ABSTRACT

THE IMPACT OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICES ON GREEN INNOVATION PERFORMANCE AMONG LARGE ISO14001-CERTIFIED MANUFACTURING FIRMS IN MALAYSIA

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The primary objective of this research is to critically investigate the impact of the chosen set of green supply chain management (GSCM) practices on green innovation performance (EIP) among large Malaysian manufacturers that are certified with ISO14001. In other words, the magnitude and direction of causality effect exerted by GSCM practices on EIP were evaluated. 107 usable primary data were gathered through self-administered survey questionnaires. The statistical analysis tools employed were PLS-SEM by utilizing SmartPLS 3.0 and Artificial Neural Network analysis (ANN) by utilizing IBM SPSS v22. A novel dual-stage PLS-ANN statistical technique was employed to determine the significance and strength of the relationships and the significant predictors were subsequently ranked. This research showcases the eminence of GSCM practices as propellers to drive EIP. Surprisingly, the relationship between cooperation with customers and investment recovery with EIP is not significant. Nevertheless, this has

broadened the horizon of existing literature by contributing to the generation of new knowledge through the provision of sensible and well-supported justifications for insignificant relationships which were conventionally significant.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Manufacturing operations essentially involve transforming inputs (in the forms of resources, components and raw materials) into outputs or finished goods which are ready to be sold to consumers (Huang & Badurdeen, 2018). The Malaysian manufacturing industries have been mushrooming prosperously in recent years and now proudly take up 25% of the nation's Gross Domestic Product (GDP) and account for more than 60% of total exports as in April 2018 (Trading Economics, 2018). According to the Department of Statistics Malaysia (2018a), the Malaysian manufacturing sector recorded an increase in output amounting to 4.1% in March 2018 and surpassed the RM1.1 trillion mark for the first time in history in terms of gross output value since Economic Census was carried out. These statistics clearly showcase the importance of the manufacturing sector towards the nation's growth and prosperity.

Manufacturing industries are often seen as key players in the continuous debates on sustainable development, especially in the current climate where forces at play try relentlessly to explore ways to strike a balance, or even better, to nurture a symbiotic relationship between industrial advancement and environmental protection (del Mar Miras-Rodríguez, Machuca, & Escobar-Pérez, 2018). Besides this, the implementation of greener supply chain management practices increasingly helps firms to propel forward by acting in the capacity of a major strategic thrust (Fang & Zhang, 2018). Henceforth, supply chains of firms must be re-engineered by incorporating environmental best practices including but not limited to the minimization of wastes and efficient and effective utilization of resources for the ultimate aims of creating a greener supply chain and producing more sustainable-oriented innovations (Neutzling, Land, Seuring, & do Nascimento, 2018).

Innovation is a driver of performance (Cai & Li, 2018). Green innovation which is aimed at mitigating any negative externalities caused by a product or process at any stage of its life cycle not only reduces environmental footprints but also contributes towards the attainment or improvement of sustainability performance (Chiou, Chan, Lettice, & Chung, 2011; Li, Zhao, Zhang, Chen, & Cao, 2018). Even though Malaysia is considered to be in its infancy in the field of green innovation (Abdullah, Zailani, Iranmanesh, and Jayaraman, 2016), many firms in Malaysia have begun greener and more innovative manufacturing processes (Fernando & Wah, 2017). Some practical examples of green innovations proudly produced by a Malaysian owned-and-grown manufacturer, Pensonic Holdings Berhad include energy-saving freezers, refrigerators, standing coolers, lightings and other electrical and electronic goods and appliances (Pensonic Holdings Berhad, 2018b). Pensonic Holdings Berhad even won the prestigious Energy Efficiency and Best Price Fan for its Table Fan PF-42 in year 2002, which was awarded by Tenaga Nasional Berhad (the biggest Malaysian electricity utility) and the Malaysian Ministry of Energy, Communications and Multimedia (Pensonic Holdings Berhad, 2018a).

Among the efforts undertaken by the Malaysian government to encourage companies to actively green their supply chains as detailed out in Budget 2018 include giving income tax exemption to the recipients of Green Sustainable and Responsible Investments (SRI) Sukuk Grant effective for applications duly received by the Securities Commission of Malaysia from the first calendar day of 2018 to the last calendar day of 2020 to promote the issuance of green bonds in Malaysia (Ministry of Finance Malaysia, 2018). Green SRI Sukuk Grant refers to the financing of projects with the objectives of conserving the natural environment and the use of energy; encouraging the use of renewable energy; reducing greenhouse gases effects; or improving the wellbeing of society (Ministry of Finance Malaysia, 2016). Besides this, Budget 2016 also detailed out government's efforts to inculcate Green Technology by allocating RM 45 million in order to implement Electricity Mobility Action Plan which includes energy review/audit; offering an annual quota of 100 megawatts by Sustainable Energy Development Authority (SEDA) under the umbrella of Net Energy Metering Scheme to promote the roll out and extensive utilization of solar photovoltaics (Ministry of Finance Malaysia, 2016). Furthermore, Budget 2018 also sees the government allocating RM5 billion that is parked under the Green Technology Financing Scheme in order to encourage investments in the industry of green technology and to promote sustainable development so as to fortify the position of Malaysia in Industrial Revolution 4.0 (Ministry of Finance Malaysia, 2018).

Besides this, the Eleventh Malaysia Plan (2016 – 2020) also sees a paradigm shift from the conventional and expensive “grow first, clean-up later” path or “end-of-pipe” approach to a much more sustainable trajectory – Green Growth – which is one of the strategic thrusts and definitely a game-changer that makes sure socio-economic development is pursued more sustainably, right from the planning stage, and continuing throughout the implementation and evaluation stages by balancing all three pillars of sustainability – economic, social, and environment, so as to better prepare Malaysia for future challenges (Economic Planning Unit, Prime Minister’s Department, Malaysia [EPU], 2015). If Green Growth is carried out successfully, Malaysia will certainly reap the rewards of increased economic growth, overall positively changed mind sets and societal behaviors, as well as positively influencing governmental and public policy decision makings, manufacturing decision makings by the industry players, and daily consumption behavior and decision makings by end-users or the general public. For example, Malaysian government will lead by example by making Government Green Procurement (GGP) compulsory for all ministries and agencies, which boosts the demand for greener products and services, henceforth encouraging industries to raise the standard and quality of their products and services to better meet green requirements by complementing current eco-labelling scheme for green products certification (Economic Planning Unit, Prime Minister’s Department, Malaysia [EPU], 2015).

All these national strategies showcase the seriousness of the Malaysian government in tackling the issues concerning sustainability and the promotion of green innovation that drives sustainability performance (Li et al., 2018).

1.1.1 Justifications on why the focus is on large ISO14001-certified manufacturing firms only

The current study focuses on large ISO14001-certified manufacturing firms only because according to the Department of Statistics Malaysia (2018b), large manufacturing firms contributed 65.6% of the 23% share of the manufacturing sector (equivalent to RM 167.21 billion) to our nation's GDP which stood at RM 1,108.2 billion at constant 2010 prices in 2016. The statistics imply that large manufacturing firms are the major contributors towards the national economy in terms of Gross Domestic Product (GDP) for the manufacturing sector.

Besides this, according to Arora and Cohen (2015), Lee, Ooi, Chong, and Seow (2014), and Zhu and Sarkis (2004), large firms naturally demonstrate higher capabilities in terms of implementing green initiatives due to the availability of more resources including funds, capital equipment, technologies and so on.

Furthermore, according to Darnall, Jolley, and Handfield (2008), Eltayeb, Zailani, and Ramayah (2011), Sroufe (2003), and Zhu, Sarkis, and Lai (2008), ISO 14001-certified firms were selected because they are expected to be well-versed in the implementation of green initiatives and therefore befit the objectives of the study.

1.2 Problem Statement

According to Hezri and Nordin Hasan (2006) and Said (2003), aggressive urbanization and rapid industrial developments have resulted in unprecedented changes and caused various environmental and sustainability issues, including air, water and soil pollutions due to improper waste management and the release of untreated and hazardous industrial toxics such as lead, mercury and other heavy metals into rivers and seas. Manufacturing facilities are believed to be the culprits for most of the environmental problems (Beamon, 1999; Lin & Ho, 2011). Urban Heat Island phenomenon (Ramakreshnan et al., 2018), drastic climate change, rising room temperature with daytime temperatures rising above 30°C year-round ("Malaysia Weather, climate and geography", 2016), devastating droughts and storms caused by El Nino and La Nina phenomena, unusual heatwave, massive floods affecting areas not known to experience floods before, freak occurrences of hailstorms, frequent flash floods, and clean water shortages (causing water rationing and water crisis), just to name a few, are the ecological problems that affect Malaysia ("El Nino dries up Asia as its stormy sister La Nina looms", 2016; Elfithri & Mokhtar, 2018; "Hailstorm and flash flood mayhem in KL", 2016).

The various socio-economic issues posed by manufacturing facilities include increase in costs of energy consumption and waste management, ultra-expensive decommissioning and decontamination costs (involving nuclear wastes), health, safety and occupational hazards involving employees and the community, unusually high rates of birth defects, infant deaths, congenital diseases, lead poisoning and cancers among the community affected, and so on. This is evidenced by the long-lasting negative impacts on the environment and socio-economic aspects caused by the operations of Bukit Merah Asian Rare Earth (ARE) (Mitsubishi joint venture plant) at Bukit Merah, Perak, Malaysia from 1982 to 1994 (Ichihara and Harding, 1995).

According to Consumers Association of Penang (2011), Bukit Merah residents invited Professor Sadao Ichikawa, a Japanese genetics and radiation expert to measure the radiation levels at the pond and open field right next to the Asian Rare Earth factory in December 1984 and October 1986. Both visits revealed radiation levels in the vicinity of the factory to be way above the permissible levels (i.e. above the maximum safety level of 0.057 millirems/hour set by the International Commission on Radiological Protection), the highest reading showed that the radiation level to be 800 times above the acceptable level. In April 1987, international experts including President of the Health and Energy Institute in the USA, Kathleen Tucker; Secretary of the Centre for Industrial Safety and Environmental Concern in India, V.T. Pathmanabhan; founder-director of the International Institute for Public Concern in Canada, Dr Rosalie Bertell; and others declared that Asian Rare Earth factory posed severe health hazards to the ecology and community.

The current Prime Minister of Malaysia, Tun Dr. Mahathir bin Mohamad commented back in June 2010 that “In Malaysia, we do have nuclear waste which perhaps the public is not aware of. We had to bury the amang (tin tailings) in Perak, deep in the ground. But the place is still not safe. Almost one square mile of that area is dangerous" (Consumers Association of Penang, 2011). Following Tun Dr. Mahathir's revelations, it was shockingly discovered by The Star Media Group Berhad (the largest paid English newspaper in terms of circulation in Malaysia) that 80,000 200-litre drums containing hazardous radioactive waste were being kept at a dump located at the Kledang Range which is about 3 kilometres away from Bukit Merah (Consumers Association of Penang, 2011). A disturbing fact revealed that the waste is actually radioactive thorium hydroxide and not amang (tin tailings), which is highly hazardous to human health and the surrounding ecosystem (Consumers Association of Penang, 2011; Findeiß & Schäffer, 2017; Poh, 2015). According to Consumers Association of Penang (2011) and Foong (2010), work to build proper underground storage facilities known as engineered cells (EC1 and EC2) at the Kledang Range only commenced in January 2011, some 29 years after Asian Rare Earth factory first started operations in 1982 and the massive decommissioning and decontamination exercise is estimated to cost around a whopping RM300 million.

The Bukit Merah residents still feel the pinch of the aftermath caused by the radioactive waste generated by Bukit Merah Asian Rare Earth as at today because of the unusually high cases of birth defects and cancers affecting the local community ("Hazards of low-level radiation", 2016). According to Jegathesan (2012), Lim (2012) and Mokhtar (2018), there have been at least 13 deaths caused by leukemia, blood poisoning and cancers in the late 1980s alone since Asian Rare Earth factory commenced operations that are being documented by a Bukit Merah resident, Dr. T. Jayabalan who practised as a public health consultant. Besides this, Dr. T. Jayabalan also found that the number of miscarriages among the Bukit Merah residents was higher than the national average after conducting a survey in 1984. Blood tests conducted in 1984 further revealed that 60 Bukit Merah children were suffering from lead poisoning. According to Koh (2012), medical examinations held in the late 1980s showed that 40% of Bukit Merah children were suffering from turbinate congestion, lymph node diseases and recurrent rhinitis. Bradsher (2011) further commented that it is highly unusual for Bukit Merah (a village with a size of 11,000 residents) to have multiple birth defects and leukemia cases within five years since Asian Rare Earth factory first commenced operations in 1982 because an academic empirical study conducted in another tin mining town posited that a community with a size of around 11,000 residents (similar to Bukit Merah's size) should only encounter one leukemia case in every thirty years. Some ignorant and preposterous plant workers even recycled radioactive wastes into "soil enhancers" by distributing contaminated soil to the local residents and claimed that the soil was very fertile and would produce lush greeneries (Consumers Association of Penang, 2018). This claim has been proven to be untrue when all the cows that grazed on the grass fertilized by the so-called "soil enhancers" died (Asian Metal Metalpedia, n.d.). These cases were documented back in the late 1980s and represented only the tip of an iceberg regarding the seriousness of the problems or consequences caused by the Asian Rare Earth factory operations because 36 years have lapsed since the commencement of its operations and there is no official statistics that clearly reported the exact numbers (including the mortality rates) of leukemia, lead poisoning, cancers and other diseases that were linked to the Asian Rare Earth factory operations for the period of 1982 - 2018.

The set-up and operations of the controversial Lynas Advanced Materials Plant in Gebeng, Pahang, Malaysia in 2012 has sparked enormous protests among local residents who fear history will repeat itself and at a much higher scale because Lynas plant is ten times more enormous comparing to Bukit Merah Asian Rare Earth and hence the radioactive wastes produced will be in multiple fold comparing to Bukit Merah Asian Rare Earth (Phua & Velu, 2012).

On top of the above-mentioned research problems, recent events that add to the existing research problems that were newly reported and published include the Kim Kim River chemical waste crisis that caused the shutdown of 111 schools and educational institutions (Benjamin & Farhaan Shah, 2019) and resulted in around 6,000 Pasir Gudang residents seeking emergency medical treatment in March and June 2019 (Tang, 2019), ammonia pollution in Sayong River that has resulted in disrupted water supply to over 17,000 Kulai and Singaporean households in April 2019 (Farhaan Shah, 2019) and arsenic contamination in Rui River that caused affected villagers developing skin diseases, including skin cancer in the Perak state, as reported in April 2019 (Looi, 2019), represent just the tip of an iceberg regarding the escalating environmental and sustainability problems that plague Malaysia in present climate, and these are the dire consequences of improper waste management/disposal caused by irresponsible manufacturing firms. A nonexecutive director of a used tyre processing manufacturing firm was charged in the Johor Bahru Sessions Court in late April 2019 for abetting three others to illegally dispose of toxic scheduled wastes into the Kim Kim River in Pasir Gudang and hence causing the chemical waste crisis (Bernama, 2019) whereas the ammonia pollution in Sayong River was caused by a leak that came from a bio-composite centre next to an oil palm manufacturing firm, that resulted in the bursting of a reservoir when the ammonia-contaminated water, which had reached the maximum level then flowed into Sayong River that supplies raw water to Johor River, which is a main river that supplies input to the water treatment plants that were shut down due to excessively high levels of ammonia and hence causing over 300,000 Johor Bahru residents being affected by water disruptions or no water supply for several days in April 2019 (Farhaan Shah, Devi, & Nordin, 2019).

On the other hand, green innovation is considered to be in its infancy in Malaysia, where the level of engagement in green innovation among Malaysian manufacturers remains well-below expectations or far from ideals (Abdullah et al., 2016). Furthermore, empirical studies which focus on GSCM practices as the drivers/antecedents/determinants of green innovation performance remain relatively scarce in extant literature (Tseng, Wang, Chiu, Geng, & Lin, 2013), where further elaborations are detailed out in section 1.5.1 “Theoretical contributions”. This research gap needs to be filled by performing empirical studies that focus on the effective determinants that drive green innovation performance among Malaysian manufacturers in view of the tremendous positive sustainability outcomes that undoubtedly denote a win-win situation for all (Annunziata, Pucci, Frey, & Zanni, 2018).

According to Cherrafi, Elfezazi, Chiarini, Mokhlis, and Benhida (2016) and Vilchez, Darnall, and Correa (2017), a multitude of internal and external stakeholders have increasingly exerted pressure on the business operations, including manufacturing firms in response to all these environmental issues. Immense competitive and stakeholder pressure as well as mounting challenges have resulted in organizations to seriously consider the possible negative environmental impacts caused by their operations and design and implement effective ways (such as green innovation, which is the focus of this study) to mitigate the negative environmental footprints (Cai & Li, 2018; Mirhedayatian, Azadi, & Saen, 2014). In the past, companies were more focused on internal environmental management but now companies are gradually realising the importance of the synergistic effects by collaborating with external supply chain partners such as customers and suppliers (Van der Laan, 2010). There is still a lack of empirical studies, especially where green supply chain management is concerned despite the rising prominence of ecological aspects in the manufacturing landscape (Prahinski & Kocabasoglu, 2006).

The Bukit Merah Asian Rare Earth case has clearly demonstrated how the mismanagement or irresponsible supply chain operations at any stage, especially during the cracking of monazite in order to extract yttrium oxide which would inevitably produce highly concentrated and radioactive "technologically enhanced naturally occurring materials" (TENORMs) once dug up, would result in a multitude of dire consequences (including health hazards and ecosystem disruptions) if proper waste management system were not in place (Furuoka, 2005). This clearly showcased the importance of establishing a robust and comprehensive green supply chain management system in order to ensure the smooth and sustainable operation at every stage of the manufacturing processes (from the acquisition of raw materials, processing inputs into saleable outputs, delivering finished goods to end customers, to the remanufacturing/recycling/proper disposal of the products at the end of the product's useful life, on top of properly managing and disposing hazardous wastes and by-products) (Moktadir, Rahman, Rahman, Ali, and Paul, 2018).

In other words, a rigorous and comprehensive green supply chain management system served as strategies to actively and innovatively curb and mitigate any environmental as well as socio-economic problems caused by a firm's supply chain activities right at the source (leveraging root cause analysis) with the primary objective of achieving tip-top performance in green innovation that will ultimately drive sustainability performance (Ahen & Zettinig, 2015; Costantini, Crespi, Marin, & Paglialunga, 2017; Zainuddin, Zailani, Govindan, Iranmanesh, & Amran, 2017). This is synonymous with killing few birds with one stone. A firm that offers a myriad of innovative products and services which serve as timely solutions to its customers besides being environmentally and socially responsible will not only portray a better image in the public's limelight, but also stands out from the crowd by possessing an intrinsic capability to sustain its competitive position (Albort-

Morant, Henseler, Leal-Millán, & Cepeda-Carrión, 2017; Zailani, Govindan, Iranmanesh, Shaharudin, & Chong, 2015).

1.3 Research Questions (RQ) and Research Objectives (RO)

In light of the intriguing and thought-provoking issues discussed above, this study was set forth in its quest to respond to the RQ on top of fulfilling the RO.

1.3.1 RQ

The primary RQs are asserted as follows:

RQ (1): Is the relationship between each of the green supply chain management practice (i.e. internal environmental management (IEM), cooperation with customers (CC), investment recovery (IR), eco-design (ED), and greening the suppliers (GS)) and green innovation performance significant and positive among large Malaysian manufacturers that are certified with ISO 14001?

RQ (2): Among the significant independent variables, which green supply chain management practice(s) has a stronger impact on green innovation performance?

1.3.2 RO

The primary RQs are asserted as follows:

RO (1) To investigate whether there is a significant and positive relationship between each of the green supply chain management practice (i.e. IEM, CC, IR, ED, and GS) and green innovation performance among large Malaysian manufacturers that are certified with ISO 14001.

RO (2) To ascertain which green supply chain management practice(s) has a stronger impact on green innovation performance among the significant predictor(s).

1.4 The breadth and width of investigation

The breadth and width of investigation of this research which serves as a guideline for the upcoming discussions in Chapters 2 to 6 is set out as follows:

a. This is a quantitative study that takes on a cross-sectional approach to critically evaluate the relationship between GSCM practice(s) (i.e. IEM, CC, IR, ED, and GS) and green innovation performance among Malaysian manufacturers.

b. This research employs self-administered survey questionnaires as an instrument to gather empirical data from target firms.

c. The target respondents of this study are the executives of large Malaysian manufacturers (with number of full-time employees > 200) that are certified with ISO14001 according to the Federation of Malaysian Manufacturers (FMM) Directory 2016 who are familiar with green supply chain practices. Examples of target respondents include ISO14001 or ISO9001 persons-in-charge, environmental, health and safety (EHS) managers, facilities managers, human resources managers, research and development (R&D) senior engineers, quality assurance (QA) managers, production managers and so on.

1.5 Significance of Study

This empirical study is indeed value-added by projecting strong theoretical, practical and managerial contributions which are discussed in the following subsections.

1.5.1 Theoretical Contributions

According to Seman, Zakuan, Jusoh, Arif, and Saman (2012a; 2012b), the relationship linking GSCM practices and green innovation is relatively under-researched, particularly in the Malaysian manufacturing landscape. Both Seman et al. (2012a) and Seman et al. (2012b) are not empirical papers where actual data collection was not conducted, even though they published a review article and a conference paper proposing the relationship between GSCM practices and green innovation among Malaysian manufacturers. Among other GSCM and green innovation researchers, Wu (2013) only focused on the IT industry in Taiwan whereas Ho, Lin, and Chiang (2009) and Zailani, Amran, and Jumadi (2011) focused on the logistics industry in Taiwan and Malaysia respectively. Mudgal, Shankar, Talib, and Raj (2010) and Abdullah et al. (2016) studied on the barriers of GSCM practices and green innovation initiatives among Indian and Malaysian manufacturing organizations respectively whereas Muduli, Govindan, Barve, Kannan, and Geng (2013) focused solely on the Indian mining industries. These findings further showcase the uniqueness and importance of the proposed research model as an enlightening framework that facilitate the empirical investigation of the possible link between the set of selected GSCM practices and green innovation among large Malaysian manufacturers in view of the mounting challenges highlighted in the research problem section, which is the focus of this study. Furthermore, the higher order dependent variable (green innovation performance) is being measured as a multidimensional reflective construct that encompasses the dimensions of green product, process and managerial innovations, and coupled with the selected set of GSCM practices as its antecedents, this one-of-a-kind model was never before examined empirically in the Malaysian manufacturing landscape. Besides this, the proposed research model can act as an immensely useful guideline to future academic investigators since it had provided a solid ground in advancing green-related frameworks, which is one of the strategic thrusts of Malaysia towards achieving Vision 2020 (Economic Planning Unit, Prime Minister's Department, Malaysia [EPU], 2015). Better still, if significant relationships could be established linking the selected set of GSCM practices and green innovation performance, the novelty of the proposed research model can be further amplified where future researchers can extrapolate on the current framework and take a few more steps further by investigating the cause-and-effect of antecedents of GSCM practices-GSCM-green innovation-sustainability performance-competitive advantage and so on, with the influence of moderators, wherever applicable. All these value-added points will undoubtedly contribute towards theory development.

