

A REVIEW ON THE IMPACT OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICES ON FIRM'S TECHNOLOGICAL INNOVATION

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ABSTRACT

Supply chain management is the process of transforming raw materials into final products and delivering them to customers. Green supply chain management (GSCM) is an emergent strategy that aims to simultaneously improve the process and quality of products, realize sustainable development, and enhance supply chain management capabilities. The implementation of GSCM practices will allow firms to achieve technological innovation. As global awareness of environmental protection rises, businesses have begun employing GSCM to enhance their core technological innovation. The objective of this paper is to bridge the theory-practice gap by discussing empirical evidence relating to GSCM practices and technological innovation so as to encourage the former's adoption by firms. In Malaysia, the manufacturing industry is one of the largest contributors to the country's pollution index. This study examines the effect of GSCM practices on the technological innovation of firms and how it can enhance IR 4.0 preparedness in Malaysia. The findings may allow managers and practitioners to understand how GSCM practices influence technological innovation, leading to better preparedness for IR 4.0. They may also help manufacturers to identify practices that need improvement.

Keywords: Green supply chain management, technological innovation, manufacturing, industrial revolution 4.0

1.1. INTRODUCTION

In the competitive global market, companies develop novel and innovative methods to maintain their competitiveness. Some companies do so by improving their environmental performance to respond to the ever-increasing environmental regulations, to reduce the environmental impact of service delivery and production, and to address the environmental concerns of their customers (Jia & Wang, 2019). Green supply chain management (GSCM), as one of the approaches toward environmental improvement, is a system that is increasingly being adopted by companies, including those in South East Asia, to address environmental issues (Rao, 2018).

In general, green or sustainable business is defined as a firm that implements green, environmentally friendly principles in its product, process, and manufacturing activity in an attempt to deal with existing environmental issues while maintaining its profit-maximizing objective (Khairani, 2012). In recent years, scholars and researchers have increasingly become interested in GSCM (Shafique et al., 2017). Practitioners are utilizing their knowledge of GSCM to reduce environmental harm, minimize waste, preserve product quality life, and conserve natural resources (Tseng et al., 2019). These emissions are relatively less important than the those generated by the product throughout its life cycle (Farabi et al., 2019). Environmental degradation has become a significant concern to enterprises as their unsustainable

strategies have caused damage to the environment. Therefore, it is necessary to reduce the negative environmental impact inflicted by traditional supply chain management practices.

To moderate this issue, information communication technologies (ICT) and innovation, in its various aspects and methods, may be able to enhance and improve every field of life. These technological innovations will provide better knowledge to businesses around the globe. Many organizations are applying this knowledge to boost their performance and gain competitive advantage in their respective markets (Geffen & Rothenberg, 2000). Most companies believe that traditional operations and production methods are ineffective and are unable to sustain the company in the competitive market. Therefore, companies are in need to implement changes in their process and production in order to catch up with the rest of the world and enable them to join the global competition (Jakobsen & Clausen, 2016). Competing in the global market requires manufacturing firms to thrust their performance and gain competitive advantage (Shafique et al., 2017). Consequently, organizations are required to remain up-to-date with the latest technologies to allow them to implement more efficient GSCM practices in place of traditional methods. This may promote innovative and more effective production and process, pushing their performance above their competitors.

1.2. PROBLEM STATEMENT

Traditional supply chain management (SCM) is the process of transforming raw materials into final products that are then distributed to the final users for consumption. In practice, it places little care for the environment. Traditional SCM is commonly accompanied with carelessness in the management of waste and emission. This has led to serious environmental problems, such as acid rain and global warming. In recent years, firms have perceived environmental sustainability as a highly significant issue. It is therefore imperative to seek an alternative that can abate environmental damage.

The principles of adding value to business and minimizing costs in the overall production system have been identified as the key drivers of competitiveness in the global market. Many firms agree that the common manufacturing objectives, such as delivery, cost, and flexibility, are no longer enough to remain competitive in the market. The implementation of innovative technologies is necessary, especially as external stakeholders require an increased focus on sustainability (Pinto et al., 2019). Accordingly, there is a need to integrate environmental sustainability principles with technological innovations to produce more efficient processes and enhance readiness toward industrial revolution (IR) 4.0.

