INFLUENCE OF ENERGY MANAGEMENT PRACTICES ON ENERGY EFFICIENCY AND CARBON EMISSION REDUCTION: MEDIATING EFFECT OF GREEN SUPPLY CHAIN PERFORMANCE

BY

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ABSTRAK

Peningkatan pengeluaran gas rumah hijau adalah salah satu kebimbangan antarabangsa yang telah mendorong kerajaan Malaysia untuk mengenakan sasaran tinggi untuk pengurangan gas karbon dioksida (CO_2) di Malaysia. Firma pengeluaran sebagai pengguna tenaga utama telah ditekan untuk meningkatkan kecekapan penggunaan tenaga dan mengurangkan pelepasan karbon dalam aktiviti operasi mereka. Kajian ini telah menjalankan kaji selidik diatas 111 firma pengeluaran in Malaysia untuk menentukan keberkesanan tekanan institusi dalam memacu amalan pengurusan tenaga ke arah mencapai kecekapan tenaga dan pengurangan pelepasan gas karbon dioksida. Ia juga bertujuan untuk mengkaji kesan pengurusan aktiviti pengurusan tenaga keatas prestasi rantaian bekalan hijau firma dan peranan rantaian bekalan hijau dalam meningkatan kecekapan tenaga dan pengurangan gas karbon dioxida. Hasil kajian ini menunjukan bahawa sedangkan tekanan institusi telah mengalakkan sokongan pengurusan dalam membina kesedaran tenaga and keupayaan teknikal untuk meningkatkan kecekapan tenaga, keprihatinan terhadap pelepasan gas karbon dioksida hampir tidak wujud dalam konteks firma pengeluaran Malaysia dan amalan pengurusan tenaga yang sedia ada masih lagi dalam peringkat awal. Prestasi rantaian bekalan hijau dipertingkatkan oleh pengurusan tenaga dan memainkan peranan sebagai perantaraan dalam meningkatkan prestasi kecekapan tenaga melalui perkongsian pengetahuan teknikal. Kajian ini menyimpulkan bahawa tekanan paksaan tidak mencapai matlamat yang dikehendaki dan telah menghasilkan isyarat bercampur-campur di kalangan firma pengeluaran, manakala tekanan normatif didapati berkesan ke atas prestasi rantaian bekalan hijau. Kekurangan tekanan persaingan dalam mengalakan pengurusan alam sekitar di kalangan industri ini lazim, walaupun jelas terdapat peningkatan dalam prestasi amalan pengurusan tenaga dan kecekapan tenaga. Kajian ini telah membuka peluang penyelidikan dan pembangunan untuk mengenal pasti alternatif baru untuk pengewangan konsep alam sekitar seperti pelepasan karbon dan aktiviti rantaian bekalan hijau.

ABSTRACT

International concern on the rising emissions of greenhouse gases (GHG) has prompted action from the Malaysian government to impose ambitious carbon dioxide (CO_2) emissions reduction targets for Malaysia. As energy consumption contributes to a majority of carbon dioxide emissions, manufacturing firms as the primary consumer of energy are under pressure to improve energy efficiency and reduce carbon emissions in their operational activities. This study conducted a survey among 111 manufacturing firms in Malaysia to determine the effectiveness of institutional pressure in driving energy management practices towards achieving energy efficiency and carbon emission reduction. It also attempts to study effects of energy management on the firm's green supply chain performance and the role supply chain plays in improving energy efficiencies or carbon emission reduction. The result of the study shows that while institutional pressure has encouraged management support in building energy awareness and technical capabilities to improve energy efficiency, concern for carbon emission are nearly non-existent within the Malaysian manufacturing context and existing energy management practices are still very much in its infancy. Green supply chain performance is enhanced by energy management and plays a mediating role in improving energy efficiency primarily through technical knowledge sharing. This study concludes that coercive pressure employed did not achieve its intended goals and have resulted in mixed signals among practicing firms, while normative pressure was found to have bounded effects on internal and external green supply chain performance. Lack of competitive pressure in environmental management among the industry is prevailing although marginal improvements in energy management practices and energy efficiency are evident. The findings in this study has opened new research and development opportunities to identify new alternatives to monetizing environmental concepts such carbon emission and green supply chain activities.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Atmospheric carbon dioxide (CO_2) concentration levels have been rising since tracking began in 1958 and fossil fuel combustion and cement production have contributed 67% of total CO_2 emissions into the atmosphere. CO_2 is absorbed partly by the ocean but in high concentration oceanic acidification is increasing leading to ecological and biological change while continuously rising atmospheric concentration leads to global warming and climate change (Cubasch et al., 2013). While CO_2 is not the only greenhouse gas contributing to the problem, it is the most prolific greenhouse gas produced by human activities (IPCC, 2005).