1.5.2 Methodological Contributions

This study purports to employ a remarkable two-stage PLS-ANN analysis. Partial least square structural equation modelling (PLS-SEM) by utilizing SmartPLS 3.0 software will first be run to examine the relationship between each GSCM practice with green innovation performance. Upon determining the significant relationships linking GSCM practices and green innovation performance, another statistical approach which is able to complement the PLS-SEM results – namely the Artificial Neural Network (ANN) analysis will be conducted by utilizing IBM SPSS v22 software to examine the Normalized Relative Importance of the significant predictors. The significant predictors will be ranked following the magnitude of Path Coefficient (for PLS-SEM) and Normalized Relative Importance (for ANN analysis) to determine the relative importance of the impact of each significant predictor on green innovation performance. The rankings as a result of both methods will be compared and sensible justifications will be provided to explain any notable differences in terms of rankings that arose from two different approaches.

A dual-stage analysis has undoubtedly proven to be stronger and much more comprehensive compared to the conventional single-stage analysis (Foo, Lee, Tan, & Ooi, 2018) where new insights will be generated for the benefit of all.

1.5.3 Practical Contributions

The proposed research model possesses the potential to play the role of a scintillating beacon that offers valuable guidance and insights on the extremely enormous magnitude of the associated impacts caused by the selected set of GSCM practices on the three-dimensional green innovation performance (namely, the green product innovation, green process innovation and green managerial innovation) to industry practitioners and management teams of manufacturing firms who need to make multiple important and urgent decisions of varying degree at different organizational levels.

Industry players will be able to precisely identify areas or “blind spots” in their organization with the objective of “extinguishing fires” (in other words, to devise effective remedial solutions with the focus of settling problems) caused by employees who carelessly disregard the industry’s best practices expounded by closely connected authorities such as compulsory policies drawn up by the Ministry of Natural Resources and Environment (NRE) or establishments such as the world-renowned International Organization for Standardization (ISO).

One cannot willfully contemplate the extent or degree of seriousness of potential damages (in terms of negative environmental impact) caused by unethical and even illegal behaviors of business operators. Hence, it is always an excellent practice by complying to various regulatory frameworks set forth by the government and also happily and voluntarily embrace green initiatives as set out by standardization bodies such as SIRIM, ISO, EMAS, RoHS and so on with open arms so as to streamline everyone’s (including world leaders and United Nations) efforts to constantly strive for a more sustainable Earth for the greater good and for the ultimate benefits of all living beings.

Again, the researcher would like to reiterate that she reasonably believes that this research study will serve as a catalyst or propeller for manufacturing firms to integrate GSCM practices along their supply chain in their ambitions to achieve green innovation performance; if GSCM practices are indeed empirically proven to have significant impact on the green innovation performance among Malaysian manufacturers that are certified with ISO14001.

Manufacturing firms will be greatly inspired to green their supply chain in view of the tremendous benefits/ rewards that are associated with their green initiatives. This is especially true if manufacturing firms indeed practice what they have preached by rigorously implementing a proven set of GSCM practices that will efficiently and effectively drive green innovation performance that will ultimately lead to the achievement of sound sustainability performance that is a strong catalyst of sustaining a firm’s competitive position in the volatile market place where competition is intense. For example, manufacturing firms will save a lot (especially financially), in terms of internal and external failure costs because a law-abiding and ethical firm certainly would not be dumping or disposing manufacturing wastes into rivers and seas and hence resulting in hefty penalties and sky-rocketing high clean-up costs when crisis such as the chemical crisis that happened in Johor’s

Kim Kim River back in March 2019 where the Malaysian government had to incur over RM 10 million in clean-up and other necessary costs since the perpetrators had no means of paying this hefty amount and this emergency situation had to be resolved soonest possible in view of the public outcry over the medical emergencies due to the inhalation of toxic fumes among the affected community (Chu, Lo, & Lim, 2019). The Malaysian government would certainly have saved over RM 10 million in mitigation costs if all the manufacturing firms have been practicing sound GSCM practices during operations. This again showcase the immense potential contributions that sound GSCM practices will yield if implemented successfully.

Last but not least, successful practitioners will serve as a benchmark for others to emulate. This is particularly true in the current climate because according to the latest ISO14001:2015 roll out, existing ISO14001-certified firms are granted a three-year transition period to migrate to the newly revised ISO14001:2015 which is more stringent in the sense that more proactive, rigorous and prominent environmental management efforts/initiatives in the strategic landscape; a renewed focus on stakeholder-centric communication strategy and life-cycle thinking; and more importantly a greater commitment from leadership are the key improvements required by ISO14001:2015 (Naden, 2016). This further helps in showcasing the importance of having the right selections of GSCM practices in place in order to achieve or even improve organizational green innovation performance which will undeniably lead to sustained competitive advantages in the ultimate quest of every organization to outshine its competitors to emerge as the winner in the constantly-evolving game of “survival of the fittest”.

1.6 Broad Outline

Chapter 1 briefly illustrates the background of the research topic, followed by the research problem, research objectives and research questions, scope of study, and the significance of study. Furthermore, theoretical and practical implications plus research limitations and corresponding recommendations to overcome the limitations are also aptly explained and illustrated. Last but not least, the brief definitions of the key terminologies that are presented in this study are provided at the end of the chapter.

Chapter 2 illustrates the main concepts of GSCM and the selected GSCM practices (i.e. IEM, CC, IR, ED, and GS) and green innovation performance (i.e. green product, process, and managerial innovations). Furthermore, a review of the five GSCM practices and the three dimensions of green innovation performance and the justifications concerning the adoption of these dimensions are also detailed out in this chapter.

Chapter 3 will systematically lay out the research framework of the study, where the logical connection linking the variables of GSCM and green innovation performance will be discussed. The proper roll-out of GSCM practices is believed to result in the attainment and/or even improvement of green innovation performance, which are essential components that safeguard a firm’s strategic position in producing highly innovative products and/or services that will not only mitigate the negative environmental externalities throughout its entire lifecycle but also benefit mankind ultimately. This is indeed a win-win solution. A concatenation of past and latest empirical studies are subsequently reviewed to formulate five hypotheses that link each GSCM practice and green innovation performance, where green innovation performance is structured as a second-order reflective construct comprising of green product, process and managerial innovations.

Chapter 4 dedicates an extensive discussion regarding the research methodology of this study. Areas that are covered include the design of the research, target population, sampling method and the determination of sample size. Besides this, the justification of primary data collection method will also be discussed. The source(s) and details of the survey questionnaire items pertaining to the independent and dependent variables are also detailed out in the operationalization of constructs section. Finally, the justifications of data processing and data analysis methods are discussed.

Chapter 5 covers the statistical analyses and testing of data in detail. The demographic details of respondents will be presented. Following that, the measurement model will first be examined by assessing its reliability, discriminant and convergent validity, before the structural model is subsequently evaluated.

Chapter 6 involves the interpretation and discussion of the statistical outcome generated by PLS-SEM and ANN analyses. Justifications of the significant and insignificant relationships between the independent and dependent variables will be explained in detail. ANN analysis will be performed to rank the significant predictors to further confirm the relative importance of the significant predictors. Justifications will be provided to explain the possible differences in terms of relative importance of the significant predictors. Besides this, theoretical and practical implications, limitations and the corresponding recommendations will also be explicated in Chapter 6. Last but not least, the primary conclusion summarizing the overall findings with proper responses given to address the RQs raised in Chapter 1 with the objective of ensuring that the research objectives are met with great satisfaction.

1.7 Definition of Terms

1.7.1 Green Supply Chain Management

Green supply chain management (GSCM) essentially involves integrating green practices along a supply chain that aim to mitigate negative environmental externalities at any stage of a product's lifecycle (Foo et al., 2018). The implementation of GSCM practices plays a crucial role in advancing green innovation which in turn will lead to sound sustainability performance and prominent competitive advantage (Lee et al., 2014; Testa & Iraldo, 2010).

1.7.1.1 Internal Environmental Management

Internal environmental management (IEM) focuses on the commitment and support from mid-level and senior management teams, inter-departmental cooperation and collaboration for environmental improvements purposes, total quality environmental management systems, the attainment of ISO 14001 certification, and sound environmental compliance and audit programs in place (Wu, 2013; Zhu et al., 2008).

1.7.1.2 Cooperation with Customers

Cooperation with customers (CC) centers on cooperating and collaborating with a firm's downstream supply chain partners (i.e. customers) for more eco-friendly product designs, cleaner production or manufacturing processes, greener packaging and minimizing the consumption of energy during product transportation (Vachon & Klassen, 2008; Zhu et al., 2008).

1.7.1.3 Investment Recovery

Investment recovery (IR) refers to the sale or recovery of excess, used, obsolete or scrap inventories or materials and disposal of redundant capital equipment such as machineries (Choi & Hwang, 2015; Zhu et al., 2008).

1.7.1.4 Eco-design

Eco-design (ED) that is also widely acknowledged as ‘‘design for the environment’’ or “green design”, involves the steps taken at the initial conception or design of a product with the ultimate aim of minimizing negative environmental footprints at every stage of a product’s lifecycle – from the initial research and development (R&D) stage to the development of prototypes, acquisition of raw materials, manufacturing process to transform inputs into finished goods that customers value, to the final disposition of a product at the end of its useful life – without compromising product functionality and performance (Eltayeb et al., 2011; Johansson, 2002; Schöggl, Baumgartner, & Hofer, 2017).

1.7.1.5 Greening the Suppliers

Greening the suppliers (GS), on the other hand, focuses on creating awareness, inculcating a sense of environmental responsibility and promoting green practices implementation among a firm’s upstream supply chain partners (i.e. suppliers) (Rao, 2002; Vachon and Klassen, 2008).

1.7.2 Green Innovation Performance

According to Chen (2008) and Chiou et al. (2011), green innovation can be aptly categorized into three domains, namely green product innovation, green process innovation and green managerial innovation.

1.7.2.1 Green Product Innovation

Wong (2012) and Wu (2013) posited that green product innovation involves applying green and innovative ideas to the design, development, manufacturing, sales and marketing of new products to yield a hugely impactful solution to effectively enhance the environmental favorability of these products.

1.7.2.2 Green Process Innovation

Chen, Lai, and Wen (2006) and Wu (2013) postulated that green process innovation involves utilizing innovative ways to minimize negative environmental externalities resulted from production processes.

1.7.2.3 Green Managerial Innovation

According to Chiou et al. (2011), and Tseng et al. (2013), green managerial innovation involves harnessing strong support and commitment from the top, senior and mid-level management teams to ensure the successful implementation of GSCM and green innovation strategies.

1.7.3 Supply chain management

Following Mentzer et al. (2001, p.18), a comprehensive definition of supply chain management is "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole".

1.7.4 Organizational Performance

According to Li, Ragu-Nathan, Ragu-Nathan, and Rao (2006), organizational performance is defined as the performance of an organization in achieving its long-term as well as short and medium-term financial (for example periodic net profit after tax) and non-financial (for example image/reputation, market share, market growth rate, et cetera) goals/objectives.

1.7.5 Manufacturing firms

Following de Matta (2017), Milgrom and Roberts (1990), and Tracey, Lim, and Vonderembse (2005), manufacturing firms convert inputs into saleable finished goods or outputs through a series of interlinked processes that involve the utilization of resources including raw materials, direct and indirect labors, machinery and equipment, technology and expertise, assembly lines, warehousing, logistics, and other primary and support functions.

1.7.6 ISO14001-certified manufacturing firms

For the purposes of this research study, ISO14001-certified manufacturing firms are manufacturing firms that have obtained the ISO14001 (Environmental Management System) certification following the requirements set-out by International Organization for Standardization (ISO) (International Organization for Standardization, 2018).

1.8 Chapter Summary

A broad overview of the study is presented in Chapter 1. The main concepts surrounding GSCM and green innovation performance were also discussed. The research problem was first identified and explained, before the development of ROs and the associated RQs. On top of these, Chapter 1 also showcased the theoretical and practical implications/contributions of the study. Furthermore, a brief summary of the research methodology was also explained. Last but not least, a general outline regarding the upcoming chapters was also presented.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Overview of the Chapter

Chapter 2 mainly discusses the concepts of green supply chain management (GSCM) and green innovation performance. In section 2.2, the theory that best represents the proposed research framework – Natural-Resource-Based View is explained in great detail. The definitions and literature review surrounding GSCM and the selected GSCM practices are further elaborated in section 2.3. In section 2.4, the definitions and literature review on the three-dimensional green innovation performance (green product innovation, green process innovation and green managerial innovation) are presented. Finally, a review on the relationships between GSCM practices and green innovation performance is presented in section 2.5.

2.2 Theoretical Background

A superfluity of stakeholders such as government agencies, employees, suppliers, customers, non-governmental organizations, trade unions, watchdogs, special interest groups, funds and capital providers including financial institutions and shareholders, the general public and so on are demanding greener and more environmentally friendly products, services and practices (Zeng, Chen, Xiao, & Zhou, 2017). In order to positively respond to the mounting pressures exerted by various stakeholders and also in an effort to provide reasonable assurance to them, on top of contributing solutions towards the mitigation of environmental and sustainability issues at global and local levels, manufacturing firms walk the walk by actively greening the supply chains (Eltayeb et al., 2011; Vilchez et al., 2017). If green and value-added practices indeed yield desirable and successful outcomes and provided that these value-adding practices are adequately embedded in the work culture to the utmost satisfaction, a firm will undoubtedly possess the capability of reaping the rewards of enhanced positive reputation in terms of greener, more sustainable and eco-durable products, processes, innovations, technologies and systems (Tseng & Bui, 2017; Vachon & Klassen, 2006).

After rigorously reviewing the literature, five Green Supply Chain Management (GSCM) practices (i.e. internal environmental management (IEM), cooperation with customers (CC), investment recovery (IR), eco-design (ED), and greening the suppliers (GS)) are found to be able to aptly and holistically represent the prevention of pollution, stewardship or management of product, and the development of sustainable strategies as advocated by Hart in his Natural-Resource-Based View theory (Hart, 1995; Hart & Dowell, 2011).

2.2.1 Natural-Resource-Based View (NRBV)

The NRBV as advocated by Hart in year 1995 is chosen as the theory to best represent the proposed research framework and is believed to possess the intrinsic qualities of laying a strong theoretical foundation in the quest to solve the research problem. The NRBV posits that the three main pillars which are made up of prevention of pollution, management of product, and development that is sustainable will form a conceptual framework for taking into account of the challenges and threats exerted by the natural environment into the management sphere at the strategic level. In other words, the three pillars of NRBV represent the proposed research framework best, including the relationships between the GSCM practices and green innovation performance (Hart, 1995). In the foreseeable future, it seems inevitable that the strategies and competencies of businesses will be constrained by and dependent upon the natural environment and whatever resources and capabilities that the ecosystem may offer (Hart, 1995).

In the past, management theory has placed a greater emphasis on political, economic, social, and technological factors to the virtual exclusion of the natural environment (Shrivastava, 1994; Shrivastava & Hart, 1992; Stead & Stead, 1992). According to Brown, Kane, and Roodman (1994) and Meadows, Meadows, and Randers (1992), in other words, this means that management theories in the past inclined to systematically omit the constraints caused by the Earth’s finite natural resources. A practical example will be the Resource-Based View (RBV) that was the brainchild of Barney (1991) which emphasized only on a firm’s internal factors or decisions that result in sustained competitive advantage, without taking into account the important role played by the natural environment (Barney, 1991; Hoskisson, Hitt, Wan, & Yiu, 1999).

In view of the increasing magnitude of environmental and socio-economic issues, however, the omission of the constraints caused by the natural environment has rendered these aforementioned theories insufficient in their capacity to pin-point key emerging sources and capabilities of sustained competitive advantages or operational successes. The NRBV is applicable in this research context because its three interlinked strategies, namely prevention of pollution, stewardship or management of product, and sustainable development are aptly and holistically represented by the constructs proposed in the Green Supply Chain Management (GSCM) practices associated with this research. Specifically, investment recovery represents pollution prevention; eco-design represents product stewardship; whereas internal environmental management, cooperation with customers and greening the suppliers represent sustainable development (Hart, 1995).

Following the Natural-Resource-Based View, GSCM practices which aptly represent the strategies or capabilities possessed by a firm are proposed to lead to and/or even improve green innovation performance which will eventually result in sustained competitive advantage (Chiou et al., 2011; Cosimato & Troisi, 2015; Mumtaz, Ali, & Petrillo, 2018; Wu, 2013).

The original definitions of the three strategic capabilities as advocated by Hart in year 1995 are as follows:

According to Rooney (1993), a pollution prevention strategy should focus on well-defined environmental objectives that seek to reduce and minimize emissions, effluents, and wastes through continuous-improvement methods and processes instead of merely depending on costly "end-of-pipe" capital investments. Furthermore, Cole (1991), Lawler (1986), Makower (1993), and Willig (1994) posited that a pollution prevention strategy is people intensive, and it depends on causally ambiguous or tacit skills development through active and voluntary employee participation and involvement in "green" teams.

On the other hand, product stewardship involves integrating Life Cycle Assessment (LCA) into a firm’s product-development process and closely coordinating and collaborating with key external stakeholders such as suppliers, customers, environmentalists, community leaders, and regulators to design and develop products that are not only of high quality but also have the least undesirable impacts throughout the product’s life cycle in order to minimize the negative environmental and socio-economic impacts of the product-in-use and waste generated during the production process or towards the end of the product’s life cycle; on top of reusing and recycling spent products (Hunt & Auster, 1990; Keoleian, Menerey, & Curran, 1993; Post & Altman, 1991; Welford, 1999).

Following Shrivastava and Hart (1995), Stikker (1992), and Welford (1995), a sustainable development strategy is advanced by fostering an unbeatable sense of environmental and social purposes which provide the grounding where a firm’s intrinsic organizational and competitive strategies are built. Jansen and Vergragt (1992) and Schmidheiny (1992) further posited that this implies that a firm needs to work tirelessly and relentlessly for a prolonged period in order to develop and disseminate technologies in the emerging economies in the pursuits of sustainability. Hart (1995) went on to explain that sustainable development will eventually lead to sustained competitive advantage as a result of organizational wide collective enthusiasm for change and innovation by gathering unique and firm-specific resources, incorporating an enduring common vision of the future and renewed focus on newly developed breakthrough technologies and competency.

In a nutshell, NRBV has laid a strong foundation in predicting the relationships between GSCM practices and green innovation performance because according to Hart (1995), the ultimate aim of the three strategic capabilities is to drive sustained competitive advantage where green innovation served as a catalytic driver of sustained competitive advantage (Chang, 2011; Chen, 2011; Gürlek & Tuna, 2018; Nanath & Pillai, 2017).

On a side note, NRBV will have an even wider and much more comprehensive coverage if NRBV covers how to leverage the capabilities brought by the latest emerging breakthrough technologies such as artificial intelligence, augmented reality, quantum computing, personalized medicine, 3D-printing and so on to best utilize and sustain the Earth’s finite resources (Cann, 2018). For example, 3D-printing, which is also known as additive manufacturing, is capable of overcoming the limitations posed by the natural environment by driving advancements in the fields of engineering, medical sciences, and manufacturing technologies (Ghosh, Ning, Wang, & Kong, 2018).

A practical example will be utilizing 3D-printing technologies as a mode to generate highly complex but amazingly precise viable and functional scaffolds to be used for tissue engineering, with the ultimate aims of overcoming the low availability of suitable donors and biocompatibility issues when the immune system of the recipient rejects the transplant (Do, Khorsand, Geary, & Salem, 2015).

2.3 Green Supply Chain Management (GSCM) Defined

Geng, Mansouri, and Aktas (2017) advocated that there are many definitions of GSCM in extant literature. For the purposes of the current study, the researcher adopted the highly credible GSCM (including GSCM practices) definitions from Zhu et al. (2008), who are the most cited and most productive authors in the field of GSCM from year 2006 onwards (de Oliveira, Espindola, da Silva, da Silva, & Rocha, 2018).

Green Supply Chain Management (GSCM) is popularly defined as robustly integrating green practices or activities along a firm’s upstream and downstream supply chain that aim at minimizing or eliminating negative environmental impacts (air, water, and land pollution) and waste of resources (energy, materials, products) throughout a product’s entire life cycle (that is, from cradle to grave) (Beamon, 1999; Hervani, Helms, & Sarkis, 2005; Zhu et al., 2008). Examples of green activities are green design, resource saving, reduction or restriction of harmful or hazardous substances, and product recycle or reuse (Sarkis & Zhu, 2018; Zhu, Qu, Geng, & Fujita, 2017).

The five GSCM practices that are empirically proven in past studies to be able to aptly represent the various critical dimensions of GSCM practices implementation and are hence in the spot light in this study are Internal Environmental Management, Cooperation with Customers, Eco Design, Investment Recovery, and Greening the Suppliers (Chiou et al., 2011; Zhu et al., 2008) which are being defined as follows:

(1) Internal Environmental Management (IEM): IEM is the practice of developing GSCM as a strategic and vital organizational imperative through the support and commitment of the senior and mid-level management teams that relentlessly work towards the attainment of organizational green/sustainability goals (Green, Zelbst, Meacham, & Bhadauria, 2012; Schulze & Heidenreich, 2017; Zhu et al., 2008). Besides this, cross-functional involvement and inter-departmental cooperation and collaboration are essential in ensuring the smooth, efficient and effective execution of a firm’s environmental plans, policies and practices (Braunscheidel & Suresh, 2018). Furthermore, IEM also involves having solid total quality and environmental management systems in place (such as being certified to and compliant with ISO14001) (Salim et al., 2018). For example, Korea Omyang Corporation which is one of the biggest manufacturers and exporters of speakers and other electronic and automotive parts in Seoul, South Korea, has restructured its organizational structure and made the functional units of production, quality assurance or quality control and research and development (R&D) to work together to mitigate any imminent and real environmental threats in the products and production lines ("Korea Omyang - Company Profile", 2018; Lee,

2009). The top management has also made these three functional units to report directly to the Managing Director. The supportive and highly-committed top management team, being ISO14001 certified and coupled with strong cross-functional involvement and collaboration have rendered Korea Omyang Corporation to become much more efficient and effective in achieving its environmental and sustainability goals (Lee, 2009).

(2) Cooperation with Customers (CC): CC requires cooperating and collaborating with customers to design cleaner production processes in order to produce environmentally sustainable products with greener packaging (Green et al., 2012; Zhu et al., 2008). Besides this, CC also involves working closely with customers to have more environmental-friendlier product and process designs that are more eco-durable and sustainable while maintaining commercial viability (Tamayo-Orbegozo, Vicente-Molina, & Villarreal-Larrinaga, 2017). Furthermore, CC also calls for reaching a consensus with customers to implement sustainable logistics distribution system that aims to minimize the consumption of resources (i.e. petrol, energy, goods loading and unloading time, manpower) and achieve greater energy and urban mobility efficiencies (Esfahbodi, Zhang, Watson, & Zhang, 2017). For example, a 37-year-old Korean electronic components manufacturer, Global Digital Solution Inc. which produces printed circuit board (PCB) has sought highly innovative technological inputs from big-sized supply chain partners, including suppliers and customers, to fill the technological void regarding wastewater treatment and water quality control technologies and know-how (Lee, 2009). Teece (2010, p. 172) posited that firms have to “deliver value to customers, entice

customers to pay for value, and convert those payments to profit" in order to successfully and effectively realize the potential of a firm's revenue model.