The manufacturing sector had the largest environmental protection expenditure in 2017 with RM1,734.9 million (Department of Statistics Malaysia, 2016). In 2013, the Ministry of Natural Resources and Environment launched a program called “E-waste Alam Alliance Malaysia”, which estimated that Malaysia will generate more than 53 million pieces of e-waste in 2020, 3.5 times higher than 1995, potentially inflicting long-term environment harm (Department of Environment Malaysia, 2015). In turn, this would affect the long-term economy of the country. To avoid such a predicament, Malaysia has expended a substantial amount of money to protect the environment. Khairuddin et al. (2015) estimated that Malaysia has produced 0.94 million tons of mismanaged plastic wastes, of which 0.14 to 0.37 million tons may have been washed into the oceans. The Green Technology Master Plan Malaysia 2017-2030 prepared by the Ministry of Energy Green Technology and Water (2009) highlighted the challenges and issues faced by the manufacturing sector in adopting GSCM practices; the implementation rate of those practices is still noticeably low.

While green practices, particularly GSCM, and technological innovation have become quite a popular subject for debate and investigation in developed countries, it seems that its research in developing countries, such as Malaysia, is rather sparse. In developed countries, such as Sweden and the United States, research in green innovation has been significant (Calza et al., 2017; Rozar et al., 2015; Seman et al., 2018; Tan et al., 2016). Though limited, there are also studies discussing the relationship between GSCM practices and technological innovation (Moori et al., 2018; Xu et al., 2019; Z. Yang et al., 2019).

1.3. SIGNIFICANCE OF THE STUDY

There is hitherto a paucity of research on the relationship between GSCM practices and technological innovation among Malaysian firms; this issue is still in the nascent stage of development. Further studies are accordingly necessary to provide more information on this topic, as Malaysian companies are still learning on how to implement GSCM in their manufacturing processes and activities. Moreover, very few studies have discussed technological innovation in its relation with IR 4.0.

By reviewing the current literature on the association between GSCM practices and firm's technological innovation, the study can provide support to managers and owners of manufacturing companies in implementing GSCM practices more effectively. This study fills the gap in literature through its exploration of the relationship between sustainability management, specifically GSCM, and firm's technological innovation in the Malaysian manufacturing industry.

2. LITERATURE REVIEW

2.1. Evolution from SCM to GSCM

Conventional SCM has focused mainly on the processes before, during, and after manufacturing. However, the post-use stage of the product life cycle is typically considered only if it promises economic benefits (Jabbour et al., 2016). SCM ultimately aims to generate higher profit for less cost, regardless of its impact to environment, people, and economy (Eltayeb & Zailani, 2014). In response to this ignorance, the incorporation of sustainability principles into industrial activities has progressively become more accepted. As Jayal et al. (2010) explained, sustainability principles must holistically encompass manufacturing product, process, and system. At the process level, toxic wastes, occupational hazards, and energy and resources consumption must be reduced. At the system level, the entire supply chain, that is, the multiple lifecycle loop of pre-manufacturing and manufacturing, as well as use and post-use, must entirely adhere to sustainability principles.

Over the past fifty years, the supply chain concept has developed from dyadic data sharing relationship between the customer and supplier to vital coordinated efforts between supply chain partners. Recently, the priority has shifted to environmental issues in individual organizations and the entire supply chain (Centobelli et al., 2018). GSCM is developed based on the essentiality of environmental awareness (Srivastava, 2007). According to Seman et al. (2018), GSCM ranges from green purchasing to integrated supply chains that involve suppliers, manufacturers, customers, and reverse logistics that "closes" the supply chain loop. Mathivathanan et al. (2018) described GSCM as a set of practices that integrate green principles with SCM, beginning from product design, purchasing, logistics, manufacturing, to waste management.