CO_2 is classified as a greenhouse gas which created as a by-product of consuming non-renewable fossil fuels such coal, petroleum and natural gas as an energy source (Thollander et al., 2007) and recently has been re-evaluated as a type of environmental cost (Lam et al., 2010). Environmental damage from CO_2 emissions lead to climate change which further increases economic risks from severe weather events such as floods which can lead to disruption of supply chain and operational losses (Halldórsson & Kovács, 2010). The threat of economic loss and destabilization of global supply chains due to global warming and climate change has created a vested interest in both governments and the public to become aware of the downsides of unmanaged CO_2 emissions (Dincer; 1999), and this has led to the creation of the Kyoto Protocol and Intergovernmental Panel on Climate Change (IPCC).

Evidence points to rising energy consumption as the primary cause of increasing CO_2 production and thus managing energy efficiency is key to creating a more sustainable economic growth while minimizing environmental and social impact (Saboori et al., 2012).

However it is also important to note that energy is a critical driver of economic activities and rising energy consumption has traditionally been seen as a sign of strong economic growth within a nation (Tugcu et al., 2012) on the other hand there are evidence that shows the causal links between energy consumption to environmental and social health degradation so nations have been wary of making severe changes that upsets the balance between economic growth and the well-being of its citizens and the environment (Ang, 2008). Sustainable energy consumption can slow further environmental degradation such that the Earth's natural carbon sinks have a chance to re-absorb some of the CO_2 emissions in the atmosphere thus preventing further melting of polar ice caps or disruption of biological diversity from acidification of ocean waters (Cubasch et al., 2013). Manufacturing and industrial activity is among the primary consumer of energy and thus responsible for a large part of the world's CO_2 emissions (Abdelaziz et al., 2011) and there is growing pressure on industrial firms to act to ensure they are both energy aware and strive towards greater energy efficiency (Okereke, 2007). In this vein, governmental programmes has been launched to encourage energy intensive manufacturing firms to perform energy audits under the auspice of the Malaysian Industrial Energy Efficiency Improvement Programme, partially funded by the United Nations Development Programme (Akker, 2008) but did not fully meet the expected result.

Energy efficiency improvement has been touted in several previous studies as the most cost effective way to help preserve the environment and at the same time providing cost savings and reputation boosts to the practicing firm, in reality it is discovered that energy efficiency holds a low priority when firms make investment and management decisions, due to economic and technical barriers (Palm & Thollander, 2010; Thollander et al., 2007; DeCanio, 1998). Several research into counteracting the reluctance of firms in adopting more environmentally friendly stance have been done, either through tightening of regulations (Larsen et al., 2012), standardized certification (Bunse et al., 2011) or raising awareness and technical capabilities (Bradford & Fraser, 2008). However still there are many firms who do

not voluntarily participate in carbon or energy management without strong financial incentives. De Groot et al(2001) cites for example rising energy prices, risks to energy security, punitive regulation or market rejection of non-environmentally friendly goods (Bunse et al., 2011) are all considered external pressures on the firm's performance.