(3) Eco Design (ED): ED or design for the environment includes activities that aim to minimize the environmental impacts of products throughout their entire life cycle by minimizing material and energy consumption in order to promote the reuse, recycle, and recovery of product components, and also to reduce or avoid the use of hazardous substances during production (Green et al., 2012; Hervani et al., 2005; Sihvonen & Partanen, 2017; Tao, Li, & Yu, 2018; Zhu et al., 2008). According to Sharma, Chandna, and Bhardwaj (2017), ED essentially revolves around ensuring the design of products meet the "recyclable and/or reusable" criteria that will leave minimal or zero negative footprints on the environment with its enhanced bio-chemical qualities. For example, Toyota Motor Corporation was the first automobile manufacturer in the world to launch an electric motor and combustion engine 2-in-1 hybrid passenger car – the infamous and awards-winning Toyota Prius in October 1997 in a move to reduce consumption of non-renewable fuel (i.e. petrol) and also to lower greenhouse gas emissions (i.e. carbon dioxide) (Toyota Corporation, 2008). According to Salleh, Roslan, Isa, Nair, and Salleh (2018), the inverter air conditioners boost significant energy efficiency in terms of electricity saving by smartly adjusting the capacity of the compressor and motor speed according to the varying cooling requirement of the external environment instead of obliging to the peak power requirement demanded by conventional non-inverter type air conditioners. Panasonic India walk the walk by launching yet another technological breakthrough product in March 2018 –

the brand-new “air-purifying” inverter air conditioners that are also equipped with nanotechnology features which Panasonic claims have the ability to remove airborne particles and give up to 99% clean air (Press Trust of India, 2018).

(4) Investment Recovery (IR): IR involves the sale of scrap and used materials, excess inventories, and excess capital equipment (Green et al., 2012; Zhu et al., 2008). According to Kazancoglu, Kazancoglu, and Sagnak (2018) and Knappich, Schlummer, Mäurer, and Prestel (2018), economic and financial gains are very much better enhanced through IR initiatives such as the recovery and subsequent sale of useful metals such as Copper and Nickel which are recovered from wastewater treatment facilities located at manufacturing plants. Some real-life examples to illustrate IR will be Stanley Black & Decker Corporation, Arlington Plating Company, SRG Global Inc., Prime Wheel Corporation, Florida Production Engineering, Electro Chemical Finishing, A-Brite Plating, Lacks Industries, Master Finish Company, and Sunspring (China plant) engaged Chemtech Systems Inc., an American chemicals recovery specialist to recover Nickel, a highly useful and corrosion-resistant transitional metal that is widely used to produce a wide variety of consumer and industrial products, including rechargeable batteries, stainless steel and so on (Chemtech Systems Inc., 2018; Cutler, 2018). According to The London Metal Exchange (2018a, b), Copper and Nickel are officially traded at USD 6,811 and USD 15,255 per ton respectively as in June 2018. This showcases how valuable Copper and Nickel are by increasing a firm’s revenues through metal recovery

from wastewater treatment and/or production scrap (Kazancoglu et al., 2018; Knappich et al., 2018).

(5) Greening the suppliers (GS): According to Chiou et al. (2011), Lee and Kim (2011), Rao (2002), Vachon and Klassen (2006) and Wu (2013), GS essentially involves selecting upstream supply chain partners (i.e. suppliers) or even subcontractors based on environmental criteria, providing environmental-oriented assistance in the forms of technical advice, training sessions, seminars and also raising awareness among the suppliers to better assist them to achieve common environmental goals, plus conducting environmental audits on certain important suppliers (usually main raw materials suppliers). Besides this, GS also involves requiring and helping the suppliers and subcontractors to be certified to established international environmental standards such as the ISO 14001 family certifications (Zhu, Feng, & Choi, 2017). Furthermore, according to Handfield, Sroufe, and Walton (2005), Morioka, Bolis, and Carvalho (2017), Schöggl et al. (2017), and Vezzoli (2018), value-added inputs from suppliers in the early stage of product design and development will reinforce the attainment of environmental and sustainability goals by determining the right eco-durable but at the same time economically viable materials, parts and components. A practical example to illustrate GS is the “Dell Supplier Principles” policy implemented by Dell Inc., an American multinational firm specializing in manufacturing computers and computer peripherals, and actively involving in technological innovations (Dell Inc., 2017; 2018). In order to do business with Dell Inc., suppliers need to comply with the eight principles explicitly enshrined in the “Dell Supplier Principles”, including being certified to

international standards like ISO 14001 (Environmental Management System), ISO 9001 (Quality Management System), and ISO 45001 or OHSAS 18001 (Occupational Health and Safety Management Systems). Furthermore, according to Cusack and Perrett (2006) and Lee (2009), in order to ensure that the final products are indeed complying with the European Union (EU) directive - Restriction of Hazardous Substances (RoHS), many large firms require their suppliers to verify that their parts and components are indeed RoHS-compliant. This clearly showcases the effectiveness of exerting the bargaining power of customers on the suppliers to ensure the suppliers are also on par in terms of sound environmental performance (Guenther, Endrikat, & Guenther, 2016).

2.3.1 Model development

Green Purchasing which is one of the five GSCM practices as confirmed by Zhu et al. (2008) in their empirical work entitled "Confirmation of a measurement model for green supply chain management practices implementation" is being replaced by Greening the Suppliers (GS) in this research study because GS represents the pivotal roles played by suppliers to a larger degree compared with green purchasing (in the dimensions of proper selection of suppliers, effective collaboration with suppliers to promote green efforts/initiatives and evaluation of suppliers), which covers the entire upstream operations of a firm in a highly condensed and concise manner (Chiou et al., 2011; Handfield et al., 2005, Lee and Kim, 2011; Morioka et al., 2017; Rao, 2002; Schöggl et al., 2017; Vachon and Klassen, 2006; Vezzoli, 2018; Wu, 2013; Zhu et al., 2017).

This is evidenced by comparing the items of measurement of both constructs as shown in Table 2.1 below. Table 2.1 clearly demonstrates that there are only two items in Green Purchasing that are implying supplier selection (i.e. GP1 and GP4), only one item is about environmental collaboration (i.e. GP2), and another two items covering supplier evaluation (i.e. GP3 and GP5). GS, on the other hand, has two items that clearly cover the function of supplier selection (i.e. GS1 and GS2), four items that cover environmental collaboration (i.e. GS2, GS3, GS4 and GS5), and one item that covers supplier evaluation (GS6).

It is worth noting that item GS2, “Requiring and assisting suppliers to obtain a third-party certification of environmental management system (EMS) such as ISO14001” covers both functions of supplier selection and environmental collaboration.

The number of items dedicating to “environmental collaboration” for Green Purchasing and GS is one and four respectively. This clearly shows that GS places more emphasis in collaborating with suppliers for environmental purposes as compared to Green Purchasing.

Additionally, Rao (2005) has proven that “greening the suppliers” has gained great popularity and relevance in the South East Asian context. Furthermore, Bowen, Cousins, Lamming, and Farukt (2001), Eltayeb et al. (2011) and Lee, Ooi, Chong, and Lin (2015) advocated that green purchasing activities need to be expanded further by incorporating more environmental collaborative activities with the suppliers to enhance the achievement of common environmental goals. Hence, GS is considered to be able to represent the procurement and purchasing function of a supply chain much more holistically and comprehensively as compared to Green Purchasing.

Table 2.1 Comparison between Green Purchasing and Greening the Suppliers

Green Purchasing **Source: adopted from Zhu et al. (2008)**		**Greening the Suppliers** **Source: adopted from Chiou et al. (2011)**	
Items of measurement:		**Items of measurement:**	
GP1. “Eco labeling of products.”	implying Supplier Selection	GS1. “Selecting suppliers by environmental criteria.”	Supplier Selection
GP2. “Cooperation with suppliers for environmental objectives.”	Environmental Collaboration	GS2. “Requiring and assisting suppliers to obtain a third-party certification of environmental management system (EMS) such as ISO14001.”	Supplier Selection & Environmental Collaboration
GP3. “Environmental audit for suppliers’ internal management.”	Supplier Evaluation	GS3. “Providing environmental awareness seminars and training for suppliers.”	Environmental Collaboration
GP4. “Suppliers’ ISO14000 certification.”	implying Supplier Selection	GS4. “Providing environmental technical advice to suppliers and contractors in order to help suppliers to meet environmental criteria.”	Environmental Collaboration
GP5. “Second-tier supplier environmentally friendly practice evaluation.”	Supplier Evaluation	GS5. “Invite suppliers to join in the development and design stage.”	Environmental Collaboration
		GS6. “Sending in-house auditor to appraise environmental performance of supplier.”	Supplier Evaluation

2.4 Review of Green Innovation Performance

Green innovation essentially involves undertaking creative initiatives to invent and innovate greener and more environmentally friendly products and processes that will leave minimal or zero negative environmental footprints on the planet (Huang & Li, 2017). Green innovation is a centripetal force to safeguard the sustainability of the Earth's finite resources (Rockström et al., 2017) besides positioning firms to gain first mover advantage in the market where "sustainability oriented" products and services are highly trendy and in popular demand nowadays (Hall, Matos, Gold, & Severino, 2018; Marcon, de Medeiros, & Ribeiro, 2017). Following Chen (2008), Chen et al. (2006), and Chiou et al. (2011), the primary categories of green innovation performance are green product innovation, green process innovation and green managerial innovation. According to Tseng et al. (2013), the multidimensionality of green innovation performance is being reflected through the measurement of multiple performance criteria.

2.4.1 Green Product Innovation defined

According to Chen (2008), Chiou et al. (2011), Tseng et al. (2013), Wong (2012), and Wu (2013), green product innovation essentially involves designing eco-friendly packaging materials (for example using less paper, plastic or Styrofoam materials), and utilizing non-toxic, non-polluting, recoverable and/or recyclable materials during production in order to produce value-added products that are not only eco-durable, environmentally friendly and sustainable, but also leave minimal negative externalities (Horvath, Mallinguh, & Fogarassy, 2018; World Economic Forum, Ellen MacArthur

Foundation and McKinsey & Company, 2016). Besides this, green product innovation also involves the practice of eco-labelling (Prieto-Sandoval, Alfaro, Mejía-Villa, & Ormazabal, 2016). According to Bioeconomy Corporation (2017), Free the Seed Sdn Bhd, a Malaysian manufacturing firm specializing in biodegradable packaging which use rice husks and straws instead of plastic and polystyrene to produce biodegradable packaging materials in an effort to elevate the country's green innovation performance besides making use of Malaysia's native resources (an act that surely boost local productivity). Besides this, manufacturers of microbial-based domestic and industrial cleaning products cleverly use living microorganisms such as beneficial bacteria as active ingredients to effectively remove grease, stains, perform deep cleaning and odor control, degrade waste and do septic system maintenance (About Cleaning Products, n.d.; Spök, Arvanitakis, & McClung, 2018). These microbial-based cleaning products are said to be less harmful to the environment (Spök et al., 2018). Another example will be British Petroleum's Deepwater Horizon Oil Spill which happened in 2010 near the Gulf of Mexico (Smith, Smith, & Ashcroft, 2011). Fueled by oxygen, regulated by nutrients such as nitrogen or phosphorus, hydrocarbon-eating bacteria such as *Colwellia*, *Cycloclasticus*, *Oceanospirillales* and many other beneficial microbes did a spectacular job of biodegrading and clearing the oil spill caused by British Petroleum on the waters of Gulf of Mexico (Biello, 2015). Besides this, Boeing 787 Dreamliner and ecoDemonstrator 787, as well as Tesla's electric cars, clean energy storage systems and solar panels are some of the breakthrough technologies that showcase exemplary green innovations that boast not only range flexibility and energy efficiency (in terms of fuel consumption) but also greatly reduced greenhouse gases emissions (especially CO_2) (Boeing, 2019; Japhe, 2018; Tesla, 2019). These real-life examples clearly showcase the tremendous environmental benefits that green product innovations bring.

2.4.2 Green Process Innovation defined

Following Chen (2008), Chiou et al. (2011), Tseng et al. (2013), and Wu (2013), green process innovation essentially involves employing creative and innovative clean or renewable technologies such as energy-saving and pollution prevention strategies to green the production processes in order to proactively minimize any negative environmental externalities caused by the production processes. Besides this, green process innovation also involves recycling, reusing and remanufacturing of parts or materials during production (Burki, Ersoy, & Dahlstrom, 2018). Business process reengineering is a good methodology to shift the paradigm of a firm’s conventional production processes towards more sustainable operations (Magon, Thomé, Ferrer, & Scavarda, 2018). Several manufacturing firms in Tianjin, China that specialize in pharmaceutical products used improved energy-saving modern gas-fired industrial boilers instead of conventional coal-fired ones during production with the aim of optimizing outputs while at the same time enhancing energy efficiency (Li & Hamblin, 2016). Another example that clearly illustrate green process innovation is Korea Omyang which has successfully reformed its cone paper production process by installing a substitute tank on the outer parameter of its manufacturing plant to recycle water (Lee, 2009). This move has not only raised productivity but has also resulted in reduced chemical and water usage, on top of minimizing wastewater discharge (Lee, 2009).

2.4.3 Green Managerial Innovation defined

The commitment and support of top and middle-level management teams cannot be underestimated in ensuring the successful execution of a firm’s policies and plans (Latan, Jabbour, de Sousa Jabbour, Wamba, & Shahbaz, 2018). Following Burki et al. (2018), Chiou et al. (2011), and Tseng et al. (2013), green managerial innovation essentially involves redesigning and redefining operational and production processes to optimize environmental efficiency. Besides this, green managerial innovation also involves revolutionizing products and services offered to achieve the latest established environmental criteria or directives (Flygansvær, Dahlstrom, & Nygaard, 2018). Global Digital Solution, a PCB (Printed Circuit Board) manufacturer in Korea, which was concerned about water pollution and wastewater treatment challenges caused by its production processes, has changed its organizational structure by setting up an “environment and safety department” to better manage wastes and toxic substances, monitor and control air, water and soil pollution and tighten fire and safety measures (Lee, 2009).

2.5 Links between GSCM practices and Green Innovation Performance

There are many empirical studies throughout the world that advocate the positive and significant relationships between GSCM practices and green innovation performance in the extant literature (Agan, Acar, & Borodin, 2013;

Choi & Hwang, 2015; Fang & Zhang, 2018; Green et al., 2012). Malaysia is of no exception (Eltayeb et al., 2011; Lee et al., 2014; Rao & Holt, 2005).

According to Fang and Zhang (2018) and Gunasekaran, Patel, and Tirtiroglu (2001), it is commonly accepted that one of the most effective ways to assess how best GSCM practices drive sustainability is through the measurement of performance consequences.

Following Tseng, Tan, and Siriban-Manalang (2013), firms are driven to incorporate GSCM practices throughout the entire life cycle of the products, from the initial conception, to designing the prototype, mass producing the approved prototype, delivering the finished goods to customers and doing proper waste management towards the end of useful life of the product, in order to keep abreast with the latest trends in green innovation.

Wu, Ding, and Chen (2012) found that the textile and apparel manufacturing firms in Taiwan have aggressively and proactively strengthened their GSCM capabilities in order to drive green innovation technology which will in turn lead to sustainable competitive advantage. Chiou et al. (2011) on the other hand, have empirically proven that greening the supplier (one of the GSCM practices) has led to significant improvement in environmental performance and enhanced competitive advantage through the mediating effect of green innovation. Furthermore, Chen (2008) has empirically demonstrated that green core competences (i.e. environmentally-oriented collective learning and capabilities of a firm) positively and significantly impact the green image and green innovation performance among Taiwanese electronic manufacturing firms.

Following past studies, it can be logically deduced that GSCM practices will lead to an improvement in green innovation performance, and hence suggesting a positive correlation between GSCM practices and green innovation performance (Agan et al., 2013; Chen, 2008; Chiou et al., 2011; Choi & Hwang, 2015; Eltayeb et al., 2011; Fang & Zhang, 2018; Green et al., 2012; Lee et al., 2014; Rao & Holt, 2005; Wu et al., 2012). The detailed arguments proposing the direction (positive, as opposed to negative) and significance of the correlation between each GSCM practice and green innovation performance that will lead to the development of hypotheses will be detailed out in Chapter 3 (as supported by past and current literature).

2.6 Chapter Summary

Chapter 2 began with the introduction of Natural Resource Based View (NRBV) theory that best represent the proposed research framework. Besides this, this chapter also detailed out the definitions, descriptions and relevant practical examples of GSCM and the tri-dimensional green innovation performance. Furthermore, sensible justifications are provided for the selection of the five GSCM practices in this study. Last but not least, a brief summary explaining the links between GSCM practices and green innovation performance are presented towards the end of this chapter. The detailed justifications supporting the direction (positive) and significance of the relationships between each GSCM practice and green innovation performance which lead to hypotheses development are detailed out in Chapter 3.

CHAPTER 3

RESEARCH FRAMEWORK AND DEVELOPMENT OF HYPOTHESES

3.1 Introduction

The focus of Chapter 3 is mainly on the relationships between GSCM practices and green innovation performance (EIP) based on past and recent literature review. The research framework developed for the present study will be presented in section 3.2 whereas hypotheses development together with the relevant literature support will be detailed out in section 3.3. Next, the hypotheses summary will be tabled out in section 3.4 and finally, Chapter 3 ends with the conclusion in section 3.5.

3.2 Model of the Study

A research framework illustrating the relationships between GSCM practices and green innovation performance is demonstrated in Figure 3.1 as shown below. Five GSCM practices, namely IEM, CC, ED, IR, and GS, are portrayed to directly affect EIP. EIP, on the other hand, is treated as a reflective three-dimensional construct that is made up of GDI, GCI and GMI. In other words, the research framework proposes that a higher level of GSCM practices implementation will lead to a correspondingly higher level of green innovation performance in a firm. This research study attempts to explore and bridge the research gaps that are present in GSCM extant literature by building a solid foundation to provide a thorough and in-depth understanding concerning the relationships between GSCM practices and green innovation performance.

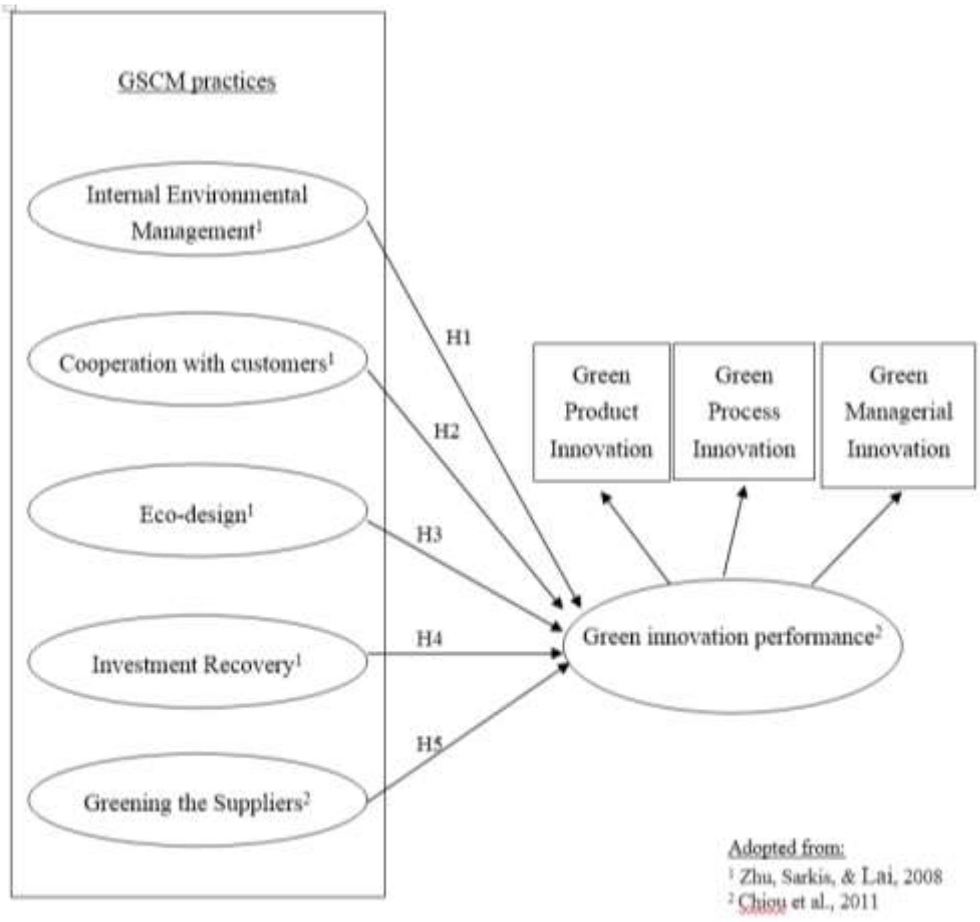

Figure 3.1 Proposed Research Framework

3.3 Development of Hypotheses

Based on past and recent empirical studies, five hypotheses are formulated in this study to reasonably forecast the impact of GSCM practices on EIP.

3.3.1 Internal Environmental Management (IEM) – Green Innovation Performance

Past and recent studies have unanimously agreed that IEM is a key factor in improving firms' performance, including green innovation performance (Carter, Ellram, & Ready, 1998; Wu, 2013; Zhu et al., 2017).

It is a well-known and irrefutable fact that the support rendered by top and middle level management teams is crucial for successful adoption and implementation of most innovations, technologies, programs, practices and activities (Burki et al., 2018; Carter et al., 1998; Diana, Jabbour, de Sousa Jabbour, & Kannan, 2017; Hamel, Doz, & Prahalad, 1989; Tseng et al., 2013). In practice, as supported by various empirical findings, top and middle management's support and commitment significantly drive green innovation performance (Albertini, 2018; Burki et al., 2018; Saunila, Ukko, & Rantala, 2018). This is because front-line and operational level executives will follow the lead and directives (in the forms of Code of Conduct, Standard Operating Procedures, plans, policies and programs) set by the top and strategic management level senior personnel in effectively executing a firm's green and sustainable practices throughout the entire value chain (Albertini, 2018; Cokins, 2017; Epstein, 2018; Sroufe & Sarkis, 2017).

To ensure complete organizational excellence in the green innovation and sustainability aspects, top and middle level management teams must be totally and full-heartedly committed and drive win-win cross-functional collaborations towards achieving and sustaining impeccable total quality and environmental management systems (Kumar & Rodrigues, 2018; Melander, 2018; Rice, 2003; Wong, Al-Obaidi, & Mahyuddin, 2018; Zsidisin & Siferd, 2001). Furthermore, being certified to well-established and internationally recognized environmental management standard such as ISO 14001 certainly laid a foundation in advancing green innovation performance in a firm, as evidenced in empirical studies conducted by Hamdoun, Jabbour, and Othman (2018), He and Shen (2017), and Li, Zheng, Cao, Chen, Ren, and Huang (2017).

Hamdoun et al. (2018), He and Shen (2017), and Li et al. (2017) all found that being ISO 14001-certified plays a vital role in advancing green innovation performance. This is because being ISO 14001-certified demonstrates to various stakeholders, including suppliers, customers, government, the general public and fellow industry players that a firm is at the very least effectively complying to a set of well-established and internationally recognized environmental standards or best practices and go through stringent and rigorous audit processes conducted by a panel of professional and independent ISO auditors to get re-certified (Boiral, Guillaumie, Heras-Saizarbitoria, & Tayo Tene, 2018). In a nutshell, the rationales behind being ISO 14001-certified is not only to satisfy customers’ criteria or expectations, but also is a smart move by firms to advance in the fields of green innovation and sustainability, which are sensational and explosive topics in today’s climate (Tseng et al., 2013; Tuczek, Castka, & Wakolbinger, 2018; Yin, Gong, & Wang, 2018).

Through strong and robust IEM, firms pave the way towards producing greener and more sustainable innovations in view of the current trend that various stakeholders are demanding greener and more eco-durable products and services that leave minimal or even zero negative environmental footprints on the planet throughout their entire lifecycle (Ansari & Kant, 2017; Burki et al., 2018; Gupta & Barua, 2017; Scur & Barbosa, 2017; Zhu et al., 2017).