One of the main issues of SCM is environmental management. Effective environmental management requires the coordination and integration of organizational processes and alignment of strategies across all firms in the supply chain (Qorri et al., 2018). Organizational processes consist of sourcing, manufacturing, distribution, information systems, marketing, and reverse logistics. These should meet the requirements of environmental standards and regulations to relieve pressure from the government, competitors, and customers; to reduce the risk of adverse publicity and environmental hazards due to non-compliance; and to improve supply chain performance (Vanalle et al., 2017). Competition forces supply chain companies to uphold the responsibility of environmental protection, not only for themselves but also all organizations in the supply chain. Organizations should therefore identify and adopt GSCM practices to yield competitive advantage. Assistance from researchers by way of studying GSCM is also pertinent to support those organizations.

There are various thrusts for manufacturing firms to shift to greener supply chain: some firms simply intend to gain positive public perception, while others believe it to be the right thing to do for the environment. In this matter, the latter is more heedful of environmental changes than the former

(Younis et al., 2019). Studies suggest that cost reduction and profitability are some of the main motivators for manufacturing companies to implement greener supply chain (Zulkefli et al., 2019). Another determinant is reverse logistics, which can further protect the ecosystem by reducing waste (Scur and Barbosa, 2017).

In earlier environmental management systems, operations managers are only involved at arm's length since the firm solely seeks to ensure compliance with environmental regulations in product and process design, marketing, logistics, and waste management. It was understood later that to meet the long-run objectives of sustainability, green strategies must be extended to the entire supply chain (Ganzarain & Errasti, 2016). In consequence, there is a growing need to integrate environmentally sound choices into SCM practices and research. This paradigm shift is the outcome of market pressure, international and domestic legislative changes, and customer demand for environmental consciousness in the supply chain (Beamon, 1999; MacDonald, 2005). Currently, there is a substantial need in selecting the most appropriate green strategy for each industry.

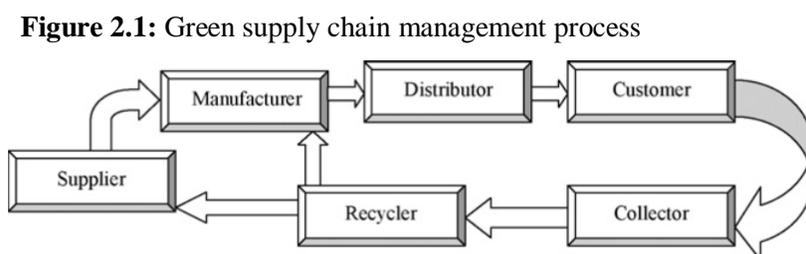
2.2. Green Supply Chain Management Practices

2.1.1. Concept

Green supply chain (GSC) has varying definitions in the literature. Some have defined it as closed-loop supply (Beamon, 1999), while others have described it as sustainable supply chain (Luthra et al., 2016; Linton et al., 2007), environmental supply chain, and ethical supply chain (Beamon, 2005). It has also been referred to as socially responsible supply chain (Salem, 2009). GSCM is the holistic effort of the firm. It is a comprehensive approach that is not solely confined to the implementation of environmentally conscious practices. Its successful application will help the firm to conserve the environment and improve performance across all management levels. GSCM will also direct companies toward sustainability in their own operations. Likewise, it will lead to greener industries and create positive impact to the environment, an outcome desperately needed in today's world.

2.1.2. The Process of Green Supply Chain Management

GSC is the amalgamation of green manufacturing and material management, green purchasing, green distribution, green marketing, and reverse logistics.



Source: Olugu et al. (2011)

Figure 2.1 illustrates the flow of materials and levels in a green supply chain. Suppliers, manufacturers, distributors, and customers work together to reduce negative environmental impacts from production and processes. The integration of forward and reverse logistics renders the entire scheme into a closed-loop supply chain, that is, it incorporates the reuse, remanufacturing, and recycling of materials into new materials or other products (Olugu et al., 2011). The GSCM process is a modification of SCM's, where it incorporates additional practices such as recycling, reuse, and remanufacturing to save cost and reduce negative environmental impact (Zaipul & Ahmad, 2017). Although the green concept is currently becoming

an emerging interest among manufacturing firms, adoption is still low, seeing that it is a costly endeavor. Rasit et al. (2019) stated that manufacturing companies will be more likely to adopt GSCM if they understand its financial and operational benefits.