External pressure to conform is studied extensively under the subject of institutional theory which states firms will only consider changing their organisational practices based on pressure that work to limit or expand acceptance of new practices (Darnall et al., 2009; Darnall et al., 2010). In this sense there has been a recent surge in adoption of ISO 14000 standards among manufacturer to conform to customer pressure driving sustainable manufacturing (Jayaram & Avittahur, 2014). Tightening regulations in European nations have also driven some of them to export their carbon footprint into Asia (Schaltegger & Csutora, 2012), opening up new markets that is ripe for manufacturing firms to engage and build differentiation via cleaner practices, improved technology and new products (Subramanian & Gunasekaran, 2014). Yet even with all these pressure, manufacturing firms will have not been found to fully adopt environmental considerations in their manufacturing operations.

Globalised supply chains have also been a contributor to carbon emissions and efforts to rein in supply chain's environmental performance have been rising steadily, leading to a development of green supply chain management. Green supply chain management (GSCM) is an area of operation management that strives to reduce the ecological footprints of manufacturing and logistical activities through the integration of environmental consideration to material, processes and internal decision making (Nelson et al., 2012). Such a supply chain integrates environmental thinking into their decisions starting from product and material selection to manufacturing processes, supplier sourcing and delivery as well as end-of-lifecycle waste management (Srivastava, 2007). GSCM practices has since been used as leverage by large buying firms to exert normative pressure on their supplier to adopt necessary environmental practices to remain relevant and competitive (Zhu

et al., 2006). Where governmental regulations are coercive in nature, normative acquiesce is voluntarily adopted to improve inter firm performance and relationship.

The evolution of green supply chains has been driven by business needs since it was first realized that a manufacturing firm could no longer fulfil the needs of its customer. Initially it was entirely focused on production efficiency and ensuring product quality but later evolved to include on time delivery and waste reduction as part of a lean supply chain management; focusing on firm agility and flexibility; before transforming to the current Green Supply Chain model (Nelson et al., 2012). In this form it can be said adoption of GSCM is a firm's response to address the growing influence of external stakeholders with regards to environmental conservation (Walker et al., 2008) and overlooking GSCM hinders operational performance (Yu et al., 2014) because many stakeholders today are highly aware of environmental performance and consider both a firm's economic performance and its "green" credentials as necessary prerequisites in their business dealings (Hervani et al., 2005). This is especially intensive in emerging economics such as South East Asia as changing competitive dimensions (Rao & Holt, 2005) and open potential to exploit the shifting emission responsibility from countries with strict emission regulations (Schaltegger & Csutora, 2012).

It is interesting to note that during literature review of energy efficiency and green supply chain management, both topics share many common grounds in environmental, financial and reputation benefits but are rarely studied together. Both calls for a multi-disciplined approach to enact holistic solutions (Nelson et al., 2012; Ball et al., 2009), highlights the need for management commitment in driving success (Palm & Thollander, 2010; Lee et al., 2013) and calls for raising awareness and capabilities to identify opportunities (Trianni, 2014; Zhu et al., 2008). One of reasons provided by Jeswani et al (2008) indicates that energy efficiency is easily understood by decision makers as a cost saving measure but carbon emissions requires a higher level of environmental awareness and preparedness (Jabbour et al., 2014). Furthermore, the use of carbon accounting is relatively

new, not standardised and rarely used by management due to difficulty in understanding the metrics and value of carbon emissions (Stechemesser & Guenther, 2012).

1.2 Background of study

From the annual statistics provided by the Energy Commission of Malaysia, it is found that year on year energy consumption has grown 3.8% from 97,256GWh in 2012 to 100,999GWh in 2013 of which 83% of that energy is produced using fossil fuel such as natural gas, coal and oil, adding that industrial firms represents a tiny 0.4% of total users of energy but consumes 43% of energy production (Energy Commission, 2013).

In a report to the United Nations Development Programme (UNDP) Malaysia stated their intention to reduce their carbon emission levels by 40% by 2020 through reduction in emission from wastes and energy consumption (Theseira, 2013). As such energy efficiency improvements would allow for significant progress to the stated carbon efficiency goals, however as the Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP) Final Report 2008 states that carbon efficiency improvements have not been significant and energy management has been poorly adopted due to lack of economic incentives and regulation, creating barriers upon firms from investing into effective energy efficiency programmes on their own (Akker, 2008). Appropriate incentives and regulations creates value rather than detracts from the firm's bottom line, creating a "win-win" coercive pressure for the firm to take up additional measures instead of considering it a waste of limited resources (Cote et al., 2008), although it could be challenging to find any "one size fits all solution" as every firm is uniquely affected by them (Lee, 2011).