On a side note, in an empirical study conducted by Murat Ar and Baki (2011), top management support was surprisingly found to be insignificantly linked to process innovation. Murat Ar and Baki (2011) attributed this insignificant relationship to other factors that were beyond the control of the top management and hence causing top management support having an insignificant relationship with process innovation. The so-called "uncontrollable" factors include sudden and inevitable changes in the operational processes which have an unprecedented adverse impact on the successful roll-out of process innovation applications, or frequent change in persons-in-charge who are not very familiar with the operating environment when these new personnel first joined the company, and so on (Dulaimi, Nepal, & Park, 2005; Hammer, 2012; Lee & Ku, 2005).

Nevertheless, since there are convincingly more literatures in support of IEM having a significant and positive relationship with EIP, hence, the relationship between IEM and EIP is hypothesized as follows:

H1: IEM is significantly and positively linked to EIP.

3.3.2 Cooperation with Customers (CC) – Green Innovation Performance

CC which focuses on downstream supply chain activities essentially involve practices such as working hand-in-hand with customers for the purposes of achieving cleaner production, greener and more sustainable packaging, more environmentally friendly product and process designs, and consuming less energy in the outbound logistics function (Murphy & Poist, 2000; Vanalle, Ganga, Godinho Filho, & Lucato, 2017; Wang, Wang, Zhang, & Zhao, 2018; Zhu et al., 2008).

In present day, firms are increasingly focusing on satisfying the demands of customers who are becoming more and more environmentally conscious and are hence asking for more “green” and eco-durable products and services so as to contribute towards achieving sustainability goals (Charter & Tischner, 2017; Lee et al., 2014; Lewis, Gertsakis, Grant, Morelli, & Sweatman, 2017; Lo & Leung, 2000).

Thus, in order to be highly responsive towards customers’ changing needs, firms that focus on and take pride in continuous improvement and always on the move by rigorously innovating their product offerings and production processes, besides redefining management control systems to achieve environmental goals and objectives, really stand out from the crowd (Song-Turner & Polonsky, 2016; Viardot, 2017).

Furthermore, when environmentally conscious customers value the “greener” and more eco-durable products that a firm offers and are willing to pay a premium or sign long-term supply contracts with that firm, this will undoubtedly strengthen the competitive position of the firm in the market, in terms of greater market share and positive “green image” (Amores-Salvadó, Martín-de Castro, & Navas-López, 2014; Prakash & Pathak, 2017; Zhang, Fu, Huang, Wang, Xu, & Zhang, 2018).

Following the rationales mentioned above, it can be logically deduced that CC will positively and significantly influence green innovation performance, as supported by de Sousa Jabbour, Vazquez-Brust, Jabbour, and Latan (2017), Diabat, Khodaverdi, and Olfat (2013), Khan and Dong (2017), Leal-Millán, Albort-Morant, Leal-Rodríguez, and Ariza-Montes (2017), and so on.

On a side note, de Sousa Jabbour et al. (2017), Lee et al. (2014), and Monjon and Waelbroeck (2003) surprisingly found that CC was insignificantly linked with environmental performance, technological innovation and product innovation respectively. de Sousa Jabbour et al. (2017) attributed this insignificant relationship to the oligopoly state of economic context for company B, where the selected group of firms that make up an industry has control over the selling price (Hayes, 2017) and hence deeming the effect of CC practices not being significant on environmental performance. Lee et al. (2014), on the other hand, attributed the insignificant relationship between CC and technological innovation to the low green awareness among the average consumer (Mourad and Ahmed, 2012).

Nevertheless, since there are convincingly more literatures in support of CC having a significant and positive relationship with EIP, hence, the relationship between CC and EIP is hypothesized as follows:

H2: CC is significantly and positively linked to EIP.

3.3.3 Eco design (ED) – Green Innovation Performance

According to Knight and Jenkins (2009), Lee et al. (2014), Sihvonen and Partanen (2017) and Zhu et al. (2008), ED is a highly useful tool in helping a firm to further improve on EIP by mainly emphasizing on the design of value-added features and technical functionalities of products and processes that leave minimal or zero negative environmental footprints throughout the entire lifecycle of the inventions or innovations.

The design stage is crucial because it is at this stage that the materials (including parts and components) are determined, meaning that a majority of the ecological impacts are embedded into the product and the cost of the product is largely decided at this critical stage (Lewis et al., 2017; Shahbazi, Jönsson, Wiktorsson, Kurdve, & Bjelkemyr, 2018).

Products that consume minimal resources (including energy) are largely more marketable and profitable and hence can secure more market share for a firm (Charter & Tischner, 2017; Lee et al., 2014). Thus, the design of a product that effectively minimizes the consumption of resources, on top of being ISO 9001 and ISO 14001 certified, as well as being compliant to the stringent

European Union’s Directive - Restriction of Hazardous Substances (RoHS) (for the electrical and electronic industry) by avoiding the use of hazardous substances during production, is largely associated with the attainment and further improvement of EIP (Albino, Balice, & Dangelico, 2009; Dangelico & Pujari, 2010; “Recast of the RoHS Directive”, 2016).

EIP is enhanced through breakthrough technologies in designing and producing green innovative products that serve as effective solutions in mitigating negative environmental externalities (Dangelico, Pujari, & Pontrandolfo, 2017; Huang & Li, 2017) and a proactive measure for pollution prevention via innovative product stewardship (Santolaria, Oliver-Solà, Gasol, Morales-Pinzón, & Rieradevall, 2011; Scur & Barbosa, 2017).

On the other hand, in an empirical study conducted by Yu, Hills, and Welford (2008) which focused on electrical and electronic manufacturing firms in China, a majority of the respondents perceived that eco-design did not lead to cost savings because even though some of the design features boast materials and energy consumption reductions which can lead to reductions in costs, but the ultimate increase in the total costs of design changes could hardly be absorbed by most responding firms. This is especially true for early adopters of eco-design where the firms are not able to recover the huge initial costs of investment in the short-run (Gottberg, Morris, Pollard, Mark-Herbert, & Cook, 2006).

Nevertheless, since there are convincingly more literatures in support of ED having a significant and positive relationship with EIP, hence, the relationship between ED and EIP is hypothesized as follows:

H3: ED is significantly and positively linked to EIP.

3.3.4 Investment Recovery (IR) – Green Innovation Performance

Following Mumtaz et al. (2018), Vanalle et al. (2017), and Zhu et al. (2008), IR involves the recovery, resale, redeployment and disposal of surplus, excess or redundant materials (including parts and components with quality problems and scrap) and capital equipment such as idle plant and machinery to at least recover some monetary values from scrap.

By reselling and disposing idle and redundant assets, IR is capable of turning surplus resources into proceeds, cut down on storage needs (such as decreasing the expenses and storage space associated with landfills). Furthermore, by deploying unused fixed assets to other company locations, this will save the firm from procuring and purchasing extra machinery and equipment, which may prove to be unnecessary expenditures (Atkinson, 2002), thus minimizing costs and wastes (Zhao, Liu, Zhang, & Huang, 2017).

According to Cottrill (1997) and Esfahbodi et al. (2017), IR is a sound practice which yields great benefits since a substantial part of the sales proceeds (≥ 70%) generated by IR are actually components of the revenues or profits for multiple industries, including the electrical and electronic and IT industries which generate huge amounts of electronic and hardware wastes (for example spoilt PCB, obsolete hardware), forestry industry, chemicals and petrochemicals industry, industrial and heavy machinery industry, consumer, healthcare, and pharmaceutical industry, and so on (Cubitt, 2016; Sarkis, 2003; Szaky, 2014).

Thus, IR, being an indispensable part of pollution prevention (Wu et al., 2012), through the sale or disposal of scrap, used and obsolete materials and/or fixed assets, not only help firms to save costs, but also play a vital role in the recovery and reproduction of green innovative products which are sustainable and eco-durable (Gupta & Barua, 2017; Lee et al., 2014). This is in line with achieving and improving EIP, as supported by Diabat et al. (2013), Gerrard and Kandlikar (2007), and Lee et al. (2014).

On the other hand, Lee et al. (2014) and Esfahbodi et al. (2017) surprisingly found that IR was not significantly linked to technological innovation and economic performance respectively. Lee et al. (2014) attributed the insignificant relationship between IR and technological innovation to the rationale that IR systems in developing countries such as Malaysia receive relatively less attention compared to developed nations such as Germany and USA due to a lack of infrastructure, relevant experience and expertise in recovering valuables such as Copper and Nickel from wastewater (Zhu & Sarkis, 2007). Esfahbodi et al. (2017) denoted the insignificant relationship between IR and economic performance to the rationale that the responding firms having insufficient control over the implementation of IR, which is perceived as an external practice and received relatively little attention among the UK manufacturing firms.

Nevertheless, since there are convincingly more literatures in support of IR having a significant and positive relationship with EIP, hence, the relationship between IR and EIP is hypothesized as follows:

H4: IR is significantly and positively linked to EIP.

3.3.5 Greening the Suppliers (GS) – Green Innovation Performance

In line with past and recent research studies, GS is essential in advancing the green innovation capabilities of a firm through proper supplier selection, strong and positive environmental collaboration with suppliers and conducting checks or audits on certain main suppliers (for example main raw materials suppliers) to ensure the upstream supply chain partners are aligning with a firm's environmental and sustainability goals (Chiou et al., 2011; Lee & Kim, 2011; Morioka et al., 2017; Rao, 2002; Schöggl et al., 2017; Vachon & Klassen, 2006; Vezzoli, 2018; Wu, 2013).

It is important to manage appropriately-chosen suppliers effectively by proactively greening the suppliers and supporting the suppliers by providing value-added inputs in an effort to solve mutual environmental problems when the suppliers need help most, besides communicating the firm's requirements clearly, will enable suppliers to deliver solutions (in the form of green and innovative products or services) that match the customer's specifications exactly (Das, 2018; Vachon & Klassen, 2006; Zhu & Geng, 2001). Furthermore, the products and/or services supplied by suppliers serve as the essential inputs or raw materials to start the production process rolling in a manufacturing firm (Black & Kohser, 2017; Grant, Wong, & Trautrims, 2017). It can be logically and reasonably deduced that parts and components that are certified with and compliant to ISO 9001 (Quality Management System), ISO 14001 (Environmental Management System) and/or RoHS will produce green products that leave minimal or zero negative footprints on the environment (Gehin, Zwolinski, & Brissaud, 2008; Lee, 2009; Wang, Huscroft, Hazen, & Zhang, 2018). This can be interpreted as a higher degree of GS implementation will lead to a correspondingly higher degree of EIP improvement (Lee et al., 2014; Morioka et al., 2017; Wu, 2013).

In view of the above rationales, GS is envisioned as an essential practice that simultaneously considers the entire upstream supply chain process from the selection of suppliers, collaborative management of suppliers up till the evaluation of the supply function with the achievement and improvement of green innovation performance in mind.

On the other hand, Fernando and Wah (2017) surprisingly found that supplier involvement which is a contributing factor of eco-innovation was insignificantly linked with environmental performance among Malaysian green technology firms. Fernando and Wah (2017) attributed this insignificant finding to the rationale that supplier involvement was not yet been optimized as an indispensable firm resource to affect environmental performance significantly. Fernando and Wah (2017) further explained that many small-sized suppliers in Malaysia lack awareness of the prominent roles played by eco-innovation principles to enhance environmental performance in a significant way.

Nevertheless, since there are convincingly more literatures in support of GS having a significant and positive relationship with EIP, hence, the relationship between GS and EIP is hypothesized as follows:

H5: GS is significantly and positively linked to EIP.

3.4 Hypotheses Summary

A summary of hypotheses is clearly laid out in Table 3.1 as follows:

Table 3.1 Summary of Hypotheses

GSCM practices	**Hypotheses Developed**
Internal environmental management (IEM)	H1: IEM is significantly and positively linked to EIP.
Cooperation with customers (CC)	H2: CC is significantly and positively linked to EIP.
Eco design (ED)	H3: ED is significantly and positively linked to EIP.
Investment recovery (IR)	H4: IR is significantly and positively linked to EIP.
Greening the suppliers (GS)	H5: GS is significantly and positively linked to EIP.

3.5 Chapter Summary

After the initial introduction in Section 3.1, the research framework/model illustrating the five-to-one relationships between GSCM practices and green innovation performance was presented in Section 3.2. Next, the past and latest empirical research findings supporting the magnitude and direction of the relationships between GSCM practices and green innovation performance that eventually led to the development of hypotheses were also detailed out in Section 3.3. Last but not least, a summary that listed out all five hypothesis was presented in a straightforward but compact table in Section 3.4. On a side note, methodological processes involving the design of the research, determination of the target population, techniques of sampling, operationalization of constructs, plus the data collection and analytical procedures would be set forth in the next chapter.

CHAPTER 4

METHODOLOGY OF RESEARCH

4.1 Foundation

The methodology of this study will be laid out in this chapter in the researcher's attempt to answer the research questions and achieve the research objectives set out in CHAPTER 1 and also to examine the research framework developed in CHAPTER 3 (specifically to test the hypotheses developed to ascertain the magnitude (significant or otherwise) and direction (positive or negative) of the correlations between GSCM practices and EIP). Besides this, data analysis method will also be discussed and justifications will be provided to justify the usage of dual-stage PLS-ANN analysis. Last but not least, construct operationalization (in the form of variables and measurements) will be presented before Chapter 4 ends with the chapter summary.

4.2 Research Design and Methodology

Following Bell, Bryman, and Harley (2018) and Nardi (2018), the main purpose of research design and methodology is not only to connect the research data to RQs, but also to undertake the necessary tools and procedures in order to best respond to the RQs. An excellent research design must ensure that the

RQs are well-fitted to the research data (Jia, Wang, & Szymanski, 2017; Stephens & Boland, 2015). According to Crane, Henriques, Husted, and Matten (2017), research design is essentially a blueprint that incorporates the research strategies, sampling procedures, data collection as well as data analysis techniques to efficiently and effectively complete the empirical research study.

4.2.1 Determination of Study Area, Target Population & Sampling Technique

With the primary objective of tackling research problems and to achieve the ROs set out in Chapter 1, the study area was focused only on Malaysia, where both the pilot and actual studies were conducted in Malaysia.

Federation of Malaysian Manufacturers (FMM) Directory 2016 was used as the source to obtain the details of the manufacturing firms (such as ISO and other certifications obtained, contact number(s), email address(es), firm address(es), name(s) of contact person(s), et cetera). Besides this, FMM Directory 2016 was also the source where the target population and sampling frame were determined. This is because FMM is considered to be one of the largest economic entities in Malaysia, boasting more than 2400 manufacturing firms, exporters and service firms as FMM members and hence is generally perceived to represent the Malaysian manufacturing and services industries very well (FMM Directory, 2016).

In this study, the target population comprises of all large ISO 14001-certified manufacturing firms as per FMM Directory 2016. Large ISO 14001-certified manufacturing firms with over 200 employees per firm (meaning firm size is 201 and above employees, following Hasan & Jandoc (2010)) are targeted because ISO 14001-certified firms are at the very least complying to the well-established international environmental management standard and have to go through periodic stringent audit and re-certification process conducted by independent and professional ISO auditors (Lloyd, 2001; Yeung & Mok, 2005) and hence are believed to be actively and rigorously embedding and implementing green supply chain practices (Darnall et al., 2008), thus making these firms highly suitable target respondents. Furthermore, only large firms are targeted because large firms naturally possess larger economic power and hence have more capabilities in terms of availability of resources (including technology, manpower, expertise, equipment, and so on) to implement GSCM practices compared to their smaller counterparts (Kim, 2006; Yook, Choi, & Suresh, 2017; Zhu & Sarkis, 2004).

Analysis shows that there are altogether 268 large manufacturing firms which are certified with ISO 14001 in Malaysia in accordance with FMM Directory 2016. Since the whole list of ISO14001-certified manufacturers as listed in the FMM Directory 2016 was used, hence, this study is a census or population study, where census denotes the collection and analysis of data from every possible case or group member in a population (Saunders, Lewis, & Thornhill, 2016). The results are believed to be able to generalize across the industries given the multitude of disciplines present. Furthermore, census study possesses the intrinsic quality of providing the greatest generalizability (Saunders et al., 2016).

This study adopted a quantitative approach of self-administered survey questionnaires (with 7-point Likert scale; with 1 representing “Strongly Disagree” and 7 representing “Strongly Agree”) to examine the magnitude and direction of the causality effects of GSCM practices on EIP among the target respondents. 7-point Likert scale was adopted instead of lower point Likert scales such as 3-point or 5-point Likert scales because according to Givon and Shapira (1984) and Marsden and Wright (2010), 7-point Likert scale has proven to be optimal in many circumstances with its capability of improving item reliability profoundly.

The target respondents are naturally the Environmental Management System (ISO 14001) Person-in-charge, Quality Management System (ISO 9001) Person-in-charge, Occupational Safety and Health (OHSAS 18001) Representative or executive from the functions of procurement, supply chain management (SCM), finance, Quality Assurance (QA), facilities, internal audit, legal team, human resources and so on, who have adequate knowledge regarding the green practices implemented in their firms (Dangelico & Pujari, 2010).

In manufacturing settings, end users can be from any department or functions, including the target respondents who comprised of the Environmental Management System (ISO 14001) Person-in-charge, Quality

Management System (ISO 9001) Person-in-charge, Occupational Safety and Health (OHSAS 18001) Representative or executive from the functions of procurement, supply chain management (SCM), finance, Quality Assurance (QA), facilities, internal audit, legal team, human resources and so on, who have adequate knowledge regarding the green practices implemented in their firms (Dangelico & Pujari, 2010). End users will communicate their requirements and specifications directly to the suppliers (if they know the suppliers, especially regarding recurrent purchases) or the purchasing team (if this is the first purchase where the end users do not know the suppliers and need the purchasing team to look up and identify suitable suppliers), nevertheless, the end users still need to communicate their requirements and specifications to the suppliers whereas the purchasing team will negotiate the purchase price and credit terms with the suppliers before Purchase Requisition (PR) is raised and subsequently Purchase Order (PO) is created and sent to the supplier after both PR and PO have been duly approved by the end user and the management team (Monczka, Handfield, Giunipero, & Patterson, 2015). Hence, it can be logically deduced that the end users (including the target respondents) have the right to choose suppliers so long as everything is in accordance with the company’s Standard Operating Procedures (SOP) and all decisions are duly approved by the top or middle level management teams, depending on the purchase monetary amount (Liu, Deng, & Chan, 2018). For example, the approval of the Director or Vice President is required if the purchase price exceeds a certain amount, for instance RM 300,000.

4.3 Data Collection method & Pilot Study results

Sekaran (2003, p. 236) suggested that "whenever possible, questionnaires are best administered personally to a group of people" to reduce interviewer bias, to clear up any doubts that the participant might have regarding the questionnaire items, and to increase response rates (Moser & Kalton, 2017; Sekaran, 2003). Hence, the method of data collection employed in this study was self-administered questionnaire approach.

Prior to pilot testing, the survey questionnaire was first pre-tested and reviewed by two senior academics with extensive experience in publications and who are experts in the field of GSCM to ensure that the survey items are easily understandable with no visible grammar errors or sentence structure problems. Next, with the objectives of ascertaining the understandability, validity and reliability of the survey questionnaire items, the questionnaire was first pilot tested among 40 industrial practitioners in the field of GSCM (including QMS/EMS/OHS representatives, facilities and SCM managers) before embarking on actual field trips. The survey questionnaires were personally delivered to and collected back from the 40 industrial practitioners by a team of paid Research Assistants in May 2017. It took around one month to complete pilot study.

The results of pilot study are demonstrated in Tables 4.1 – 4.4 as shown below. First of all, reliability has been established since all values of Composite Reliability and Cronbach's Alpha exceeded the recommended thresholds of 0.6 and 0.7 respectively (Bagozzi & Yi, 1988; Nunnally &

Bernstein, 1994), as shown in Table 4.1. Besides this, the researcher has also established content validity via the assessment of literatures and seeking expert opinions of the survey items (Hulland, Baumgartner, & Smith, 2018). Next, discriminant validity has also been established since the $\sqrt{\text{AVE}}$ for each construct exceeds the correlations of all other constructs (Fornell & Larcker, 1981), as shown in Table 4.2. Besides this, Table 4.4 also demonstrates that all HTMT values are lower than the cut-off point of 0.85, hence discriminant validity has been further affirmed (Henseler, Ringle, & Sarstedt, 2015). Last but not least, convergent validity has also been established since all factor loadings > 0.5 (Fornell & Larcker, 1981), composite reliability > 0.7 (Fornell & Larcker, 1981), and AVE > 0.5 (Fornell & Larcker, 1981), as demonstrated in Tables 4.1 and 4.3 as shown below.

Table 4.1 Reliability results for Pilot Study

Constructs	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
CC	0.9550	0.9670	0.8800
ED	0.8520	0.9100	0.7720
EIP	0.9150	0.9320	0.6070
GCI	0.8320	0.8990	0.7480
GDI	0.8800	0.9170	0.7360
GMI	0.9280	0.9650	0.9330
GS	0.9420	0.9540	0.7770
IEM	0.9720	0.9760	0.8550
IR	0.9150	0.9350	0.8270

Table 4.2 Fornell-Larcker results for Pilot Study

	CC	ED	GCI	GDI	GMI	GS	IEM	IR
CC	***0.9380***							
ED	0.7190	***0.8790***						
GCI	0.1080	0.0610	***0.8650***					
GDI	0.3470	0.4780	0.5820	***0.8580***				
GMI	0.3170	0.3140	0.6640	0.7530	***0.9660***			
GS	0.6870	0.6950	0.2710	0.5350	0.4410	***0.8820***		
IEM	0.4330	0.6820	0.1560	0.3780	0.2000	0.4610	***0.9250***	
IR	0.3300	0.4100	0.0710	0.3680	0.2160	0.3180	0.3850	***0.9100***

Table 4.3 Cross Loadings results for Pilot Study

	CC	ED	GCI	GDI	GMI	GS	IEM	IR
CC1	**0.9570**	0.7180	0.0920	0.3440	0.3400	0.6720	0.3880	0.3380
CC2	**0.9670**	0.6660	0.1080	0.3450	0.3230	0.6470	0.4390	0.3210
CC3	**0.8800**	0.5610	0.0540	0.2480	0.1930	0.4600	0.3100	0.2070
CC4	**0.9470**	0.7270	0.1350	0.3470	0.3040	0.7480	0.4630	0.3420
ED1	0.5590	**0.9180**	0.1020	0.4190	0.3050	0.6490	0.6260	0.3560
ED2	0.8990	**0.8300**	0.0690	0.3500	0.2840	0.7200	0.4890	0.3930
ED3	0.4680	**0.8860**	-0.0130	0.4880	0.2390	0.4710	0.6760	0.3370
GCI1	0.0620	0.0870	**0.8560**	0.5010	0.5340	0.2670	0.2160	-0.0270
GCI2	0.1960	0.0450	**0.8480**	0.5740	0.6460	0.2910	0.0590	0.1760
GCI3	0.0070	0.0250	**0.8910**	0.4240	0.5320	0.1350	0.1380	0.0220
GDI1	0.1770	0.4480	0.2750	**0.7960**	0.4360	0.4270	0.3410	0.2650
GDI2	-0.0200	0.1920	0.3560	**0.7690**	0.4980	0.1800	0.2780	0.1530
GDI3	0.4060	0.4460	0.6890	**0.9500**	0.7930	0.5460	0.3180	0.3790
GDI4	0.5140	0.5230	0.5800	**0.9040**	0.7730	0.6120	0.3660	0.4160
GMI1	0.3230	0.3460	0.6940	0.7680	**0.9690**	0.4300	0.2440	0.2470
GMI2	0.2880	0.2570	0.5840	0.6830	**0.9630**	0.4220	0.1370	0.1670
GS1	0.6430	0.6060	0.2900	0.5160	0.3940	**0.8910**	0.4550	0.2260
GS2	0.6660	0.6240	0.3140	0.5070	0.4020	**0.9050**	0.4430	0.2580
GS3	0.6250	0.5970	0.2030	0.4290	0.4030	**0.8980**	0.4510	0.3500
GS4	0.6020	0.6270	0.2280	0.4250	0.3530	**0.8940**	0.3620	0.3400
GS5	0.6180	0.6860	0.2010	0.4800	0.4040	**0.9300**	0.3720	0.3210
GS6	0.4630	0.5310	0.1780	0.4580	0.3740	**0.7630**	0.3430	0.2000
IEM1	0.5040	0.7290	0.0890	0.3810	0.1660	0.4550	**0.8770**	0.4180
IEM2	0.4470	0.7180	0.0390	0.3480	0.1940	0.4030	**0.9400**	0.3750
IEM3	0.4640	0.6870	0.2000	0.3600	0.1910	0.4830	**0.9430**	0.4120
IEM4	0.3610	0.5510	0.2060	0.3340	0.1820	0.4010	**0.9280**	0.3230
IEM5	0.3740	0.6150	0.0920	0.3190	0.1870	0.4450	**0.9370**	0.3180

IEM6	0.3710	0.5820	0.2410	0.3650	0.1810	0.4330	**0.9400**	0.3290
IEM7	0.2800	0.5450	0.1000	0.3320	0.1920	0.3560	**0.9040**	0.3120
IR1	0.0920	0.2630	0.0030	0.2070	0.0630	0.1720	0.2700	**0.9230**
IR2	0.0440	0.1660	-0.0120	0.2020	0.0670	0.1310	0.2160	**0.8390**
IR3	0.4710	0.4950	0.1150	0.4370	0.2950	0.3950	0.4360	**0.9630**

Table 4.4 HTMT results for Pilot Study

	CC	**ED**	**GCI**	**GDI**	**GMI**	**GS**	**IEM**	**IR**
CC								
ED	**0.8030**							
GCI	0.1180	**0.1060**						
GDI	0.3530	0.5420	**0.6430**					
GMI	0.3270	0.3510	0.7480	**0.8050**				
GS	0.7070	0.7800	0.2980	0.5630	**0.4710**			
IEM	0.4420	0.7490	0.1870	0.4110	0.2080	**0.4790**		
IR	0.2440	0.3780	0.1110	0.3290	0.1640	0.2750	**0.3520**	

Once the understandability, reliability and validity have been established, the researcher proceeded to actual data collection which took around five months to complete. The actual data collection began in early June 2017 and ended in mid-November 2017.