Inefficient resource consumption, environmental pollution, and waste generation in the manufacturing industry inflict negative impact on the environment (Wyawahare & Udawatta, 2018). GSCM is one of the foremost strategies that can overcome these challenges and simultaneously improve organizational, environmental, and social performance (Negi & Anand, 2016). The process of implementing GSCM requires strong commitment from government agencies and organizations (Muasya & A, 2018). Nonetheless, it is quickly becoming a major strategy for businesses.

Green or sustainable supply chain incorporates sustainable environmental processes into the traditional supply chain. These processes include product design, supplier selection, material purchasing, distribution, product manufacturing and assembly, and end-of-life management (Khan et al., 2016). To mitigate the harmful impact of business activities and supply chain operations, GSCM creates or adds value to the entire process of the supply chain. The upshot is the enhancement of the organization's environmental performance by reducing waste in manufacturing, cutting down manufacturing costs, reusing and recycling products, building positive image, and increasing efficiency of assets and satisfaction of customers. These are the goals of GSCM (Khan et al., 2018).

2.1.3. The Extension of Green Supply Chain Management

Beamon (1999) defined GSC as the extension of the traditional supply chain that aims to reduce the adverse impact of a product to the environment throughout its entire cycle. This extension comes in the form of supplemental activities, which include resource saving, green design, product recycle and reuse, and hazardous materials abatement. GSCM involves different types of initiatives and activities that help the undertaking organization to cope with external stakeholder pressure and boost the overall supply chain performance (Qorri et al., 2018).

GSCM is extended throughout the entire supply chain process, which includes purchasing, manufacturing, material management, distribution, and logistics (Mohamad et al., 2018). It is a concept that allows the industry to minimize its adverse impact to the environment by demonstrating environmental responsibility in every stage of the supply chain and organizational processes (Wyawahare & Udawatta, 2018). Walmart, the American leading global retailer, displays increased awareness toward the environmental by providing green material (Christopher, 2011). It aims to be entirely supplied by renewable energy, to produce zero waste, and to sell products that conserve the environment and consumer health. It has also developed a supplier sustainability index to evaluate the products of its suppliers (Negi & Anand, 2016).

GSCM has caught the attention of scholars following the growing focus on the environment and its impact to organizational performance. Srivastava (2007) stated that GSCM includes green purchasing, green design, green distribution, green production, logistics, marketing, and reverse logistics. Walker et al. (2008) maintained that GSCM practices encompass all stages of the product lifecycle, such as production, purchasing, distribution, consumption, and disposal. GSCM relates to various activities in the supply chain, such as production, design, supply, assembly, packaging, logistics, and distribution (Eltayeb & Zailani, 2014). Therefore, issues in GSCM practices are wide and diverse. Like conventional supply chain management research, GSCM studies are typically limited by the objectives and goals of the researcher.

Green supply chain integrates eco-friendly concepts into supply chain management to achieve environmental sustainability, which is manifested in a number of green practices, including green purchasing, green distribution and warehousing, green transportation (e.g. using biofuels), green manufacturing processes, and end-of-life management (Christopher, 2011). Their implementation will enable the realization of sustainable development in social, environmental, and economic aspects, as well as the achievement of competitive advantage in the industry. Green supply chain practices have generated positive outcomes for many firms in various aspects, but its implementation is not without challenges

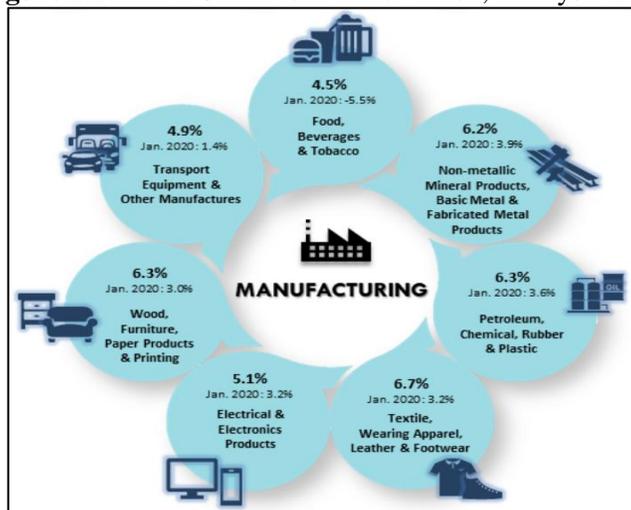
(Allaoui & Goncalves, 2013). Its adoption may require manufacturing firms to expend substantial effort, as it may involve the restructuring of business processes and the product itself (Kumar et al., 2018).