Most recently the Asean Economic Committee (AEC) has proposed energy efficiency and conservation goals by reaching out to the private sectors to improve energy use through the use of awareness programmes to influence changes in individual behaviour, working methods and energy intensive industrial practices. It also seeks to encourage

technological development and financial backing for energy efficiency and conservation investment and implementation (AEC, 2014). It argues that as member nations of the AEC continues to pursue economic growth; energy consumption and CO_2 emissions are expected to triple the current outputs, putting serious pressure on maintaining energy security and environmental stability (Suryadi, 2012). In the same report it was noted that Malaysia's natural gas reserves are diminishing and the Malaysian government has imposed additional regulations to further improve energy efficiency with the Efficient Management of Electrical Energy Regulations 2008 which will require manufacturing firms consuming more than 3 million kWh (kilowatt hour) over 6 months will be required to engage a registered energy manager, reinforcing the fact that energy efficiency is important and failure to improve incurs additional costs to the business.

Literature of previous studies indicates barriers to energy efficiency stems from poor management support, lack of knowledge or awareness of energy efficiency among employees, high risk of uncertainty from process changes and lack of immediate financial and economic benefits. As a result, firms rarely invest significantly into energy efficiency without external stimulus such as rising energy prices or uncertainty in energy security (Bunse et al., 2011). In the absence of economic driving forces, energy management proposals usually encounter lukewarm reception in management decision making (Palm & Thollander, 2010). Moreover even within firms participating in energy management programmes, the level of commitment given to such programmes differ between firms based on technical capabilities, size of firm, technology employed and other organisational factors (Gordić et al., 2010). National energy policies will need to account for these concerns and provide the necessary encouragement to ensure the stated emission goals are widely supported and achievable without affecting economic viability and competitiveness.

ASEAN nations' export based economy with trading partners from many developed countries means the customers are sensitive to environmental impacts of their consumer behaviours and have in the past successfully influence manufacturers to adhere to certain

minimum environmental standards. Depending on the locale, these standards might be voluntary or regulated but regardless, creates external pressure to react to the needs of the consumer. This external force is the main driver of the development of GSCM within firms and in manufacturing activities, with each supplier along the chain required to conform to all environmental stipulations by the focal firm thus create incentives for supplying firms to also adopt GSCM practices to remain competitive and relevant.

GSCM practices are intended to nurture environmental consciousness in strategic decision making and incorporate systemic organisational and inter-organisational implications of environmentally influential policies. It is expected to provide an alternate driver to influencing energy efficiency investments and strategic thinking within an organisation. Driven primarily by the evolution of customer's behaviour towards "green" products, an economic welfare environment has been born where greening investments have proved to bring significant financial returns by creating competitive advantage through improving brand reputation and influences on existing internal manufacturing processes (Barari et al., 2012). Certain facet of GSCM initiatives in Malaysia has previously been studied and shown to provide measurable performance improvement in internal processes as well as economic benefits to the firm and increased customer satisfaction and loyalty (Eltayeb et al., 2011). Most of all, GSCM practices require the firm to shift existing organisation culture, managerial behaviours and employee thinking process to find innovative solutions to improving environmental performance.

Zero Carbon Manufacturing has been proposed as a perfect balance of economic production while ensuring neutral environmental impact by integrating a comprehensive systems approach involving innovations in manufacturing process, supply chain movement and design of product, where improvements in one system process can be re-applied into another system thus ensuring each solution is not only individually considered, but also fits as an element into a larger system that promotes interdisciplinary work and knowledge

sharing (Ball et al., 2009). Based on the current state of implementation in Malaysia, it is still long way before Zero Carbon Manufacturing can be realized.