Again, a team of ten paid Research Assistants personally collected data from 113 randomly selected targeted firms located in all over Malaysia (including 21 firms in Selangor, 19 firms in Johor, 23 firms in Penang, 7 firms in Perak, 13 firms in Melaka, 1 firm in Kuala Lumpur, 8 firms in Negeri Sembilan, 10 firms in Kedah, 5 firms in Sarawak, 5 firms in Pahang and 1 firm in Terengganu). Contacts and appointments were first made with the target respondents through phone calls and/or emails before setting foot in the firms personally. Every Research Assistant was given a cover letter explaining the objective and nature of the survey. It is worth noting that all data collectors collected data using identical ways, i.e. personally delivering the survey questionnaires to the target respondents and collected the completed survey questionnaires on the spot to ensure consistency and comparability of results (Moser & Kalton, 2017).

4.4 Determination of Sample Size & Sampling Results

There are a total of 268 large ISO 14001-certified manufacturing firms as per FMM Directory 2016 (with number of employees > 200). After discounting 40 firms that participated in Pilot Study, a balance of 228 firms were left for actual study purposes. Out of these 228 firms, only 113 firms took part in the actual study, hence giving us a response rate of 49.56%. It is worthy to note that all responses were complete with no missing values. Hence, the effective response rate remained at 49.56%. However, out of these 113 cases, a total of 6 cases were identified to be outliers after performing Mahalanobis distance analysis. This eventually left the researcher with only 107 cases (113 cases - 6 outliers) to run PLS-SEM analysis. The effective response rate of 49.56% in this study is considered acceptable compared to other empirical operational research studies which also focused on manufacturing firms, as conducted by Luthra, Garg, and Haleem (2016); Blome, Foerstl, and Schleper (2017); González-Benito, Lannelongue, Ferreira, and Gonzalez-Zapatero (2016); and Chang (2011) with effective response rates of 24.6%, 18.8%, 15.33% and 21.2% respectively.

There are many different schools of thoughts on the minimum sample size required (Kock & Hadaya, 2018). The “Guru” of PLS-SEM, Hair, Hult, Ringle, and Sarstedt (2016) advocated that the standard rule of thumb to determine the smallest sample size to run PLS-SEM path analysis is multiply the total number of arrows pointing to an endogenous variable with ten. Since a maximum of 5 arrows are pointing to the endogenous variable (EIP), therefore, following Hair et al. (2016), the minimum sample size is 50 and 107 cases (113 cases - 6 outliers) are more than sufficient to run PLS-SEM.

Furthermore, according to Geng et al. (2017) who conducted a systematic literature review on all the empirical papers published from 1996 until 2015 which solely focus on the manufacturing industries in the emerging economies in Asia (i.e. Indonesia, Malaysia, Thailand, Vietnam, Taiwan, China, India, South Korea and Philippines) that reported the empirical results of the impact of GSCM practices on firm performance in the manufacturing industry, 9 studies showed a similar sample size of 119 or less. For example, 52 data sets were collected from South East Asian countries by Rao and Holt (2005), 89 data sets were gathered in China by Zhu, Sarkis, and Lai (2007), 101 data sets were collected from Taiwan by Peng and Lin (2008), 107 data sets were gathered in China and Taiwan by Yang, Lin, Chan, and Sheu (2010), 113 data sets were gathered in China by Kuei, Chow, Madu, and Wu (2013), 75 data sets were collected from India by Nagarajan, Savitskie, Ranganathan, Sen, and Alexandrov (2013), 98 data sets were collected from India by Gopal and Thakkar (2015), 119 data sets were collected from Malaysia by Lee et al.

(2015), and 105 data sets were collected from Malaysia by Zailani, Jeyaraman, Vengadasan, and Premkumar (2012). These statistics showed that the effective sample size of 107 cases (113 cases - 6 outliers) in this study is deemed acceptable in view of the similarities in terms of demographic and socio-cultural factors between Malaysia and other developing South East Asian countries.

4.5 Variables & Measurement

In the first part of the survey questionnaire, demographic questions such as age, gender, education level, position in the firm, length of time in the firm, and primary job scope were directed to the target respondents.

In the second part of the survey questionnaire, details of the firm such as firm age, primary industry, number of employees (reflecting firm size), status of the firm (being ISO 14001-certified or otherwise), other certifications attained (for example being certified to ISO 9001 (QMS) and/or ISO/TS 16949 (QMS specification for the automotive industry) and/or Good Manufacturing Practice (GMP) and/or HALAL (a quality standard that fulfills the Muslim Syariah law) and/or OHSAS 18001 (Occupational Health and Safety Assessment Series; according to ISO Update (2018), OHSAS 18001 is being superseded by the newly published ISO 45001 effective from year 2018) and/or Hazard Analysis and Critical Control Points (HACCP) and/or KOSHER (a food standard) and/or ISO 22000 (Food Safety Management System)).

In the last part of the survey questionnaire, the measurement items of all GSCM and EIP constructs were presented. In order to accurately measure the constructs, the questionnaire items were adopted from established past studies on GSCM and EIP which were developed by world-renowned researchers who are experts in these fields, namely Zhu et al. (2008) and Chiou et al. (2011).

The measurement items for all constructs are presented in Table 4.5 below.

Table 4.5 Measurement items for all constructs

“GSCM Practices”:

[1]“*Internal Environmental Management”*
“IEM1”: “Commitment of GSCM from senior managers.”
“IEM2”: “Support for GSCM from mid-level managers.”
“IEM3”: “Cross-functional cooperation for environmental improvements.”
“IEM4”: “Total quality environmental management.”
“IEM5”: “Environmental compliance and auditing programs.”
*“IEM6”: “ISO 14001 certification.”
*“IEM7”: “Environmental Management Systems.”

[1]“*Cooperation with Customers”*
“CC1”: “Cooperation with customers for eco design.”
“CC2”: “Cooperation with customers for cleaner production.”
“CC3”: “Cooperation with customers for green packaging.”
“CC4”: “Cooperation with customers for using less energy during product transportation.”

[1]“*Eco Design”*
“ED1”: “Design of products for reduced consumption of material/energy.”
“ED2”: “Design of products for reuse, recycle, recovery of material and/or component parts.”
“ED3”: “Design of products to avoid or reduce use of hazardous products and/or their manufacturing process.”

[1]“*Investment Recovery”*
“IR1”: “Investment recovery (sale) of excess inventories/materials.”
“IR2”: “Sale of scrap and used materials.”
“IR3”: “Sale of excess capital equipment.”

[2]*“Greening the Suppliers”*

“GS1”: “Selecting suppliers or subcontractors based on environmental criteria.”
“GS2”: “Requiring and assisting suppliers or subcontractors to obtain a third-party certification of environmental management system (EMS) such as ISO14001.”
“GS3”: “Providing environmental awareness seminars and training sessions for suppliers.”
“GS4”: “Providing environmental technical advice to suppliers and subcontractors to help them to meet environmental criteria.”
“GS5”: “Inviting suppliers to join in the early product design and development.”
“GS6”: “Sending in-house auditors to appraise the environmental performance of suppliers.”

“Green Innovation Performance”:

[2]*“Green Product Innovation”*

“GDI1”: “Using less or non-polluting/toxic materials (Using environmentally friendly materials).”
“GDI2”: “Designing or improving environmentally friendly packaging (e.g. use less paper and plastic materials) for existing and new products.”
“GDI3”: “Recovering company’s end-of-life products and recycling.”
“GDI4”: “Using eco-labeling.”

[2]*“Green Process Innovation”*

“GCI1”: “Lower consumption of energy (e.g. water, electricity, gas and petrol) during production/use/disposal.”
“GCI2”: “Recycle, reuse and/or remanufacture of materials or parts.”
“GCI3”: “Use of cleaner or renewable technology to make savings and prevent pollution (such as energy, water and waste etc.).”

[2]*“Green Managerial Innovation”*

“GMI1”: “Redesign/redefine of operation and production processes to improve environmental efficiency.”
“GMI2”: “Redesigning and improving products or services to meet new environmental criteria or directives.”

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*items were dropped from PLS-SEM path analysis due to factor loading lower than the recommended threshold of 0.7

[1] Source: adopted from Zhu et al. (2008)

[2] Source: adopted from Chiou et al. (2011)

4.6 Data Analysis Techniques

PLS-SEM was used to examine the research model because the model satisfied the rules of thumb of using PLS-SEM method (further justifications are provided as follows).

PLS-SEM using SmartPLS 3.0 was used because PLS-SEM is perfectly capable of analysing small sample sizes (Aguirre-Urreta & Marakas, 2010; Hair et al., 2016) where it is proven by Wong (2013) that 91 is the suitable minimum sample size for PLS-SEM analysis, even for extremely complicated models. It is common knowledge that it is not easy to gather large, complete and usable data from the manufacturing firms in Malaysia (Eltayeb et al., 2011). The response rate among manufacturing firms is known to be generally low worldwide (Inman, Sale, Green, & Whitten, 2011). Another edge that PLS-SEM possesses is that it does not require multivariate normal distribution to be achieved (Chin, Marcolin, & Newsted, 2003; Hew, Lee, Ooi, & Wei, 2015), thus further suggesting flexibility of this analysis technique in examining multifaceted constructs with plenty of indicators (Hew, Lee, Ooi, & Lin, 2016). Nevertheless, multivariate normality test was performed by using SPSS Statistics v22 and since the skewness and kurtosis statistics are below the recommended threshold of 3 and 10 respectively, hence, normality was established (Kline, 2011).

Table 4.6 Model Fit Results

	Saturated Model	Estimated Model
SRMR	0.072	0.074
d_ULS	4.063	4.224
d_G1	n/a	n/a
d_G2	n/a	n/a
Chi-Square	infinite	infinite
NFI	n/a	n/a

Besides this, Model Fit is acceptable since the Standardized Root Mean Square Residual (SRMR) value is below 0.08, as shown in Table 4.6 (Hu & Bentler, 1999; SmartPLS GmbH, 2018b).

Following Saunders et al. (2016), exploratory study is a study that aims to seek new insights into phenomena, to ask questions, and to assess the phenomena in a new light. Since this study showcases a one-of-a-kind model that was never before examined empirically in the Malaysian manufacturing landscape as justified in Chapter 1, hence suggesting not only the uniqueness of the model but also highlighting the scarcity of similar studies in Malaysia. Furthermore, Hair et al. (2016) further advocated that exploratory studies involve determining which independent variables are, relatively speaking, better predictors of the dependent variable. The propositions advocated by Hair et al. (2016) are very much aligned with research objective number 2 of this study. These justifications further affirm that the current study is exploratory rather than confirmatory in nature.

In a nutshell, following Hair et al. (2016), PLS-SEM was selected over covariance-based SEM because this study is exploratory rather than confirmatory in nature, and the sample size of this study also satisfied the 1:10 rule of thumb to undergo PLS path analysis.

4.6.1 Justifications of using dual-stage PLS-ANN analysis

In this study, the structural model was subsequently being examined by running artificial neural network (ANN) analysis following PLS-SEM analysis.

ANN analysis was run to complement PLS-SEM analysis. In ANN analysis, only the significant predictors were ranked according to their strength of influence on the dependent variable, EIP. The rankings were then compared to the rankings established in the initial PLS-SEM analysis. In PLS-SEM analysis, all the predictors were ranked according to their magnitude of influence on EIP. Next, sensible justifications were provided regarding the difference in rankings generated by PLS-SEM and ANN analyses. Further details and justifications of this dual-stage PLS-ANN analyses will be provided in Chapter 5.

4.7 Chapter Summary

In a nutshell, Chapter 4 laid out the research methodology of this study where descriptions on the determination of target population, study area and sampling method used, minimum sample size and adequacy of sampling results, justifications on data analysis technique and construct operationalization were provided.

CHAPTER 5

DATA ANALYSIS DISCUSSION

5.1 Foundation

CHAPTER 5 exhibits the outcomes and tabulates the results of the analysis in the researcher’s attempt to answer the research questions and examine whether the hypotheses formulated are supported or not. CHAPTER 5 will only analyze and present the 107 cases (113 cases - 6 outliers) that have been collected and fit for further PLS-SEM analysis. The descriptive statistics results would first be presented followed by the presentation and discussion of results obtained from the analyses of the measurement model and structural model. Besides this, testing of Common Method Bias (CMB) and Non-response Bias would also be discussed. Next, the effect sizes would be reviewed. Last but not least, the results obtained from Artificial Neural Network (ANN) analysis where the significant predictors are ranked according to their strength of influence on the dependent variable (EIP) and the subsequent comparison between PLS-SEM and ANN rankings would be presented. Furthermore, sensible justifications would also be provided in an attempt to explain the notable differences in the rankings. Finally, the chapter summary subsequently wraps up CHAPTER 5.

5.2 Characteristics of Demographic Profile

Following Saunders et al. (2016), descriptive statistics enable researchers to describe and compare variables numerically. Saunders et al. (2016) went on to describe the purpose of descriptive analysis is to gain an accurate profile of events, persons or situations.

The detailed analysis of the demographic background of respondents is exhibited in Table 5.1 below. The primary objective of this analysis is to provide demographic background details of respondents who participated in the survey. Table 5.1 depicts the frequency (*f*) and corresponding percentage of each demographic variable to illustrate the respondents' characteristics including gender, age group, highest education completed, length of tenure in the sampled firms, job position, and primary job scope.

Table 5.1 Demographic Background Details of Respondents

Variables	***f***	**%**
Sex		
Female	55	51.4
Male	52	48.6
Age		
26-30	16	15.0
31-35	23	21.5
36-40	19	17.8
41-45	25	23.4
> 45	24	22.4
Level of Education Completed		
Without a college degree	1	0.9
Diploma/Advanced diploma	15	14.0

Variables	***f***	**%**
Bachelor degree/Professional qualification	68	63.6
Master degree	23	21.5
Tenure with the company		
< 1 year	8	7.5
1-2	17	15.9
3-5	26	24.3
6-10	21	19.6
11-20	19	17.8
> 20	16	15.0
Position with the company		
Executive	42	39.3
Manager/HOD	36	33.6
GM/Director/CEO	4	3.7
ISO14001 Representative/PIC	21	19.6
ISO9001 Representative/PIC	4	3.7
Primary job scope		
Production	6	5.6
Sales/Marketing	2	1.9
Administration	4	3.7
Environmental, health & safety (EHS)	40	37.4
Document control	3	2.8
Internal audit	1	0.9
Other (Management system)	1	0.9
Finance	1	0.9
HR	9	8.4
Procurement/Purchasing	1	0.9
Quality assurance (QA)	19	17.8
Facilities	4	3.7
Design Team	1	0.9
Others*	15	14.0

*Respondents involved in more than one job scopes

As shown in Table 5.1, the two gender groups are almost evenly distributed with 51.4% of females and 48.6% of males. The percentage of females is only 2.8% higher compared to their male counterparts. A majority of the respondents (i.e. 63.6%) are above 35 years old, with 17.8%, 23.4% and 22.4% of the respondents being in the age groups of between 36 and 40 years of age, between 41 and 45 years of age, and above 45 years of age respectively. Only 36.5% of the respondents are aged 35 years old and below, with 15% and 21.5% of them being in the age groups of 26 – 30 years old and 31 – 35 years old respectively. Regarding the highest education completed, a high proportion of the respondents possess a Bachelor degree or professional qualification and above, with 63.6% of the respondents having a Bachelor degree or professional qualification and 21.5% of them possessing a Master degree. A minority of the respondents have no college degree (i.e. 0.9%) whereas the remaining 14% of the respondents are equipped with a Diploma or Advanced Diploma. As for the length of time with the company, respondents who have been working for the sampled firms for 6 years and above have a simple majority (i.e. 52.4%) over the respondents who have been with the firms for 5 years and below (i.e. 47.6%). As shown in Table 5.1, there are 19.6%, 17.8% and 15% of the respondents who have been with the sampled firms for 6 - 10 years, 11 - 20 years and above 20 years respectively whereas 7.5%, 15.9% and 24.3% of the respondents have been working for the sampled firms for less than 1 year, 1 – 2 years, and 3 – 5 years respectively. Table 5.1 further shows that 100% of the respondents are at the executive level and above, with 39.3% of the respondents being executives (for example senior accountants, senior engineers, system analysts, staff engineers, assistant managers and so on), 33.6% of the respondents occupying the position of Manager or Head of Department, and only 3.7% of them occupy the post of Director or General Manager or Chief

Executive Officer. The balance 23.3% of the respondents are either ISO 14001 or ISO 9001 Person-in-charge, specifically 19.6% of them are ISO 14001 Person-in-charge whereas 3.7% of them are ISO 9001 Person-in-charge. As for primary job scope, the highest percentage of respondents (i.e. 37.4%) are working in the Environmental, health and safety (EHS) department whereas the second highest percentage of respondents (i.e. 17.8%) are attached to the Quality Assurance (QA) department. The remaining 5.6%, 1.9%, 3.7%, 2.8%, 0.9%, 0.9%, 0.9%, 8.4%, 0.9%, 3.7%, and 0.9% are involved in the functions of Production, Sales/Marketing, Administration, Document Control, Internal Audit, Management System, Finance, Human Resource, Procurement/Purchasing, Facilities, and Design Team respectively. It is worth noting that 14% of the respondents are involved in other departments which are not explicitly listed in the survey questionnaire. These “others” functions include Compliances (Regulatory), Technical matters, Lean Six Sigma Coordinator, and System Management and Customer Technical Services.

5.3 Characteristics of Company’s Profile

The detailed analysis of the company profile of sampled firms is presented in Table 5.2 below. The primary objective of performing this analysis is to provide demographic details regarding the company background information of respondents who participated in the survey. Table 5.2 depicts the frequency and corresponding percentage of each demographic variable to illustrate the company background of respondents including category of organizations, types of organizations, number of employees (reflecting firm size), status of organizations (i.e. whether the firms are being ISO14001-certified or not) and type of ownership of the firms.

Table 5.2 Firms' Profile

Variables	***f***	**%**
Firm Category		
Manufacturing	107	100.0
Firm Type		
Electrical & electronics products	35	32.7
Cement & cement-related products	4	3.7
Computer, IT & technological products	3	2.8
Paper and paper products	1	0.9
Primary & fabricated metal products	9	8.4
Furniture and related products	2	1.9
Textiles & textile products	3	2.8
Solder products	2	1.9
Medical devices and/or equipment	2	1.9
Female sanitary products	1	0.9
Pottery, china & earthenware	1	0.9
Printing and reproduction of recorded media	1	0.9
Toiletries products	1	0.9
Food & beverage products	3	2.8
Rubber products	4	3.7
Machinery & hardware	2	1.9
Wood & sawmill	2	1.9
Transportation equipment	2	1.9
Chemical products	5	4.7
Metal stamping products	1	0.9
Plastic products	10	9.3
Glass & glass products	1	0.9
Motor vehicles	1	0.9
Other products manufactured	11	10.3
Number of employees		
201 - 500	46	43.0
501 – 1000	24	22.4
1001 - 2000	26	24.3

Variables	***f***	**%**
2001 – 5000	9	8.4
More than 5000	2	1.9
Status of organization		
ISO certified (i.e. ISO14001)	107	100
Ownership		
Foreign owned company (MNC)	70	65.4
Government-linked company (GLC)	1	0.9
Local private family owned company (Not publicly-listed on Bursa Malaysia)	25	23.4
Local private company (Publicly-listed on Bursa Malaysia)	6	5.6
Joint venture with foreign company/companies	5	4.7

As shown in Table 5.2, 100% of the sampled firms are manufacturers. Most number of sampled firms (i.e. 32.7%) are from the electrical and electronics industry whereas 57% of the sampled firms are involved in the manufacturing of cement and cement-related products, computer, IT and technological products, paper and paper products, primary and fabricated metal products, furniture and related products, textiles and textile products, solder products, medical devices and/or equipment, female sanitary products, pottery, china and earthenware, printing and reproduction of recorded media, toiletries products, food and beverage products, rubber products, machinery and hardware, wood and sawmill, transportation equipment, chemical products, metal stamping products, plastic products, glass and glass products, and motor vehicles. The specific percentage for each industry is being tabled out in Table 5.2. The balance 10.3% of the sampled firms manufacture “other” products which are not explicitly listed out in the survey questionnaire. These “other” products include quarry (manufacture of other non-metallic mineral products such as premix, aggregates, and asphaltic concrete wearing course (ACWC)), rare earth products, palm oil refining and palm kernel crushing, bearings, gears, gearing and driving elements (manual racks and pinion steering gears) and power racks, games and toys, copper rod and wire, refrigeration products such as freezer and chillers, stationery, magnetic products, air-conditioners components and assembly for furniture parts, parts and accessories for motor vehicles and their engines such as air conditioners, laminated leaf springs, and radiator, automotive parts and components, protection film/tape, recycling and recovering of scheduled wastes, tobacco products such as tobacco and cigarettes, and solar cells. Following Doidge, Kahle, Karolyi, and Stulz (2018), Lee and How (2018), Mueller, Ouimet, and Simintzi (2017), and Robinson and Simmons (2018), number of employees reflect firm size. Furthermore, following Hasan and Jandoc (2010), since all of the sampled firms are well above 200 employees, hence all of the firms are large, with a majority of the sampled firms (i.e. 57%) having over 500 employees. Specifically, 22.4%, 24.3%, 8.4% and 1.9% of the sampled firms have 501 – 1000 employees, 1001 – 2000 employees, 2001 – 5000 employees and over 5000 employees respectively. The remaining 43% of the participating firms have 201 – 500 employees. Besides this, it is also noteworthy that 100% of the sampled firms are certified with ISO 14001. Furthermore, a majority of the participating firms (i.e. 65.4%) are foreign owned companies (also known as Multinational Corporations (MNC)) whereas the second highest percentage (i.e. 23.4%) denotes local private family owned companies which are not publicly-listed on Bursa Malaysia. The remaining participating firms are joint venture with foreign company/companies (i.e. 4.7%), local private companies which are publicly-listed on Bursa Malaysia (i.e. 5.6%), and government-linked company (GLC) (i.e. 0.9%).