2.3. GREEN SUPPLY CHAIN MANAGEMENT IN MALAYSIA

In Malaysia, GSCM and technological innovation can be said to still be preliminary. Most companies in the country are still left behind. Green supply chain has not been implemented in business procedures (Abdullah et al., 2016). As Eltayeb et al. (2011a) discovered, the level of acceptance and adoption of GSC practices are lower in Malaysian organizations compared to foreign and multinational companies. Some obstacles for its implementation in Malaysia are size of organization (Shamsuddin et al., 2017) and high adoption cost. Those that have implemented GSCM are mostly larger manufacturing companies (Lee et al., 2010). According to Abdullah et al. (2016), the adoption of GSCM entails high costs due to training, learning, high technology procurement, and capability development. Moreover, research and debate on green innovation in Malaysia are still lacking. These suggest that the concept is still in the preliminary stage for Malaysian companies. There are certain barriers that the firms must overcome to implement GSCM and green innovation. It is also imperative that manufacturing firms develop their capabilities to enable the adoption of GSCM and green innovation, thus promoting sustainable economic growth.

The economic sectors of Malaysia have progressively transformed over the past 50 years. The decline of mining and quarrying and agriculture sectors has affected the overall GDP. The service sector contributed to 55.3% of the economy with a growth of 6.5% in 2018. It was followed by the manufacturing sector, whose share of GDP and growth rate were respectively 23.6% and 4.9%. Meanwhile, agriculture and mining and quarrying contributed only 15.2% of GDP, witnessing a decline in growth rate by 4.7% (DOSM, 2019). Moreover, there is an annual increase in employment in the manufacturing sector. In 2017, the sector employed 2,241,802 persons, before increasing by 36,080 in 2018 (DOSM, 2020a). These statistics indicate that the growth of Malaysia's manufacturing sector has contributed to the growth of the overall economy. Still, rapid industrialization has caused detrimental effect to the environment, driven mainly by increased pollution and waste and rapid consumption of natural resources.

Figure 2.2: Index Of Industrial Production, Malaysia 2020



Source: DOSM (2020b)

According to the latest Industrial Production Index (IPI) (February 2020) (Figure 2.2), the Malaysian manufacturing industry saw an overall growth of 5.8% compared to last year (DOSM, 2020b). The growth of the IPI was driven by the increment in sectoral indices: manufacturing (5.6%), mining (6.1%), and electricity (6.8%). The major contributors of manufacturing growth were Electrical and

Electronics Products (5.1%); Non-metallic Mineral Products, Basic Metal and Fabricated Metal Products (6.2%); and Petroleum, Chemical, Rubber and Plastic Products (6.3%).

The Malaysian government is currently preparing the Twelfth Malaysia Plan 2021-2025 (12MP), the country's five-year strategy, which will be presented before the parliament and public in August 2020. This plan targets three dimensions, namely environmental sustainability, economic empowerment, and social re-engineering. Under environmental sustainability are such issues as climate change mitigation and adaptation, green technology, and renewable energy. All three dimensions aim to realize the Sustainable Development Goals (SDGs) outlined by the United Nations. The 12MP suggests that Malaysia is planning to go green in the coming years to improve its economy, environment, and society.

While studies on GSCM practices are prevalent in developing and developed countries, they have been limited in Malaysia (Seman et al., 2018). The adoption of GSCM will differ from one country to another, as they are confronted by barriers that are perhaps unique to each country, such as firm size, suppliers, buyers, communities, customers, environmental regulations, mode of implementation, and internal and external pressures (Eltayeb et al., 2011; Jabbour et al., 2016; Seman et al., 2018). GSCM practices in developed countries like Japan, Germany, and other European countries are already advanced (Scur & Barbosa, 2017). However, developing countries like Malaysia still consider GSCM as a new concept in practice and research (Rao, 2002; Umar et al., 2016).

