness, there are several main features that manufacturing firms can consider. Green value, which consist of recycling, green image, green product features and green materials are critical environmental friendliness features. These features are widely practiced and implemented by