5.4 Descriptive Statistics

Table 5.3 Descriptive Analysis of Variables (n = 107)

Constructs	**Mean**	**SD**	**Minimum**	**Maximum**
GSCM				
Internal Environmental Management	6.6822	0.5834	4.00	7.00
Investment Recovery	6.4984	0.6433	5.00	7.00
Eco Design	6.4548	0.7708	4.00	7.00
Cooperation with Customers	6.4042	0.7707	4.00	7.00
Greening the Suppliers	6.1994	0.7876	3.67	7.00
Green Innovation Performance	6.5317	0.6368	4.33	7.00
Green Product Innovation	6.5117	0.6733	4.50	7.00
Green Process Innovation	6.5452	0.6641	4.00	7.00
Green Managerial Innovation	6.5514	0.6657	4.00	7.00

The main objective of performing a descriptive analysis of the constructs is to obtain an overall understanding with regards to the GSCM-EIP relationships among the sampled firms. Table 5.3 revealed that the mean score generated for the GSCM practices ranged from 6.1994 (GS) to 6.6822 (IEM), showing that the implementation of GSCM practices in the sampled firms is rather high. IEM, with a minimum value captured at 4.00 and a maximum value captured at 7.00, is the GSCM practice that reported the highest mean score. This implies that the support and commitment from the top and middle level management teams, coupled with a robust environmental management system (including being certified to ISO 14001) and effective cross-functional collaboration clearly play a vital role in the GSCM dimension. Meanwhile, GS has the lowest mean score among the five GSCM practices, with the smallest value captured at 3.67 and the largest value captured at 7.00. This can be deduced that greening the upstream supply chain partners is the weakest construct among the five GSCM practices. However, the mean score of 6.1994 is still considered to be well above average, which implies that GS is an important, if not indispensable GSCM practice that should not be overlooked.

5.5 Testing of Common Method Bias

Tan, Ooi, Chong, and Hew (2014, p.298) described Common Method Bias (CMB) as “the overlapping between two variables due to high correlations between the underlying constructs”. Following Podsakoff, MacKenzie, Lee, and Podsakoff (2003), CMB may exist if responses are gathered from a single source of respondents for both independent and dependent variables.

After reviewing the empirical evidence on the impact of method bias on covariation between constructs as well as item validity and reliability, MacKenzie and Podsakoff (2012, p.10.27) have reached a conclusion that “the evidence shows that method biases can significantly influence item validities and reliabilities as well as the covariation between latent constructs. This suggests that researchers must be knowledgeable about the ways to control method biases that might be present in their studies”.

In this study, following Podsakoff et al. (2003), both procedural and statistical remedies were employed in the researcher’s attempt to control any potential CMB issue. As for procedural remedies, the researcher used simple and easily understandable English language in framing the questionnaire items, the descriptions of questionnaire items used to measure the constructs were highly concise, the anonymity of respondents is 100% guaranteed, and the respondents were given reasonable assurance that there were no right or wrong responses and all responses would be kept strictly confidential. These procedural remedies are in line with the procedural remedies implemented by Hew et al. (2016).

As for statistical remedies, following Hew, Tan, Lin, and Ooi (2017), the researcher used a two-step approach to evaluate the severity of CMB issue in this study. The traditional Harman's single factor test was first conducted and the cumulative percentage yielded was 52.511%, which is slightly higher than the recommended threshold of 50% (Hew et al., 2015). Substantive testing was performed by using common method bias analysis (run on SmartPLS 3.0 software) endorsed by Hew et al. (2017), Lee and Scott (2015) and Liang, Saraf, Hu, and Xue (2007) to further examine CMB in this study.

In other words, in order to provide a more comprehensive and holistic assessment on the CMB issue, further confirmation was conducted through common method factor analysis and correlation analysis. The results from the common method factor analysis (Table 5.4) showed that the substantive factor loadings are significant and substantially larger than then method factor loadings (Liang et al., 2007). Furthermore, most of the method factor loadings are either negative or having very small values and are mostly insignificant (Hew et al., 2017). Based on the ratio of the substantive variance to the method variance of 52:1, it can be concluded that there is no CMB issue (Hew et al., 2017). Besides the statistical remedies, robust procedural remedies (as detailed out in the third paragraph of section 5.5) were also performed. Based on the procedural and statistical remedies, the CMB problem has been successfully ruled out (Hew et al., 2017).

Table 5.4 Common method factor analysis

Constructs	Indicators	Substantive factor loading (R1)	R1 square	Method factor loading (R2)	R2 square
CC	CC1	0.7900***	0.6241	0.1185	0.0140
	CC2	0.9781***	0.9567	-0.0276	0.0008
	CC3	1.0307***	1.0623	-0.1377	0.0190
	CC4	0.8310***	0.6906	0.0489	0.0024
ED	ED1	1.0505***	1.1036	-0.1075$^{(*)}$	0.0116
	ED2	0.8665***	0.7508	0.1085$^{(*)}$	0.0118
	ED3	0.9353***	0.8748	-0.0037	0.0000
GCI	GCI1	0.9989***	0.9978	-0.0733	0.0054
	GCI2	1.0892***	1.1864	-0.1702$^{(*)}$	0.0290
GDI	GDI2	0.9131***	0.8338	0.0109	0.0001
	GDI3	1.0332***	1.0675	-0.1509	0.0228
	GDI4	1.0313***	1.0636	-0.1497	0.0224
GMI	GMI1	1.0301***	1.0611	-0.0532	0.0028
	GMI2	0.9405***	0.8845	0.0525	0.0028
GS	GS2	1.0199***	1.0402	-0.1535	0.0236
	GS3	0.9939***	0.9878	-0.1671*	0.0279
	GS4	0.8392***	0.7043	0.0493	0.0024
	GS5	0.8237***	0.6785	-0.0119	0.0001
	GS6	0.7522***	0.5658	-0.0207	0.0004
IEM	IEM1	0.9862***	0.9726	-0.0742	0.0055
	IEM2	1.0039***	1.0078	-0.1061*	0.0113
	IEM3	0.9253***	0.8562	0.0308	0.0009
	IEM4	0.8587***	0.7374	0.0558	0.0031
	IEM5	0.7698***	0.5926	0.1011	0.0102
IR	IR1	0.8692***	0.7555	0.0277	0.0008
	IR2	0.8375***	0.7014	0.0223	0.0005
	IR3	0.8451***	0.7142	-0.0544	0.0030
AVG		**0.8970**	**0.8212**	**0.0003**	**0.0158**

Notes:

1. IEM6, IEM7, GCI3, GDI1 & GS1 were dropped due to their poor loading on EIP.

2. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{(*)}p<0.10$.

Out of a total of 32 measurement items, 5 items (IEM6, IEM7, GCI3, GDI1 & GS1) were excluded from PLS path analysis due to their factor loading being lower than the recommended threshold of 0.7 (Yu, 2012). The total number of measurement items has subsequently been reduced to 27.

5.6 Measurement Model Analysis

Henseler (2017) denotes that the measurement model quantifies and work out the relationship between the latent constructs and the associated indicators. Therefore, the composite reliability, discriminant validity and convergent validity must first be assessed in order to confirm the adequacy of the measurement model before subsequent PLS-SEM analysis could be performed (Aboelmaged, 2018).

5.6.1 Convergent Validity and Reliability

According to Saunders, Lewis, and Thornhill (2009), reliability refers to the extent to which the data collection technique or analysis procedure will yield consistent findings or results despite numerous attempts or in multiple trials or on other occasions. Following Hair, Ringle, and Sarstedt (2011), factor loadings should exceed 0.70 in order to ensure indicator reliability and composite reliability should be above 0.70 in order to ensure internal consistency reliability. Besides this, Cronbach’s alpha also famously serves as an indicator of reliability (Vaske, Beaman, & Sponarski, 2017) and a measurement model is considered to have established reliability if the Cronbach’s alpha values for all constructs exceeded the cut-off point of 0.7 (Nunnally, 1978).

On the other hand, according to Hair et al. (2011), convergent validity denotes the measurement of the degree of convergence of measurement items of a construct. Tan et al. (2014, p.299) further illustrate convergent validity as “the capability of a construct to yield the same results even though different approaches are engaged”. In this study, convergent validity was assessed based on the three main criteria established by Fornell and Larcker (1981):

(a) The factor loadings of all items must exceed 0.50
(b) The composite reliability values for all constructs must exceed 0.70
(c) The average variance extracted (AVE) values must exceed 0.50

Hair et al. (2016) connoted that the measurement of convergent validity is derived from AVE; while AVE “equals the average proportion of variance explained of each reflective indicator of a latent variable” (Henseler, 2017, p.185). The rightmost column of Table 5.5 reports the AVE values for all constructs, in which IEM = 0.8292; CC = 0.8251; IR = 0.7229, ED = 0.9026; GS = 0.7033; GDI = 0.8084; GCI = 0.8397; and GMI = 0.9703. Since the AVE values for all constructs exceeded the recommended threshold of 0.50, therefore, it is confirmed that convergent validity is well-established (Fornell & Larcker, 1981; Hair et al., 2011).

Composite reliability, on the other hand, does not only serve as a strong indicator for reliability, but also signify convergent validity when the composite reliability value exceeds the recommended threshold of 0.7 (Bagozzi, & Yi, 1988; Fornell & Larcker, 1981; Nunnally & Bernstein, 1994). The fifth column of Table 5.5 reports the composite reliability values for all constructs, in which IEM = 0.9604; CC = 0.9496; IR = 0.8865, ED = 0.9653; GS = 0.9340; GDI = 0.9440; GCI = 0.9401; and GMI = 0.9849. Since the composite reliability values for all constructs exceeded the recommended threshold of 0.70, hence, it can be further confirmed that both reliability and convergent validity have been established (Bagozzi, & Yi, 1988; Fornell & Larcker, 1981; Nunnally & Bernstein, 1994). In other words, where reliability is concerned, the internal consistency in this study is high because the values of composite reliability for all constructs exceed the recommended threshold of 0.70 (Hair et al., 2011).

Besides composite reliability, Cronbach's alpha also famously serves as an indicator of reliability (Vaske et al., 2017) and a measurement model is considered to have established reliability if the Cronbach's alpha values for all constructs exceeded the cut-off point of 0.7 (Nunnally, 1978). However, it is worth noting that composite reliability is a more appropriate indicator of reliability for PLS-SEM analysis when juxtaposed with Cronbach's alpha because all indicators are not assumed to be equally reliable in composite reliability analysis (Hair et al., 2011). Nevertheless, the fourth column of Table 5.5 demonstrated that the Cronbach's alpha values for all constructs are well above the recommended cut-off point of 0.7 (Nunnally, 1978), in which IEM = 0.9481; CC = 0.9290; IR = 0.8074, ED = 0.9460; GS = 0.9149; GDI = 0.9209; GCI = 0.9040; and GMI = 0.9694. Since the Cronbach's alpha values for all constructs exceeded the recommended threshold of 0.70, hence, it can be concluded that reliability has been well-established (Nunnally, 1978; Nunnally & Bernstein, 1994).

Table 5.5 Reliability and Convergent Validity

Constructs	**Scale Type**	**Loadings**	**Cronbach's alpha**	**Composite Reliability**	**AVE**
First Order Factors					
Internal Environmental Management (IEM)	Reflective		0.9481	0.9604	0.8292
IEM1		0.9255			
IEM2		0.9175			
IEM3		0.9503			
IEM4		0.9040			
IEM5		0.8527			
Cooperation with Customers (CC)	Reflective		0.9290	0.9496	0.8251
CC1		0.8966			
CC2		0.9535			
CC3		0.9063			
CC4		0.8752			
Investment Recovery (IR)	Reflective		0.8074	0.8865	0.7229
IR1		0.8915			
IR2		0.8535			
IR3		0.8034			
Eco Design (ED)	Reflective		0.9460	0.9653	0.9026
ED1		0.9570			
ED2		0.9617			
ED3		0.9312			
Greening the Suppliers (GS)	Reflective		0.9149	0.9340	0.7033
GS2		0.8969			
GS3		0.8611			
GS4		0.8802			

Constructs	**Scale Type**	**Loadings**	**Cronbach's alpha**	**Composite Reliability**	**AVE**
GS5		0.8112			
GS6		0.7288			
Second Order Factors					
Green Product Innovation (GDI)	Reflective		0.9209	0.9440	0.8084
GDI2		0.9263			
GDI3		0.8939			
GDI4		0.8934			
Green Process Innovation (GCI)	Reflective		0.9040	0.9401	0.8397
GCI1		0.9330			
GCI2		0.9397			
Green Managerial Innovation (GMI)	Reflective		0.9694	0.9849	0.9703
GMI1		0.9849			
GMI2		0.9852			

As shown in the third column of Table 5.5, the factor loadings of all items were well above the acceptable cut-off point of 0.50 (Fornell & Larcker, 1981). This indicated that more than one-half of the variance of the indicators have been accounted for (Avkiran, 2018). Furthermore, when there is a second order factor in the research model, according to Chin (1998) and Van Riel, Henseler, Kemény, and Sasovova (2017), the convergent validity of the first order factors needs to be established first by assessing the strength of PLS outer loadings of the first order factors (GDI, GCI and GMI) on the second order factor (EIP). Table 5.6 aptly demonstrated that all first order factors (GDI, GCI, and GMI) load very highly on the second order factor (EIP). Therefore, it is confirmed that convergent validity has been well-established following Grappi, Romani, and Barbarossa (2017).

Table 5.6 PLS loadings on EIP

Second Order Construct	First Order Constructs	PLS outer loadings	T-Statistics
EIP	GDI	0.9551	80.8297***
	GCI	0.9619	83.0423***
	GMI	0.9352	41.0136***

Note: all loadings are significant at $p < 0.001$; EIP = Green innovation performance; GDI = Green product innovation; GCI = Green process innovation; GMI = Green managerial innovation

In line with the theoretical considerations laid out in Chapter 2, here are two empirical considerations to prove and validate that EIP is indeed a reflective model (Diamantopoulos & Siguaw, 2006).

The first empirical consideration posits that all EIP items must be highly correlated and interchangeable (Diamantopoulos & Siguaw, 2006), in terms of displaying high and positive intercorrelations (Wong, 2013). Table 5.5 has clearly demonstrated that both reliability and internal consistency for EIP are high (>0.70); and the factor loadings of all EIP items have surpassed the recommended threshold of 0.50. Besides this, the AVE values of all EIP constructs (GDI, GCI and GMI) were well above the recommended cut-off point of 0.50. Hence, following Diamantopoulos and Siguaw (2006), Fornell and Larcker (1981), Hair et al. (2011), Nunnally (1978), Nunnally and Bernstein (1994), the first empirical consideration has been successfully fulfilled.

According to Diamantopoulos and Siguaw (2006), the second empirical consideration posits that all items must have identical sign with the construct besides sharing significant relationships with the construct. Table 5.6 clearly demonstrated that all of the EIP dimensions (i.e. GDI, GCI, and GMI) have positive sign, load very highly on EIP and are significant on the second order construct (EIP) at confidence level 0.1%, therefore further confirming convergent validity. Furthermore, Table 5.8 also clearly showed that the value of indicator loading of every construct very well surpassed all of the other cross loadings except for GCI3 which loaded on GCI at a value of 0.8750, which is marginally lower compared to the occasion when GCI3 loaded on GMI at a value of 0.8981, with a marginal difference of only 0.0231. Hence, heterotrait-monotrait (HTMT) inference test was performed as a substantive test for discriminant validity. According to Henseler et al. (2015), HTMT inference test is a superior approach in assessing discriminant validity. Since the fifth and sixth columns of Table 5.9 clearly demonstrated that the HTMT inference test values in the lower and higher bounds columns are significantly below 1.0, therefore, it is confirmed that discriminant validity has been well-established (Hair et al., 2011; Henseler et al., 2015; Sarstedt, Ringle, & Hair, 2017). In a nutshell, the second empirical consideration is fulfilled and hence further confirming that EIP is a reflective model.

5.6.2 Discriminant Validity

According to Hair et al. (2016, p.316), discriminant validity denotes “the extent to which a construct is truly distinct from other constructs, in terms of how much it correlates with other constructs, as well as how much indicators represent only a single construct”. Following Fornell and Larcker (1981) and Hair et al. (2011), the discriminant validity of a reflective measurement model can be confirmed when the $\sqrt{\text{AVE}}$ of all constructs surpass all the other inter-correlations and the loading of any indicator should far exceed all of its cross loadings. Table 5.7 has clearly demonstrated that all of the values of $\sqrt{\text{AVE}}$ (the on-diagonal values) are well above the other inter-correlations (the off-diagonal values). Besides this, Table 5.8 also clearly showed that a construct's indicator loading very well surpassed the cross loadings of all the other constructs. Furthermore, heterotrait-monotrait (HTMT) inference test was performed as a substantive test for discriminant validity. According to Henseler et al. (2015), HTMT inference test is a superior approach in assessing discriminant validity. Since the fifth and sixth columns of Table 5.9 clearly demonstrated that the HTMT inference test values in the lower and higher bounds columns are significantly below 1.0, therefore, it is confirmed that discriminant validity is well-established (Hair et al., 2011; Henseler et al., 2015; Sarstedt, Ringle, & Hair, 2017).

Table 5.7 Discriminant Validity Test Results

	CC	ED	GCI	GDI	GMI	GS	IEM	IR
CC	***0.9084***							
ED	0.8320	***0.9501***						
GCI	0.6662	0.7138	***0.9164***					
GDI	0.7134	0.7441	0.8627	***0.8991***				
GMI	0.6851	0.6551	0.8950	0.8208	***0.9850***			
GS	0.7055	0.5611	0.6210	0.6430	0.6707	***0.8386***		
IEM	0.6590	0.6724	0.6024	0.6419	0.5771	0.4271	***0.9106***	
IR	0.6502	0.6734	0.5698	0.6262	0.5185	0.4613	0.7624	***0.8502***

Note: On-diagonal values represent $\sqrt{\text{AVE}}$ whereas off-diagonal values represent inter-correlations

Table 5.8 PLS-SEM Loadings and Cross-Loadings

	CC	ED	GCI	GDI	GMI	GS	IEM	IR
CC1	***0.8966***	0.7840	0.6440	0.6414	0.6027	0.6338	0.6340	0.6298
CC2	***0.9535***	0.7980	0.6271	0.6848	0.6589	0.6426	0.6094	0.6443
CC3	***0.9063***	0.7254	0.5477	0.6430	0.5978	0.6157	0.5864	0.5157
CC4	***0.8752***	0.7120	0.5987	0.6211	0.6280	0.6715	0.5631	0.5666
ED1	0.7408	***0.9570***	0.6725	0.7117	0.5910	0.4588	0.6476	0.6652
ED2	0.8016	***0.9617***	0.7383	0.7281	0.6375	0.5616	0.6803	0.6998
ED3	0.8301	***0.9312***	0.6191	0.6797	0.6388	0.5791	0.5853	0.5489
GCI1	0.6151	0.6751	***0.9330***	0.7936	0.7805	0.5030	0.5647	0.5730
GCI2	0.5596	0.6286	***0.9397***	0.8007	0.7805	0.5724	0.5041	0.5127
GDI2	0.6957	0.6652	0.8026	***0.9263***	0.8300	0.6172	0.5412	0.5272
GDI3	0.5760	0.6706	0.7715	***0.8939***	0.6284	0.5275	0.5502	0.6296
GDI4	0.5941	0.6168	0.7473	***0.8934***	0.6715	0.5676	0.5664	0.5501
GMI1	0.6505	0.6344	0.8967	0.7848	***0.9849***	0.6321	0.5660	0.5021
GMI2	0.6990	0.6560	0.8667	0.8319	***0.9852***	0.6890	0.5709	0.5192
GS2	0.6056	0.4350	0.4748	0.5275	0.5289	***0.8969***	0.2857	0.3514
GS3	0.4870	0.4231	0.4634	0.5448	0.4659	***0.8611***	0.2991	0.3281
GS4	0.6010	0.5512	0.6114	0.5417	0.6191	***0.8802***	0.3616	0.4446
GS5	0.5453	0.4064	0.4612	0.4934	0.5862	***0.8112***	0.4026	0.3587
GS6	0.5214	0.3994	0.4368	0.4241	0.4695	***0.7288***	0.3156	0.3579
IEM1	0.5829	0.5475	0.5407	0.5872	0.5344	0.3841	***0.9255***	0.6551
IEM2	0.5322	0.5202	0.5487	0.5572	0.5636	0.3673	***0.9175***	0.6640
IEM3	0.6249	0.6756	0.5530	0.6240	0.5645	0.4106	***0.9503***	0.7575
IEM4	0.6508	0.6597	0.5692	0.5629	0.5155	0.4054	***0.9040***	0.6783
IEM5	0.6098	0.6586	0.5315	0.5900	0.4451	0.3764	***0.8527***	0.7149
IR1	0.5854	0.6040	0.5280	0.5349	0.4986	0.4195	0.7077	***0.8915***
IR2	0.5493	0.6390	0.4798	0.5625	0.3778	0.3309	0.7310	***0.8535***
IR3	0.5218	0.4697	0.4422	0.5000	0.4434	0.4273	0.4969	***0.8034***

Table 5.9 HTMT inference test (with bootstrapping)

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.50% (Lower bound)**	**97.50% (Higher bound)**
CC -> EIP	-0.0200	-0.0060	0.0130	-0.2890	0.2330
ED -> EIP	0.4020	0.3870	-0.0150	0.1150	0.7570
EIP -> GCI	0.9620	0.9640	0.0020	0.9340	0.9800
EIP -> GDI	0.9550	0.9580	0.0030	0.9290	0.9740
EIP -> GMI	0.9350	0.9380	0.0020	0.8830	0.9720
GS -> EIP	0.3620	0.3730	0.0110	0.1860	0.5390
IEM -> EIP	0.2170	0.2040	-0.0130	-0.0010	0.4370
IR -> EIP	0.0190	0.0200	0.0010	-0.2200	0.2480

5.7 Analysis of the Structural Model

Once the reliability, convergent validity and discriminant validity of the measurement model have been established, the researcher proceeded to evaluate the structural model by performing PLS-SEM analysis. The analysis was run on SmartPLS 3.0 statistical software. The structural model as demonstrated in Figure 5.1 was evaluated by testing for construct collinearity, evaluating the significance and relevance of the structural model relationships, determining the Coefficient of Determination (R^2), Path Coefficients, Predictive Relevance (Q^2) and Effect Sizes. After running PLS-SEM analysis, Artificial Neural Network (ANN) analysis which greatly complemented PLS-SEM analysis was subsequently performed where only the significant predictors were ranked. The rankings resulted from PLS-SEM and ANN analyses were then compared and sensible justifications were provided in the researcher's attempt to explain the notable differences in terms of rankings of significant predictors.