According to Chia (2019), Malaysia is facing difficulties in preventing or reducing waste from manufacturing companies. In 2019, illegal chemical waste was dumped into the Kim Kim River in Pasir Gudang, Johor, producing toxic fumes that affected about 6,000 people, hospitalizing 2,775. The victims were mostly schoolchildren, and the incident caused 110 schools near the river to be closed. In 2006, the Federal Government allocated RM114 million to rehabilitate the most polluted rivers under the "One State One River" program. In the past three years, Malaysia has spent over RM25 million to clean up polluted rivers due to the buildup of illegally dumped waste (Aruna, 2014). Rapid industrialization and urbanization have negatively affected the environment and polluted the atmosphere (Chin et al., 2019).

2.4. TECHNOLOGICAL INNOVATION

2.4.1. Concept

Schumpeter (1939) defined technological innovation as "a new combination of means of production, that is, as a change in the factors of production (inputs) to produce products (outputs) that enables organization to achieve their expected performance". This process involves the application of technical methods, device, system, practices, and skills to develop business process or product (OECD, 2018). Applied innovative technological knowledge can transform the functional or experiential characteristics of a product, service, or business process. Technological capabilities consist of knowledge about certain technologies and the best way to use them so as to advance them beyond the state of the art (Lee et al., 2018). Organizations should develop innovation capabilities and encourage corporate entrepreneurship to promote technological innovation, create opportunities for scientific and technological investment, and ensure sustainable growth in the competitive market (Rojas et al., 2014).

2.4.2. Antecedents of Technological Innovation

According to Lee et al. (2018), the proper implementation of SCM practices by Chinese firms has enabled them to achieve superior technological innovation performance, especially in terms of product and process. Technological innovation can directly enhance the performance of a company. A recent study in Indonesia by Naway and Rahmat (2019) examined the moderating effect of technology integration on the association between supply chain capabilities and supply chain performance. The evidence from this study is potentially useful for practitioners, policymakers, and operations manager.

Technological innovation could promote GSCM implementation by offering novel ideas and approaches to manufacturers. Chen et al. (2006) stated that green innovation could facilitate the

implementation of environmental management systems, such as GSCM, to satisfy the firm's environmental requirements. Technology management researchers are mainly concerned with developing novel technology and improving upon existing one. Innovation is seen as "a continuous process during which the innovation changes form as it is used and assimilated" (Gopalakrishnan & Damanpour, 1997). Kafetzopoulos and Psomas (2015) examined the relationship between the various dimensions of innovation capabilities (product, process, marketing, and organizational innovation) and company performance. They found that these innovation capabilities positively influence operational performance, enabling the company to gain competitive advantage. In addition, the study suggested that improving operational performance elements will improve the quality of products and make them more attractive to customers.

Innovation is a significant driver of economic growth. Schumpeter (1934) argued that creative destruction, the dynamic innovation process where old processes are replaced by new technologies, is the main driver of economic development. Firms innovate by improving productivity and reducing costs to gain competitive advantage. Innovation is therefore the leading factor for sustaining business value (Cool & Schendel, 1988; Juniati et al., 2019). Organizations are able to enhance their performance through innovative activities in developing a new product and process (Armbruster et al., 2008). Ryu (2016) holds that the technological innovations of service-oriented firms can be applied to the traditional manufacturing sector to encourage innovation.

Nonetheless, technological innovation alone is not a sufficient driver of performance and competitive advantage. Innovation includes technological activities, such as developing and introducing new technologies, as well as non-technological activities, like customer interaction, transformation of organizational methods, and re-establishment of business strategies and external network (Armbruster et al., 2008; Ryu, 2016). Scholars hold differing views on how to measure technological innovation. A recent study conducted on the Brazilian chemical industry employed such indicators as electricity consumption, water consumption, pollutant emissions, and raw material (Moori et al., 2018). The study discovered that technology partially mediates the effect of GSCM on performance.