1.3 Problem Statement

Energy management is becoming more critical as competition for economic growth intensifies in South East Asia. The ASEAN Economic Community (AEC) is opening their borders in 2015 to allow for freer trade and lower barriers while noting that greenhouse gas emission is an issue that needs mitigation (AEC, 2008). There is an opportunity for regional firms to gain a competitive advantage for their products if they have a green credential to access this brand new emerging market. The Malaysian government has taken steps to improve energy efficiency through new regulations on high energy intensity industries (Suryadi, 2012) and implementing government assisted programmes such as the Malaysian Industrial Energy Efficiency Improvement Programme (MIEEIP) in 2008 to help audit, create awareness and implement improvements in key industries (Theseira, 2013) with the hopes that such practices will become the best practices for the industry. Despite extensive efforts by the United Nations Development Programme (UNDP) and government assistance, voluntary participation in energy efficiency improvements was not found to widely accepted, especially among small and medium sized industries often citing financial and resources problems (UNDP, 2006). As there is some disconnect between established policies and real world performance there is a need to understand the key drivers and dimensions preventing the uptake of energy management among firms in Malaysia.

Research studies have shown industrial adoption of energy efficiency to be lagging behind and there is low commitment within organisation and management to support innovation and investment into energy efficiency due to several factors such as limited technical knowledge (Plambeck, 2012), lack awareness on identifying potential benefits of energy saving (Bunse et al., 2011) and lack of motivation by decision maker to break

predefined processes risking operational losses (Tonn & Martin, 2000) or in employees seeking to avoid change (Kannan & Boie, 2003). Benefits of energy efficiency have been well studied however it is usually in the context of developed nations such as Netherlands (Phylipsen et al., 2002), Sweden (Thollander et al., 2007) and Germany (Kannan & Boie, 2003). In Asian countries, CO_2 emissions are only just gaining interest over economic development as environmental degradation and human health issues become more apparent to public awareness (Rao & Holt, 2005). While pressure is mounting to account for CO_2 emissions in manufacturing, firms finds it difficult to implement effective carbon reduction programmes, partly due to the complexity in determining the sources and causes of excessive carbon emissions (Nakajima et al., 2014) and partly due to the lack of visible direct financial benefits (Schaltegger & Csutora, 2012) especially for smaller firms with low energy intensity (Lee, 2012) unless it can be conclusively proven to be beneficial to the sustainability of the firm (Cote et al., 2008).

Lack of previous studies from a management standpoint on energy efficiency has stymied rapid understanding of energy management among decision makers. Current literature on energy or carbon management is focused on assessment (Shi & Meier, 2012), technology change (Shan et al., 2012) and variation of measurement (Park et al., 2009) which are all in the bounds of engineering and mechanical journals. Even in literature on energy efficiency decision making it is found that managers have difficulty in understanding key terms unless assisted by trained energy efficiency specialists (Sandberg & Söderström, 2003). For smaller businesses it may become a burden to hire a dedicated energy specialist but in initial stages it is still recommended as the experts brings with them experience from other industry practices which is invaluable in motivating interest and awareness of issues among practitioners of energy management (Kannan & Boie, 2003). Thollander et al (2007) discussed about “Project Highland” where energy auditors are assigned by the local authorities to help conduct initial assessment and training does indeed seems to bring positive results in energy conservation, however a similar programme by the MIEEIP

produced only limited and short term improvements (Gan et al., 2013) signifying there are other factors in play in promoting energy management programmes.

Implementing an energy management programme requires organisational changes from top management down to the employees to break from the “business as usual” mindset that operational management is usually focused on (Lozano, 2012). In fact standardized energy management programmes such as ISO 50001 proposes a multistep process to encourage awareness, adoption and implementation of energy efficiency (ISO, 2011) although previous research indicates the perception of energy efficiency differs based on industry sector, firm size and energy intensity (Bradford & Fraser, 2008). This variation is a result of limited slack resources that the firm can call upon (Plambeck, 2012) and the management’s focus on “attention economy” where it is more important to maximize profits using the limited time and human resources available, instead of expanding capabilities on future long term needs (Cote et al., 2008). Success in energy management programmes requires sufficient organisation resources to be allocated, support from both the management and staff and appropriate skills to implement changes (Jabbour et al., 2014).