5.7.1 Multicollinearity Testing

According to Cohen, West, and Aiken (2014), there might be multicollinearity problem when the correlations between two or more predictor variables are high and multicollinearity problem poses the risk of adversely affecting the outcome/results of regression analysis. Hence, multicollinearity test was conducted to ascertain whether the correlations are high among predictor variables in order to avoid repeated results (Goodhue, Lewis, & Thompson, 2017). Following Latan et al. (2018), the Variance Inflation Factor (VIF) values served as an indicator in assessing multicollinearity. As a rule of thumb to rule out multicollinearity problem, the VIF values of all predictor variables must be below 5.0 (Ping, Yeang, & Muthuveloo, 2017; Rosso at al., 2017; Teoh, Lee, & Muthuveloo, 2017; Thien, Shafaei, & Rasoolimanesh, 2018). Since Table 5.10 has clearly demonstrated that the VIF values of all predictor variables are well-below the cut-off point of 5.0, hence, multicollinearity problem has been successfully ruled out in this study.

Table 5.10 Multicollinearity Testing

Construct	**Standardized Coefficients (Model 1: EIP)**	**Collinearity Statistics**
Constant	β	VIF
IEM	0.2171(*)	2.7621
CC	-0.0195	4.7250
IR	0.0190	2.7319
ED	0.4020*	3.6988
GS	0.3618***	2.0143

a. Dependent Variable: Model 1 = EIP
Note: EIP = Green innovation performance; IEM = Internal environmental Management; CC = Cooperation with customer; IR = Investment recovery; ED = Eco design; GS = Greening the supplier

5.7.2 Structural Model Evaluation

Following Avkiran (2018) and Hair, Sarstedt, Hopkins, and Kuppelwieser (2014), a bootstrapping routine with 5000 sub-samples was run by using SmartPLS 3.0 software in order to determine the path coefficients, t-statistics and p-values of the relationships between GSCM practices and EIP as shown in Figure 5.1 below. The PLS-SEM analysis was conducted in order to answer the first two research questions as indicated as follows:

RQ (1): Which GSCM practice(s) (i.e. IEM, CC, IR, ED, and GS) determine EIP among large Malaysian manufacturers that are certified with ISO 14001?

RQ (2): Is the relationship between GSCM practices and EIP significant and positive among large Malaysian manufacturers that are certified with ISO 14001?

Table 5.14 has clearly demonstrated that the dimensions of IEM, CC, IR, ED, and GS explained 68.18% (R^2 value) of EIP. Hence, this has proven that the selected GSCM practices indeed are capable of predicting EIP.

Furthermore, the PLS-SEM results as shown in Table 5.11 have demonstrated that IEM ($\beta = 0.2171$, $p < 0.10$); ED ($\beta = 0.4020$, $p < 0.05$); and GS ($\beta = 0.3618$, $p < 0.001$) have significant relationship with EIP, with ED showcasing the strongest association. Hence, H1, H3, and H5 were very well supported. On the other hand, the dimensions of CC ($\beta = -0.0195$, $p > 0.05$) and IR ($\beta = 0.0190$, $p > 0.05$) did not have a significant relationship with EIP. With this, H2 and H4 were found not to be supported. To address RQ1 and RQ2, this study found that three out of five GSCM practices, namely IEM, ED, and GS influenced EIP significantly and positively.

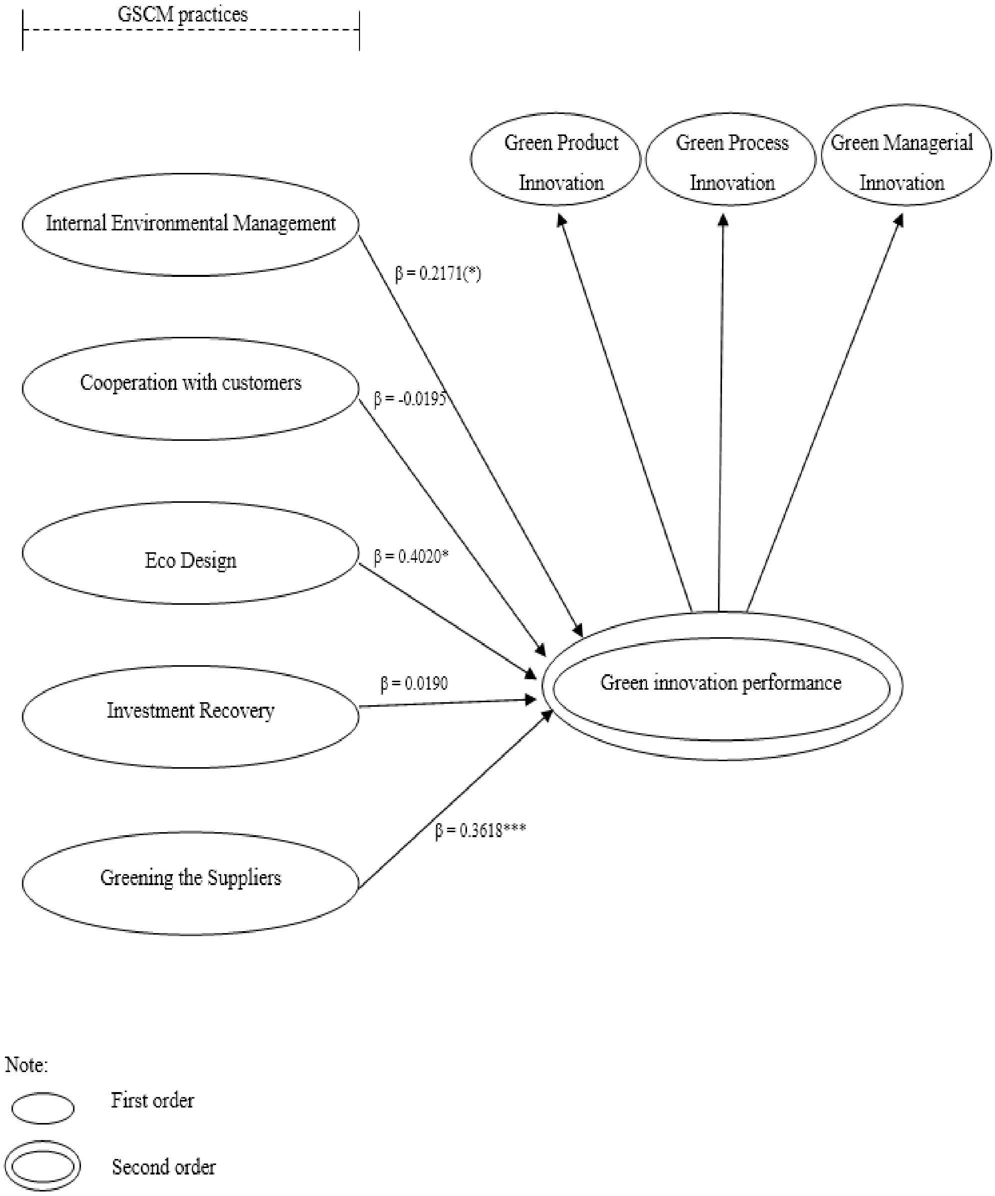


Figure 5.1 The relationship between GSCM and EIP

Table 5.11 Hypotheses Testing (PLS-SEM Results)

Hypo.	Path	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P Values	Supported
H1	**IEM →EIP**	**0.2171**	**0.2141**	**0.1117**	**1.9430**	**0.0521(*)**	**Yes**
H2	CC→ EIP	-0.0195	-0.1086	0.0846	0.2310	0.8173	No
H3	**ED→ EIP**	**0.4020**	**0.3925**	**0.1643**	**2.4466**	**0.0145***	**Yes**
H4	IR→ EIP	0.0190	0.0997	0.0755	0.2517	0.8013	No
H5	**GS→ EIP**	**0.3618**	**0.3715**	**0.0933**	**3.8778**	**0.0001*****	**Yes**

Note: $p < 0.001$***; $p < 0.05$*; $p < 0.10$(*) where $t > 3.291$; $1.96 < t < 2.58$; $1.645 < t < 1.96$

5.7.3 Coefficient of Determination (R^2)

According to Henseler (2017), the Coefficient of Determination (R^2 value) of an endogenous variable act as a starting point to evaluate a structural model by quantifying the percentage of variance of an endogenous variable that is explained by the exogenous variables. Henseler (2017) further posits that R^2 value generally lies between 0 and 1 (i.e. from 0% to 100%). A higher R^2 value generally denotes a stronger predictive power of the exogenous variables in explaining the proportion of variance of an endogenous variable (Ho, 2018). R^2 results obtained from Table 5.14 has clearly demonstrated that the dimensions of IEM, CC, IR, ED, and GS explained 68.18% of EIP. Hence, this has proven that the selected set of GSCM practices indeed possess relatively high predictive power in predicting EIP.

5.7.4 Path Coefficients

Table 5.12 has clearly displayed the path coefficients of all constructs.

Table 5.12 Path Coefficients of Constructs

	IEM	CC	IR	ED	GS	EIP
IEM						**0.2171(*)**
CC						-0.0195
IR						0.0190
ED						**0.4020***
GS						**0.3618*****
EIP						N/A

Note: $p < 0.001$***; $p < 0.05$*; $p < 0.10$(*)

Table 5.12 clearly demonstrated that IEM ($\beta = 0.2171$, $p < 0.10$); ED ($\beta = 0.4020$, $p < 0.05$); and GS ($\beta = 0.3618$, $p < 0.001$) have positive and significant direct impact on EIP. On the other hand, CC ($\beta = -0.0195$, $p > 0.05$) and IR ($\beta = 0.0190$, $p > 0.05$) have relatively weak and insignificant direct path effects on EIP.

5.7.5 Predictive Relevance (Q^2)

According to Vinzi, Chin, Henseler, and Wang (2010), the Q^2 test which was famously developed by Stone (1974) and Geisser (1975), is used together with the Coefficient of Determination (R^2) test with the objective of evaluating the predictive relevance of endogenous variables. The Q^2 test serves as an indicator to show how well the parameter estimates and the extent of observed values being reproduced by a model (Vinzi et al., 2010). Regarding the measurement values of Q^2, Wong (2013, p.27) posited that "a value of 0.02, 0.15 and 0.35 signify that an exogenous construct has a small, medium, or large predictive relevance for a selected endogenous construct". SmartPLS GmbH (2018a) further denoted this as the blindfolding approach which can be employed to compute the Q^2 value in PLS-SEM analysis. Hair et al. (2016) further recommended the usage of cross-validated redundancy (1-SSE/SSO) as a basis of measurement of Q^2 since this value has incorporated the primary elements of the path model (in terms of structural model information) with the objective of predicting the omitted data points. Table 5.13 has clearly demonstrated that the value of cross-validated redundancy of EIP (i.e. 0.4874) which exceeded the recommended threshold of 0.35 signified that the set of selected GSCM practices has a considerably large predictive relevance for EIP (Wong, 2013).

Table 5.13 Cross-validated Redundancy

Total	1-SSE/SSO
EIP	0.4874

Note: SSE = Sum of squares of prediction errors; SSO = Sum of squares of observations

Table 5.14 Results of R2 and Q2 values

Endogenous Latent Variable	R^2 Value	Q^2 Value
EIP	0.6818	0.4874

The results for R^2 and Q^2 values for EIP are clearly demonstrated in Table 5.14. The R^2 value showcases the predictive relationship among variables whereas the Q^2 value plays an important role in ascertaining the accuracy of the predictive relationship between exogenous and endogenous variables in the model (Ali, Kim, & Cobanoglu, 2018). Ali et al. (2018) further posited that a structural model is considered as demonstrating predictive relevance when $Q^2 > 0$. Hence, the R^2 value of 0.6818 or 68.18% (> 50%; indicating moderately substantial predictive accuracy, according to Hair et al. (2016)) and a Q^2 value of 0.4874 (> 0; indicating predictive relevance, according to Hair et al. (2016)) for EIP have clearly demonstrated that the selected set of GSCM practices were capable of explaining 68.18% of variances of the endogenous variable (EIP) and has a considerably high predictive relevance for EIP (Wong, 2013).

5.8 The Effect Sizes (f^2)

According to Hair et al. (2016), f-square (f^2) effect size is used to measure the change in R^2 (Coefficient of Determination) when a particular exogenous variable is omitted from a model with the objective of determining whether that omitted exogenous variable exerts a substantial effect on the endogenous variable or not. Following the recommendation of Cohen (1988), the rule of thumb in assessing f^2 effect size is:

a) < 0.02 indicating no effect

b) 0.02 represents small effect

c) 0.15 represents medium effect

d) 0.35 represents large effect

Table 5.15 has clearly demonstrated the effect sizes (f^2) of all exogenous variables (IEM, CC, IR, ED and GS) on the endogenous variable (EIP) with the use of blindfolding feature in SmartPLS 3.0. Besides this, analytical remarks following the rule of thumb established by Cohen (1988) are also detailed out in Table 5.15.

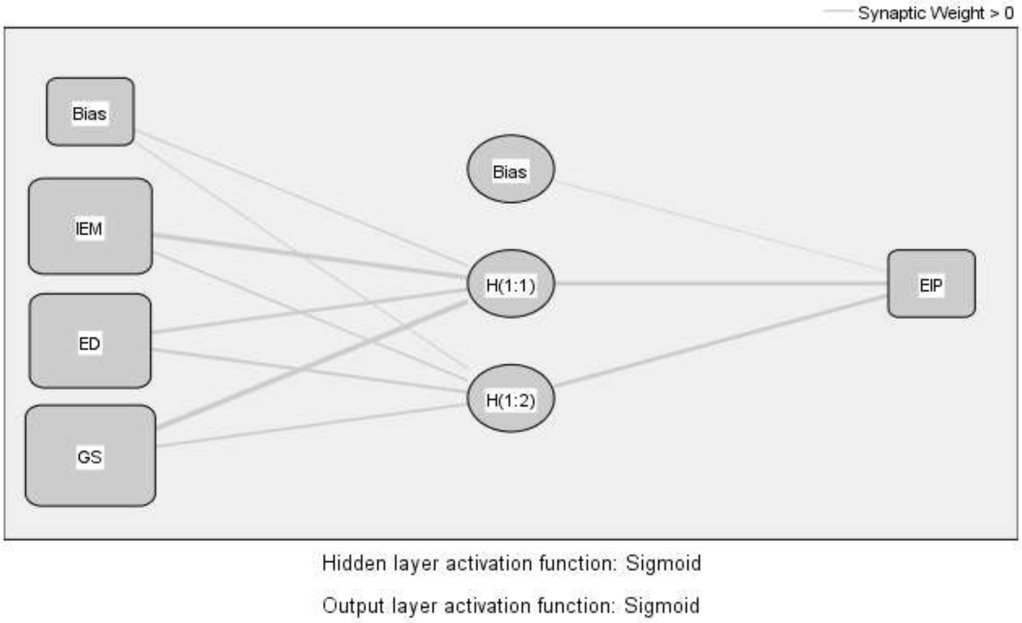
Table 5.15 Effect Size on DV – EIP

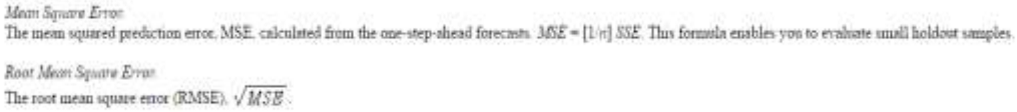
IV	**Path coefficient**	**f^2**	**Remarks**
IEM	0.2171	0.0536	$0.02 < f^2 < 0.15$ → in between small to medium effect
CC	-0.0195	0.0003	< 0.02 → no effect
IR	0.0190	0.0004	< 0.02 → no effect
ED	0.4020	0.1373	≈ 0.15 → medium effect
GS	0.3618	0.2042	$0.15 < f^2 < 0.35$ → close to large effect

Note: DV = Dependent variable; IV = Independent variable; IEM = Internal Environmental Management; CC = Cooperation with Customers; IR = Investment Recovery; ED = Eco Design; GS = Greening the Suppliers

5.9 Artificial Neural Network (ANN) Analysis

After PLS-SEM analysis has been completed, Artificial Neural Network (ANN) analysis was subsequently run by using IBM SPSS statistical software (Version 22) with the objective of complementing results obtained from PLS-SEM analysis by ranking only the significant predictors in terms of normalized relative importance (in percentage). According to Oparaji, Sheu, Bankhead, Austin, and Patelli (2017), ANN is a widely-used and very powerful artificial intelligence (AI) technology that is capable of combining several non-linear functions with the objective of capturing non-linear relationships between input data and a label. In ANN analysis, statistically significant reflective exogenous variables (i.e. IEM, ED and GS) served as input neurons whereas the reflective endogenous variable (EIP) served as the resultant output neuron as shown in Figure 5.2 below. According to Foo et al. (2018) and Leong, Hew, Lee, and Ooi (2015), ANN is highly flexible in the way that multivariate assumptions such as linearity and normality are not compulsory to be fulfilled.




Mean Square Error
The mean squared prediction error, MSE, calculated from the one-step-ahead forecasts. $MSE = [1/n]\ SSE$. This formula enables you to evaluate small holdout samples.

Root Mean Square Error
The root mean square error (RMSE). $\sqrt{MSE}$.

Figure 5.2 ANN model developed

Table 5.16 RMSE mean of ANN model

Input: IEM, ED, GS
Output: EIP

	Training			Testing			
Neural network	**N**	**SSE**	**RMSE**	**N**	**SSE**	**RMSE**	**Total**
ANN1	97	1.144	0.1086	10	0.021	0.0458	107
ANN2	96	1.191	0.1114	11	0.301	0.1654	107
ANN3	96	0.996	0.1019	11	0.164	0.1221	107
ANN4	96	0.904	0.0970	11	0.171	0.1247	107
ANN5	97	0.890	0.0958	10	0.095	0.0975	107
ANN6	96	0.898	0.0967	11	0.043	0.0625	107
ANN7	96	1.091	0.1066	11	0.043	0.0625	107
ANN8	96	1.186	0.1111	11	0.018	0.0405	107
ANN9	96	0.993	0.1017	11	0.007	0.0252	107
ANN10	97	0.950	0.0990	10	0.042	0.0648	107
		mean	0.1030		**mean**	0.0811	
		SD	0.0060		**SD**	0.0446	

Table 5.17 Relevance of reflective exogenous variables in ANN model

	Number of non-zero synaptic weight in the connections of predictor variables with hidden neurons.		
Neural network	**IEM**	**ED**	**GS**
ANN1	2	2	2
ANN2	2	2	2
ANN3	2	2	2
ANN4	2	2	2
ANN5	2	2	2
ANN6	2	2	2
ANN7	2	2	2
ANN8	2	2	2
ANN9	2	2	2
ANN10	2	2	2

In order to ascertain the predictive accuracy of ANN analysis, Root Mean Square of Error (RMSE) for every neural network was computed. Hew, Badaruddin and Moorthy (2017) posited that a lower RMSE value actually signifies better data fit and higher predictive accuracy. Hence, the low mean RMSE values for training (0.1030) and testing (0.0811) as exhibited in Table 5.16 clearly showed that the ANN model developed (as displayed in Figure 5.2 above) has demonstrated reasonably good data fit and considerably high predictive accuracy. Besides this, the quantity of non-zero synaptic weight linked to hidden neurons (as shown in Table 5.17) was used to assess the relevance of reflective exogenous variables in the ANN model.

Furthermore, Table 5.18 further demonstrated the ranking of the significant predictors in terms of the percentage of normalised relative importance by employing sensitivity analysis. GS emerged as the gold medallist among the significant predictors of EIP (with 100% normalised relative importance) followed by ED and IEM with 93% and 69% normalised relative importance respectively.

Table 5.18 Relative importance ranking results

	Relative Importance		
Neural network	**IEM**	**ED**	**GS**
ANN1	0.327	0.319	0.354
ANN2	0.305	0.347	0.348
ANN3	0.199	0.294	0.506
ANN4	0.210	0.421	0.369
ANN5	0.155	0.432	0.414
ANN6	0.228	0.389	0.382
ANN7	0.303	0.346	0.351
ANN8	0.324	0.306	0.370
ANN9	0.257	0.420	0.323
ANN10	0.319	0.270	0.411
Average relative importance	**0.263**	**0.354**	**0.383**
Normalized relative importance	**69%**	**93%**	**100%**
Ranking	**3RD**	**2ND**	**1ST**

5.10 Comparison of rankings between PLS-SEM and ANN analyses

Table 5.19 Comparison between PLS-SEM and ANN output

IV	Original Sample (O)/Path Coefficient	T-Statistics	P-Value	Findings	Ranking (PLS-SEM) [based on Path Coefficient]	Ranking (ANN) [based on Normalized relative importance (%)]	ANN results: Normalized relative importance (%)	Matched or not
GS	**0.3618**	**3.8778**	**0.0001**	**Significant & positive**	**2**	**1**	**100%**	**Not matched**
ED	**0.4020**	**2.4466**	**0.0145**	**Significant & positive**	**1**	**2**	**93%**	**Not matched**
IEM	**0.2171**	**1.9430**	**0.0521**	**Significant & positive**	**3**	**3**	**69%**	**Matched**
IR	0.0190	0.2517	0.8013	Insignificant	N/A	N/A	N/A	N/A
CC	-0.0195	0.2310	0.8173	Insignificant	N/A	N/A	N/A	N/A

Following Khoshroo, Emrouznejad, Ghaffarizadeh, Kasraei, and Omid (2018), only significant predictors are ranked in ANN analysis. The comparison of ranking results generated from PLS-SEM and ANN analyses were systematically laid out in Table 5.19. The results seemed intriguing and interesting because ED was ranked as number one in PLS-SEM analysis but dropped to the second place in terms of the strength of influence in ANN analysis. The same goes to GS which was positioned as number two in PLS-SEM analysis but has successfully clinched the first place in relation to relative importance in ANN analysis. According to Goodfellow, Bengio, and Courville (2016), this phenomenon might be caused by the capability of ANN in capturing both non-linear and linear relationships among the variables during analysis. In other words, after taking into account the non-linear relationship between GS and EIP, GS actually emerged as the more important factor as compared to ED. This veracity would not be revealed if only PLS-SEM were conducted, and therefore showcasing that the dual-stage PLS-ANN analysis as a value-added approach in effectively complementing the single-stage PLS-SEM results.

5.11 Chapter Summary

Chapter 5 began with a brief introduction followed by a systematic presentation of results and findings from data analysis. The descriptive statistics results were first presented followed by the discussion of results obtained from the analyses of the measurement model and structural model. Besides this, testing of Common Method Bias (CMB) and Non-response Bias were also presented. The findings revealed that H1 (IEM → EIP), H3 (ED →

EIP), and H5 (GS → EIP) were supported whereas H2 (CC → EIP) and H4 (IR → EIP) were not supported. The findings in CHAPTER 5 will be further scrutinized and discussed in detail in CHAPTER 6 which will draw general conclusions where findings and results from other researchers will be compared. Furthermore, sensible justifications as to why H2 and H4 were not supported will also be provided in Chapter 6. Last but not least, the results obtained from ANN analysis where the significant predictors were ranked according to their strength of influence on the dependent variable (EIP) and the subsequent comparison between PLS-SEM and ANN rankings were presented. Furthermore, sensible justifications explaining the notable differences in the rankings were also offered.

CHAPTER 6

CONCLUSION

6.1 Initiation

CHAPTER 6 lays out the discussions regarding the results as to why three hypotheses are being supported and why the other two hypotheses are not being supported. Sensible justifications following past and recent literature reviews and empirical findings will be provided to justify significant as well as insignificant relationships. Next, the three research questions will also be discussed prior to the presentation of theoretical, practical and methodological implications. Last but not least, the limitations of this study and corresponding recommendations as well as future research directions will be presented before a summary wraps up the chapter.

6.2 Discussions on Hypotheses

The justifications supporting the three significant and two insignificant relationships within the context of past and recent literature reviews and empirical findings are detailed out in this section.