A commonly accepted classification of innovation is the Oslo Manual (OECD, 2005), which distinguishes four types of innovation: product, process, marketing, and organizational. Technological innovation consists of product and process innovation, whereas non-technological innovation comprises marketing and organizational innovation (OECD, 2005). However, in line with previous studies, the present study focuses only on technological innovation (product, process, marketing, and organizational innovation). The other types are not considered as their inclusion may complicate the model.

Revolutionary advancements in technology systems over the past three decades have influenced every aspect of daily life. One such progress was the shift from personal computers to smart devices and cloud computing infrastructure. The beginning of this era of technological innovation was marked by the integration of ubiquitous computing systems and computer-based automation interconnected via intranet and internet (Menon & Shah, 2019; Wang, 2019). The implementation of such a network within the operations and productions environment is termed IR 4.0. This revolutionary progress is distinguished by the use of new, innovative technologies throughout the manufacturing process. These include advanced robotics and artificial intelligence, software-as-a-service, new marketing models, hi-tech sensors, cloud computing, the Internet of Things, data capture and analytics, digital fabrication (including 3D printing), navigation tools, autonomous vehicles, and mobile devices. Applying these practices creates an interoperable global value chain that can be accessed and shared by companies around the globe (Geissbauer et al., 2016). The implementation of GSCM practices will encourage the adoption of new or improved technologies, allowing the company to connect machine and human via cyber-physical systems.

The Malaysian Ministry of International Trade and Industry (MITI) has allocated RM210 million in 2019-2021 to stimulate and assist the industry's transition to Industry 4.0 (MITI, 2018). The Malaysia Productivity Corporation will conduct the Readiness Assessment program to help up to 500 small and medium enterprises (SMEs) to move toward Industry 4.0 technologies. The comprehensive program intends to assist companies to assess their readiness and capabilities to adopt Industry 4.0 processes; to help them develop feasible strategies and plans to perform outcome-based intervention projects; to determine their state of readiness in adopting Industry 4.0 technologies; and to identify the gaps and opportunities for

improvement and growth toward Industry 4.0. The introduction of Industry 4.0 technologies into the manufacturing industry can considerably improve its whole supply chain process (Tjahjono et al., 2017). Companies must identify the possible threats and opportunities of these new technological innovations in relation to the entire supply chain and IR 4.0.

2.5. GREEN SUPPLY CHAIN MANAGEMENT PRACTICES AND TECHNOLOGICAL INNOVATION

Innovation is an important device in improving the performance of environmental management, which will allow the company to comply with environmental protection regulations (Lai et al., 2003; Lin et al., 2019). The implementation of GSCM practices will promote technological innovation in the company, consequently improving its overall performance. In this study, technological innovation is defined as a new combination of means of production, that is, as a change in the factors of production (inputs) to produce products (outputs) that enable the organization to achieve their expected performance. This process involves the application of technical methods, device, system, practices, and skills to develop business process or product (OECD, 2018). This study investigated the relationship between GSCM practices and technological innovation (product, process, and organizational). Adoption of the former is expected to reduce negative environmental impact and encourage differentiated product development (Camisón & Villar-López, 2014; Lee et al., 2018; OECD, 2018). Innovation may reduce the ineffective and inefficient use of natural resources, thus cutting down costs and fostering sustainability (Calza et al., 2017). Companies are induced to consider the increasing rate of human consumption and raise awareness on the environmental impact of consumption choice. The environmental attributes of new products and services can be used for marketing differentiation (Ma et al., 2017; Orsato, 2006; Porter & Linde, 1995).

Several studies have examined the association between green technology and innovation and how they influence competitiveness and performance. Technology mediates the performance of Brazilian chemical firms (Moori et al., 2018). Technology and innovation seem to direct management toward higher productivity and awareness of the necessity to balance costs to make the organization more environmentally friendly (Yang & Roh, 2019). This can be achieved through innovation in business and resource management (Cosimato & Troisi, 2014). Umar et al. (2016) examined small and medium manufacturing firms in Nigeria and found that GSCM has a significant influence on technological innovation.