As the MIEEIP project discovered, the local Malaysian economic environment prevents effective use of standardized practices due to risk avoidance, lack of knowledge and awareness, having low management commitment, low level of support from employees plus lack of economic incentives and regulations (Theseira, 2013). Voluntary energy efficiency programmes in other countries have largely been driven by energy security and prices especially those with high dependency on imported energy source (Hepbasli & Ozalp, 2003) which is not a high priority for most firms in Malaysia although the new Electrical Energy Regulation 2008 is trying to change this. Exacerbating the problem supply chain activities have been mostly ignored by management as a function of the procurement department only and not considered as a holistic operation required by every facet of the business’ performance (Nakajima et al., 2014).

Green supply chain management (GSCM) however is a part of a business' growing supply chain value stream and a major differentiator for competitive advantage due to growing customer demands for low environmental and social impact goods (Seuring & Müller, 2008). Participation in greening the supply chain has received much better response from manufacturing firms where extensive studies have been done to quantify the monetary benefits of going green (Zhu et al., 2011; Zhu et al., 2013). Whether voluntary or coerced by market forces, previous studies of Green Supply Chain Management (GSCM) shows positive improvement of environmental performance in firms in terms of waste reduction, air and water quality but in the context of supplier management, transportation, product lifecycle, materials and design of products but not in the manufacturing process (Yu et al., 2014). It is to note however the term "green" is very loosely defined and certain firms may associate it with lean supply chains which does focus on strategies to minimize waste, non-value added activities and improving equipment utilization (Kim & Min, 2011) whereas GSCM strategies focus on minimizing the impact of supply chain on the natural environment (Mollenkopf et al., 2011).

There is a need for an indicative framework that assists in decision making on energy management and carbon management programmes which can be quantified and related to the firm's green supply chain performance metrics which are commonly available, well understood and have known value to managers.

1.4 Research Questions

This study strived to answer the following research questions to develop an underlying understanding of the proposed framework. The proposed framework attempts to answer the following states:

i) Does energy efficiency leads to carbon emission reduction?

ii) Do energy management practices improve energy efficiency?

iii) Do energy management practices lead to carbon emission reduction?

iv) Is there a relationship between energy management practices on green supply chain performance?

v) Is there a relationship between green supply chain performances toward energy efficiency?

vi) Is there a relationship between green supply chain performances on carbon emission reduction?

vii) Does the green supply chain mediate the relationship between energy management practices towards energy efficiency?

viii) Does the green supply chain mediate the relationship between energy management practices on carbon emission reductions?

1.5 Research objectives

Research objectives are used in pursuant of the stated research questions and are the basis of which hypotheses used to test the proposed framework will be based on. Based on the previous section, this study engages in the following research objectives.

i) To examine if energy efficiency leads to positive carbon emission reduction

ii) Investigate whether energy management practices leads to improving energy efficiency

iii) Investigate whether energy management practices leads to positive carbon emission reduction

iv) Examine the effect of energy management practices on green supply chain performance

v) Examine the effect of green supply chain performance on improving energy efficiency

vi) Examine the effect of green supply chain performance on increasing carbon emission reduction

vii) To find out if there are any empirical justification for green supply chain performance to mediate the relationship between energy management practices towards energy efficiency

viii) To find out if there are any empirical justification for green supply chain performance to mediate the relationship between energy management practices towards carbon emission reduction

1.6 Significance of study

This study contributes to further development of theoretical knowledge of energy management, carbon management and green supply chain. It also strives to provide practical contribution which may then be applied by the industry and finally societal benefits for both general stakeholders and the industry themselves.

1.6.1 Theoretical Contribution

This study contributes to supporting several findings in existing literature on energy management and energy efficiency in relation to its application within Malaysia as it has not been done before. Current literature on carbon and energy management is mostly based on developing engineering and mechanical measurements (Okereke, 2007), but less so from the view point of organisation theory.