6.2.1 Hypothesis 1 (IEM → EIP)

Statistical analysis showed that IEM is significantly and positively linked to EIP, and hence deeming H1 being supported. This finding is in line with many past and recent literature reviews and empirical studies which unanimously agreed that IEM is a key factor in improving firms' performance, including green innovation performance, including but not limited to Burki et al. (2018), Carter et al. (1998), Diana et al. (2017), Hamel et al. (1989), Wu (2013), Zhu et al. (2017). It is a well-known and irrefutable fact that the support and commitment rendered by top and middle level management teams being crucial for successful adoption and implementation of most innovations, technologies, programs, practices and activities (de Jesus Pacheco, Carla, Jung, Ribeiro, Navas, & Cruz-Machado, 2017; Huang, Hu, Liu, Yu, & Yu, 2016; Maçaneiro, da Cunha, & Balbinot, 2013; Tseng et al., 2013). Various empirical findings posited that top and middle management's support and commitment significantly drive green innovation performance because front-line and operational level executives will follow the lead and directives (in the forms of Code of Conduct, Standard Operating Procedures, plans, policies and programs) set by the top and strategic management level senior personnel in effectively executing a firm's green and sustainable practices throughout the entire value chain (Albertini, 2018; Cokins, 2017; Epstein, 2018; Saunila et al., 2018; Sroufe & Sarkis, 2017). Besides this, seamless and effective cross-functional collaborations have been proven to achieve and sustain impeccable total quality and environmental management systems (Kumar & Rodrigues, 2018; Melander, 2018; Rice, 2003; Wong et al., 2018; Zsidisin & Siferd, 2001). Furthermore, being certified to well-established and internationally recognized environmental management standard such as ISO 14001 certainly laid a foundation in advancing green innovation performance in a firm, as evidenced in empirical studies conducted by Hamdoun et al. (2018), He and Shen (2017), and Li et al. (2017). Through strong and robust IEM, firms have successfully paved the way towards producing greener and more sustainable innovations in view of the current trend that various stakeholders are demanding greener and more eco-durable products and services that leave minimal or even zero negative environmental footprints on the planet throughout their entire lifecycle (Ansari & Kant, 2017; Burki et al., 2018; Gupta & Barua, 2017; Scur & Barbosa, 2017; Zhu et al., 2017). This is evidenced in Korea Omyang Corporation which has successfully restructured its organization and made the functional units of production, quality assurance or quality control and research and development (R&D) to work together to mitigate any imminent and real environmental threats in the products and production lines ("KOREA OMYANG - Company Profile", 2018; Lee, 2009). The top management has also made these three functional units to report directly to the Managing Director. The supportive and highly-committed top management team, being ISO14001 certified and coupled with strong cross-functional involvement and collaboration have rendered Korea Omyang Corporation to become much more efficient and effective in achieving its environmental and sustainability goals (Lee, 2009). The explained factor (IEM) is able to explain the situation in Malaysia as demonstrated by empirical studies which were conducted in Malaysia that yielded similar findings/results such as Goh, Zailani, and Abd Wahid (2006), Lee et al. (2014), and Zailani et al. (2015).

6.2.2 Hypothesis 2 (CC → EIP)

Statistical analysis surprisingly showed that CC is not significantly linked to EIP. This implies that CC has no significant impact on EIP. This finding is in contrary to past studies conducted by de Sousa Jabbour et al. (2017), Diabat et al. (2013), Khan and Dong (2017), Leal-Millán et al. (2017), and others who posited that CC is significantly and positively linked to EIP. This interesting finding might be caused by geographically-dispersed customers lacking the necessary awareness, knowledge and expertise to influence EIP is a substantial way (Ind, Iglesias, & Markovic, 2017; Mourad & Ahmed, 2012; Scaringella, Miles, & Truong, 2017; Sole & Edmondson, 2002) since 65.4% of the respondent firms are MNCs and hence have a wide range of international customers. Besides this, the respondent firms might be having far-from-excellent relationships with customers, the customers might not want active involvement with the manufacturers, and the knowledge gap between customers and manufacturers might be wider than the desirable level (Abdullah et al., 2016; Alam, 2006; Asch, 2001; Franke & Piller, 2004; Islam, Bagum, & Rashed, 2012; Lenka, Parida, Sjödin, & Wincent, 2018; Nambisan, 2002; Senn, 2012; Shetty & Manoharan, 2012; Yuan, Pangarkar, & Wu, 2016). All these factors play an imminent role in contributing towards the insignificant relationship between CC and EIP. Furthermore, empirical studies conducted by de Sousa Jabbour et al. (2017) in Brazil, Lee et al. (2014) in Malaysia, and Monjon and Waelbroeck (2003) in France also showed that CC did not impact innovation performance significantly due to similar reasons mentioned above. Nevertheless, firms should not give up on collaborating with customers with the objective of building strategic alliances and “1 + 1 > 2” synergism on top of fostering win-win relationships that will benefit both customers and manufacturers in the sustainability index in the long run (Cao & Zhang, 2011; Carroll & Shabana, 2010; Kumar, Subramanian, & Ramkumar, 2018).

6.2.3 Hypothesis 3 (ED → EIP)

Statistical analysis showed that ED is significantly and positively linked to EIP, and hence deeming H3 being supported. This finding is in line with many past and recent literature reviews and empirical studies which unanimously agreed that ED is an immensely useful tool in helping a firm to further improve on EIP by putting great emphasis on the design of value-added features and technical functionalities of products and processes that leave minimal or even zero negative environmental externalities throughout the entire lifecycle of the inventions or innovations (Knight & Jenkins, 2009; Lee et al., 2014; Sihvonen & Partanen, 2017; Zhu et al., 2008). The design stage is of utmost importance because it is at this stage that the materials (including parts and components) are determined, meaning that a majority of the ecological impacts are embedded into the product and the cost of the product is largely decided at this critical stage (Lewis et al., 2017; Shahbazi et al., 2018). The design of a product that effectively minimizes the consumption of resources, on top of being ISO 9001 and ISO 14001 certified, as well as being compliant to the stringent RoHS directive (for the electrical and electronic industry) by avoiding the use of hazardous substances during production, is largely associated with the attainment and further improvement of EIP (Albino et al., 2009; Dangelico & Pujari, 2010; "Recast of the RoHS Directive", 2016). EIP is effectively enhanced through breakthrough technologies in designing and producing green innovative products that serve as effective solutions in mitigating negative environmental externalities (Dangelico et al., 2017; Huang & Li, 2017) and a proactive measure for pollution prevention via innovative product stewardship (Santolaria et al., 2011; Scur & Barbosa, 2017). This is evidenced in Toyota Motor Corporation being the first automobile manufacturer in the world to launch an electric motor and combustion engine 2-in-1 hybrid passenger car – the infamous and awards-winning Toyota Prius in October 1997 in a move to reduce consumption of non-renewable fuel (i.e. petrol) and also to lower greenhouse gas emissions (i.e. carbon dioxide) (Toyota Corporation, 2008). Besides this, Panasonic India also walk the walk by launching yet another technological breakthrough product in March 2018 – the brand-new "air-purifying" inverter air conditioners that are also equipped with nanotechnology features which Panasonic claims have the ability to remove airborne particles and give up to 99% clean air (Press Trust of India, 2018). According to Salleh et al. (2018), the inverter air conditioners boost significant energy efficiency in terms of electricity saving by smartly adjusting the capacity of the compressor and motor speed according to the varying cooling requirement of the external environment instead of obliging to the peak power requirement demanded by conventional non-inverter type air conditioners. These smart moves by the manufacturers have not only satisfied the demands of increasingly environmentally conscious consumers, but also contributed to the environmental and sustainability goals by effectively combatting greenhouse gas effects and global warming through the significant reduction of carbon dioxide (CO_2) gas emissions (Arning, Van Heek, & Ziefle, 2018; Lee, Hashim, Ho, Fan, & Klemeš, 2017). The explained factor (ED) is able to explain the situation in Malaysia as demonstrated by empirical studies which were conducted in Malaysia that yielded similar findings/results such as Ghazilla, Sakundarini, Taha, Abdul-Rashid, and Yusoff (2015), Khor and Udin (2013), and Lee et al. (2014).

6.2.4 Hypothesis 4 (IR → EIP)

Statistical analysis surprisingly showed that IR is not significantly linked to EIP. This implies that IR has no significant impact on EIP. This finding is different from past studies conducted by Cottrill (1997), Cubitt (2016), Diabat et al. (2013), Esfahbodi et al. (2017), Lee et al. (2014), Sarkis (2003), Szaky (2014), Wu et al. (2012), and others who posited that IR is significantly and positively linked to EIP. This interesting finding might be caused by a lack of awareness, knowledge, skills, experience and expertise in terms of implementing IR among the employees of respondent firms (Hoffman, Parejo, Bessant, & Perren, 1998; Silva & Leitão, 2007; Silva, Leitao, & Raposo, 2008; Woolman & Veshagh, 2006). Besides this, the respondent firms might be lacking in infrastructure, technology and facilities to implement IR successfully (Abdullah et al., 2016; Silva et al., 2008; Zhu & Sarkis, 2007; Zhu & Zhao, 2003). Furthermore, IR is more well-established in advanced and developed nations such as the USA and European countries compared to emerging and developing nations such as Malaysia who is still in its infancy in this area where IR may not be a manufacturing priority (Kapetanopoulou & Tagaras, 2011; Lee et al., 2014; Zhu & Zhao, 2003; Zsidisin & Hendrick, 1998). In other words, Malaysia as a developing nation might be at the early stage of implementing IR and it might be too early to witness noticeable positive and significant results at the current stage (Jayarathna, 2016; Lee et al., 2014; Savita, Dominic, & Ratnam, 2015). The employees in the respondent firms might be reluctant to risk moving out of their comfort zone to innovate IR processes aggressively (Pawanchik & Sulaiman, 2010). The explained factor (IR) is able to explain the situation in Malaysia as demonstrated by empirical studies which were conducted in Malaysia that yielded similar findings/results such as Abdullah et al. (2016), Lee et al. (2014), and Pawanchik and Sulaiman (2010). Nevertheless, firms should work relentlessly to overcome the above-mentioned barriers with the objective of ensuring the implementation of IR is of paramount success that yields great economic and sustainability benefits for the betterment of firms and society (Esfahbodi et al., 2017; Hong, Zhang, & Ding, 2018; Zhao et al., 2017).

6.2.5 Hypothesis 5 (GS → EIP)

Statistical analysis showed that GS is significantly and positively linked to EIP, and hence deeming H5 being supported. This finding is in line with many past and recent literature reviews and empirical studies which unanimously agreed that GS is essential in advancing the green innovation capabilities of a firm through proper supplier selection, strong and positive environmental collaboration with suppliers and conducting checks or audits on certain main suppliers (especially main raw materials suppliers) to ensure the upstream supply chain partners are aligning with a firm’s environmental and sustainability goals (Chiou et al., 2011; Lee & Kim, 2011; Morioka et al., 2017; Rao, 2002; Schöggl et al., 2017; Vachon & Klassen, 2006; Vezzoli, 2018; Wu, 2013). Furthermore, according to Handfield et al. (2005), Morioka et al. (2017), Schöggl et al. (2017), and Vezzoli (2018), value-added inputs from suppliers in the early stage of product design and development will reinforce the attainment of environmental and sustainability goals by determining the right eco-durable but at the same time economically viable materials, parts and components. Hence, it can be logically and reasonably deduced that parts and components that are certified with and compliant to ISO 9001, ISO 14001 and/or RoHS will produce green products that leave minimal or zero negative externalities on the environment (Gehin et al., 2008; Lee, 2009; Wang et al., 2018). This further reinforced and affirmed the proposition that a higher level of GS will lead to a correspondingly higher level of EIP (Lee et al., 2014; Morioka et al., 2017; Wu, 2013). This is evidenced in the rewards reaped by Dell Inc. through the rigorous implementation of "Dell Supplier Principles" policy which requires suppliers to comply with the eight principles explicitly enshrined in the "Dell Supplier Principles", including being certified to international standards like ISO 14001, ISO 9001, and ISO 45001 or OHSAS 18001 in order to scale greater heights on the sustainability barometer by ensuring that the technological products (especially Dell hardware) attain high Energy Star that undoubtedly add value to the existing portfolio of sustainable and eco-durable products that are available in the market which boost the twin turbo engines of high performance and superb energy efficiency (Dell Inc., 2017; 2018; Hafer, 2017; Mesaad, Alansari, Ahgamdi, Saad, & Hemalatha, 2017; Radpour, Mondal, & Kumar, 2017; Ranjith, Tamizharasi, & Balamurugan, 2017). In a nutshell, GS is envisioned as an essential practice that simultaneously considers the entire upstream supply chain process from the selection of suppliers, collaborative management of suppliers up till the evaluation of the supply function with the achievement and improvement of green innovation performance in mind. The explained factor (GS) is able to explain the situation in Malaysia as demonstrated by empirical studies which were conducted in Malaysia that yielded similar findings/results such as Hsu, Tan, and Zailani (2016), Lee et al. (2014), and Zailani et al. (2012).

6.3 Discussions on RQs

Based on the analysis of statistical results as presented in CHAPTER 5, sub-sections 6.1 - 6.3 will discuss the responses to all three research questions as follows:

6.3.1 Response to RQ1

In relation to RQ (1) – "Is the relationship between each of the green supply chain management practice (i.e. internal environmental management (IEM), cooperation with customers (CC), investment recovery (IR), eco-design (ED), and greening the suppliers (GS)) and green innovation performance significant and positive among large Malaysian manufacturers that are certified with ISO 14001?", it was revealed that IEM, ED and GS have a positive and significant relationship with EIP whereas CC and IR did not have a significant relationship with EIP. This implies that being positive and significant determinants of EIP, an increase in the magnitude of the implementation of IEM, ED and GS will result in a corresponding improvement in EIP in parallel direction. On the other hand, an increase in the level of implementation of CC and IR did not result in any noticeable or visible improvement in EIP.

6.3.2 Response to RQ2

In response to RQ (2) – "Among the significant independent variables, which green supply chain management practice(s) has a stronger impact on green innovation performance?", it is interesting to note that PLS-SEM and ANN analyses revealed different results in terms of ranking of significant predictors. The results seemed intriguing and interesting because ED was ranked as number one in PLS-SEM analysis but dropped to the second place in terms of the strength of influence in ANN analysis. The same goes to GS which was positioned as number two in PLS-SEM analysis but has successfully clinched the first place in relation to relative importance in ANN analysis. According to Goodfellow, Bengio, and Courville (2016), this phenomenon might be caused by the capability of ANN in capturing both non-linear and linear relationships among the variables during analysis. In other words, after taking into account the non-linear relationship between GS and EIP, GS actually emerged as the more important factor as compared to ED. This veracity would not be revealed if only PLS-SEM were conducted, and therefore showcasing that the dual-stage PLS-ANN analysis as a value-added approach in effectively complementing the single-stage PLS-SEM results.

6.4 Contributions/Implications

This study has certainly yielded value-added cognizance with regards to the significance of GSCM practices in propelling EIP among Malaysian manufacturing firms. Furthermore, the dual-stage PLS-ANN method has provided a fresh perspective regarding the ranking of significant predictors. In a nutshell, this study has not only broadened the horizon of existing literature by contributing to the generation of new knowledge through the provision of sensible and well-supported justifications for insignificant relationships which were conventionally significant (CC → EIP and IR → EIP), but is also projecting strong theoretical, practical and managerial contributions which are discussed in the following subsections.

6.4.1 Theoretical Contributions/Implications

According to Seman et al. (2012a; 2012b), the link between GSCM practices and green innovation is relatively under-researched, particularly in the Malaysian manufacturing landscape. Hence, the proposed research model further projects the uniqueness and importance of an enlightening framework that is capable of facilitating the empirical investigation of the relationships between GSCM practices and EIP from the view point of large Malaysian manufacturers in view of the mounting challenges highlighted in the research problem section, which is the focus of this study. Furthermore, the second order dependent variable (green innovation performance) is being measured as a multidimensional reflective variable that encompasses the dimensions of green product, process and managerial innovations, and coupled with the selected set of GSCM practices as its antecedents, this one-of-a-kind model was never before examined empirically in the Malaysian manufacturing landscape. Besides this, the proposed research model can act as an illuminating guideline to academics since it had provided a solid ground in propelling and further advancing green-related frameworks, which is one of the strategic thrusts of Malaysia towards achieving Vision 2020 (Economic Planning Unit, Prime Minister's Department, Malaysia [EPU], 2015). Better still, significant relationships that have been established linking the selected set of GSCM practices and EIP can further amplify the novelty of the proposed research model where future researchers can extrapolate on the current framework and take a few more steps further by investigating the cause-and-effect of antecedents of GSCM practices-GSCM-green innovation-sustainability performance-competitive advantage and so on, with the influence of moderators, wherever applicable. All these value-added points will undoubtedly contribute towards theory development in the field of green and sustainable supply chain management practices. In other words, the significant results produced by this empirical study further affirm the propositions of Natural-Resource-Based View (NRBV) theory which advocates that the ultimate aim of the three strategic capabilities is to drive sustained competitive advantage where green innovation served as a catalytic driver of sustained competitive advantage (Chang, 2011; Chen, 2008; Gürlek & Tuna, 2018; Hart, 1995; Nanath & Pillai, 2017). On the other hand, even though cooperation with customers and investment recovery are surprisingly not significantly linked to green innovation performance, however, this has contributed to new knowledge development with sensible justifications being aptly provided in the discussion of results section (Foo et al., 2018).

6.4.2 Practical Contributions/Implications

The proposed research model possesses the potential to play the role of a scintillating beacon that offers valuable guidance and insights on the extremely enormous magnitude of the associated impacts caused by the selected set of GSCM practices on the three-dimensional EIP to industry practitioners and management teams of manufacturing firms who need to make multiple important and urgent decisions of varying degree at different organizational levels.

Industry players will be able to precisely identify areas or “blind spots” in their organization with the objective of “extinguishing fires” (in other words, to devise effective remedial solutions with the focus of settling problems) caused by employees who carelessly disregard the industry’s best practices expounded by closely connected authorities such as compulsory policies drawn up by the Ministry of Natural Resources and Environment (NRE) or establishments such as the world-renowned ISO.

One cannot willfully contemplate the extent or degree of seriousness of potential damages (in terms of negative environmental impact) caused by unethical and even illegal behaviors of business operators. Hence, it is always an excellent practice by complying to various regulatory frameworks set forth by the government and also happily and voluntarily embrace green initiatives as set out by standardization bodies such as SIRIM, ISO, EMAS, RoHS and so on with open arms so as to streamline everyone’s (including world leaders and United Nations) efforts to constantly strive for a more sustainable Earth for the greater good and for the ultimate benefits of all living beings.

Again, the researcher would like to reiterate that she reasonably believes that this research study will serve as a catalyst or propeller for manufacturing firms to integrate GSCM practices along their supply chain in their ambitions to achieve EIP; especially in view of the statistical results that vehemently demonstrated that GSCM practices are indeed exerting significant impact on EIP among large Malaysian manufacturers that are certified with ISO14001.

Manufacturing firms will be greatly inspired to green their supply chain in view of the tremendous benefits/ rewards that are associated with their green initiatives.

Last but not least, successful practitioners will serve as a benchmark for others to emulate. This is particularly true in the current climate because according to the latest ISO14001:2015 roll out, the newly revised ISO14001:2015 is much more stringent. More proactive, rigorous and prominent environmental management efforts/initiatives in the strategic landscape; a renewed focus on stakeholder-centric communication strategy and life-cycle thinking; and more importantly a greater commitment from leadership are the key improvements required by ISO14001:2015 as compared to the previous versions of ISO14001, such as ISO14001:2004 and ISO14001:2008 (Naden, 2016). This further helps in showcasing the importance of having the right selections of GSCM practices in place in order to achieve or even improve EIP which will undeniably lead to sustained competitive advantages in the ultimate quest of every organization to outshine its competitors to emerge as the winner in the constantly-evolving game of “survival of the fittest”.

6.4.3 Methodological Contributions/Implications

This study has successfully employed a remarkable two-stage PLS-ANN analysis. PLS-SEM by utilizing SmartPLS 3.0 software was first run to examine the relationship between each GSCM practice with EIP. Upon determining the significant relationships between GSCM practices and EIP, ANN analysis was performed by utilizing IBM SPSS v22 software to examine the Normalized Relative Importance of the significant predictors. The significant predictors were ranked as per the magnitude of Path Coefficient (for PLS-SEM) and Normalized Relative Importance (for ANN analysis) with the objective of determining the relative importance of the impact of each significant predictor on EIP. The rankings as a result of both methods were compared and strong justifications were provided to explain the notable differences in terms of rankings that arose from the two different approaches. A dual-stage analysis has undoubtedly proven to be stronger and much more comprehensive compared to the conventional single-stage analysis (Foo et al., 2018) where new insights were generated for the benefit of all.

6.5 Limitations, Recommendations and Future Directions

Similar to other empirical studies, there are some limitations present in this study. The first limitation identified in this study is this study employed a cross-sectional approach where data was gathered at a specific point of time. Future studies may contemplate embarking on a longitudinal research that has a three-year timeframe so as to better confirm the magnitude and direction of cause-and-effect relationship between independent and dependent variables (Trentin, Forza, & Perin, 2015). Besides this, this research utilized a 100% quantitative approach. Non-verbal communication data (for example body language) as well as more detailed and in-depth responses may be captured by ways of mixed or qualitative research methods. In-depth interviews and even observation can serve as effective remedies to solve information deficiencies which are inherent in pure quantitative studies (Goldstein & Drucker, 2006). Furthermore, the primary focus of this research study is on Malaysian manufacturers. Future studies may consider widening the scope of study by covering more extensive geographical regions such as other Asia-Pacific, American, African and European nations to compare and contrast findings in developed and developing nations and also to further improve generalizability (Nguyen, 2017). Last but not least, the researcher would certainly employ more updated but highly reliable, valid and well-cited variables or items of measurement that are highly relevant to the research framework in future studies, depending on availability.

6.6 Chapter Encapsulation

To summarize, a research framework was developed in this study, linking the five GSCM practices (i.e. IEM, CC, IR, ED, and GS) and EIP among large Malaysian manufacturers that are certified with ISO 14001. In other words, the relationships between the five GSCM practices and EIP were being tested with the objective of assessing the impact of this selected set of GSCM practices on EIP.

The results in this study indicated that three out of five GSCM practices (i.e. IEM, ED and GS) are significantly and positively linked to EIP whereas CC and IR were surprisingly found to be insignificantly related to EIP. Therefore, hypotheses H1, H3, and H5 were supported. On the other hand, hypotheses H2 and H4 were not supported because statistical results not only show that the p-values for H2 and H4 were greater than 0.05, findings also revealed that the path coefficients were not significant (i.e. $\beta < 0.2$). In other words, CC and IR do not have a significant impact on EIP in this study.

Sensible justifications following past and recent literature reviews and empirical findings were provided in the researcher’s attempt to justify significant as well as insignificant relationships. Besides this, the three research questions were also being discussed prior to the presentation of theoretical, practical and methodological contributions. Last but not least, the limitations of this study and corresponding recommendations as well as future research directions were laid out towards the end of this chapter.

In a nutshell, the researcher humbly believes that there is no one-size-fits-all solution to any problem, including environmental and sustainability issues. Nevertheless, firms must build on an established framework (for example a set of green and sustainable best practices) that is empirically proven to result in improvements in overall firm performance, including green innovation and sustainability performance, by designing and implementing green practices that are specifically tailored to suit a firm’s customized needs and requirements so as to optimize firm performance and at the same time achieve organizational goals and aspirations of becoming a highly responsible global citizen in terms of leaving minimal or even zero negative environmental footprints on Planet Earth.

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