Technological innovation is becoming an important and promising area in GSCM through which companies can moderate the direct and indirect organizational and environmental impact of their process and product. A few studies have examined the association between GSCM practices and green innovation. Seman et al. (2018) conducted one such study on 123 Malaysian manufacturing firms, highlighting that only a small number of empirical studies have investigated the relationship between the two variables. The authors found that GSCM leads to innovation.

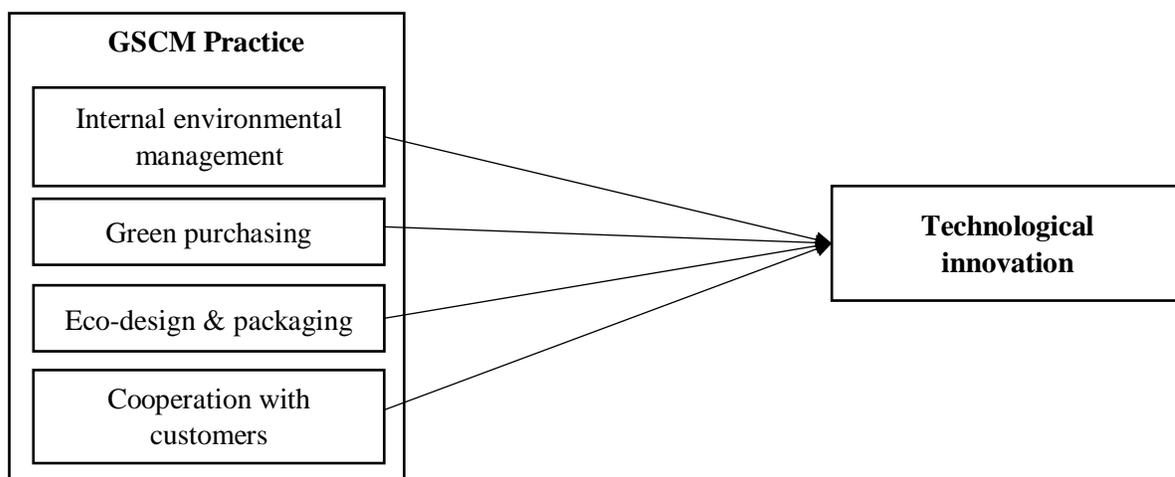
A recent study by Yang et al. (2019) analyzed the relationship between GSCM and green information systems (GIS). The study surveyed 214 managers of training centers in China. They found that GSCM has direct influence on organizational innovation, enhancing operational efficiency and reducing environmental footprint. The study suggested that “informal alignment constitutes more of a necessary condition for the technology aspect but more of a sufficient condition for the task aspect of digital innovation”. In addition, the study indicated that GSCM practices lead to smoother digital innovation, as the management side of organizational innovation will set the tone for the technological side.

3. PROPOSED CONCEPTUAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

This paper intends to propose a conceptual framework to determine the effects of GSCM practices on technological innovation in Malaysian manufacturing firms. The extant literature revealed four GSCM dimensions that influence technological innovation: internal environmental management, green purchasing,

eco-design and packaging, and cooperation with customers. Figure 3.1 shows the conceptual framework based on the above discussion.

Figure 3.1: Conceptual Framework of the study



The study has also proposed the following hypotheses:

Hypothesis 1: Internal environmental management positively influences technological innovation.

Hypothesis 2: Green purchasing positively influences technological innovation.

Hypothesis 3: Eco-design and packaging positively influence technological innovation.

Hypothesis 4: Cooperation with customers positively influences technological innovation.

4. CONCLUSION AND LIMITATION

The research culminates in a proposed conceptual framework for GSCM practices and technological innovation in the Malaysian manufacturing industry. Identifying and adopting these practices would facilitate better understanding and conceptualization of GSCM. The literature suggests that the adoption of GSCM practices has numerous economic and environmental benefits. The paper contributes by supporting and extending the argument about the importance of incorporating green-based activities into manufacturing supply chains to promote technological innovation and improve environmental efficiency. It attempts to clarify the steps that organizations must take toward green and sustainable development. This study also finds similar future research in other sectors, such as agriculture and construction, to further the understanding of GSCM practices, as they may differ from a sector to another.

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