This study also tries to expand existing literature on carbon management and green supply chain by proposing a new theoretical framework linking a firm's green supply chain performance to its energy and carbon management performance. Part of the current problem had been the difficulty to quantify the value of carbon reduction in the long term and low energy intensity of many firms (Saboori et al., 2012) and the lack of a proper understanding of carbon accounting among Malaysian manufacturing firms (Schaltegger & Csutora, 2012).

If green supply chain performance is found to support the development of energy management or carbon management or vice versa, it would greatly expand both current theoretical knowledge; especially since existing literature on energy management rarely focuses on carbon emissions as the outcome; and create new practical applications from a management standpoint.

It also studies the mediating role of green supply chain performance towards improving internal energy management practices that will lead to both energy efficiency improvements and carbon emission reduction. This mediating factor is novel to this study as while green supply chains have in the past measured environmental performance as part of its metrics (Zhu et al., 2006) there is limited evidence to suggest that green supply chain functions as a mediator to improving performance of energy efficiency. By linking green supply chain management into the model, it helps visualize the relationship supply chains play in developing energy efficiency and also how internal organization practices can affect the firm's supply chain performance, providing yet another avenue of institutional pressure that can be applied in future studies using the theoretical framework.

1.6.2 Practical Contribution

Decision makers face multitudes of conflicting alternatives on a daily basis and have a tendency to focus on the most beneficial outcomes using the limited amount of resources available to them. This study attempts to suggest a new value stream for both green supply chain and energy management, ultimately leading to improved carbon emission reductions. This current gap exists because there is a lack of understanding on the economic benefits or opportunities available to exploit on the part of industry leaders (Jabbour et al., 2014). By proposing several practical dimensions to study, it tries to find a working relationship between organisation practices and positive performance outcome thus allowing firms to better channelling their limited resources to achieving higher performance in their energy

initiatives. In the past environmental and carbon emission consideration has been ignored as it is deemed complex and inconsequential (Cote et al., 2008).

For this reason, understanding the intensity of these energy management practices is the key to designing appropriate policy, incentives and regulation for enhancing desirability of energy efficiency within the industry. This "energy efficiency gap" needs to be explored further because the usual economic forces that drive organization change have fails to encourage firms to evolve in the desired direction (Thollander et al., 2010). On the other hand green supply chain management have often been cited as an effective normative driver that promotes adoption of better environmental practices that is balanced with economic or productivity benefits to the firm while providing significant improvements to the environment and society. If green supply chain does play a mediating role in the relationship between energy management practices towards energy and carbon management performance, it would create a new instrument for policy makers to use and leverage higher adoption of future energy management programmes.

Decision makers can also make use of the findings of this study to help justify development costs in their organization, either in training or execution of energy improvement projects, where the findings indicates positive expectations in those areas. This study also tried to find a positive feedback loop between internal energy management practices to the firm's green supply chain performance (e.g. higher energy management practices leads to higher green supply chain performance, which then mediates a better relationship between energy management and energy efficiency or carbon emission) leading to overall performance improvements to all operational activities within the firm. Such finding would indicate support for firms to invest and develop their energy management programmes to realise immediate economic benefits from cost savings to long term overall benefit of higher productivity, reduced wastes and optimization of profits.

1.6.3 Societal contribution

Through improvement of energy efficiency, carbon emission are expected to drop below the threshold of the earth's capability to re-absorb atmospheric CO_2 and as a result halt further climate change which threatens the livelihoods of humans and industry alike. Reducing energy consumption also leads to better energy security and sustainable energy prices for everyone that relies on it be it the consumers or industrial players. Rising awareness and technical capability of firms in energy management invites innovation among manufacturers to develop new energy efficient products for the masses and further leads to other sustainable practices in the long term. Renewed focus on supply chain performance also increases inter firm development for the betterment of the environment and society on a proactive and voluntary basis, rather than through governmental regulations which usually lags behind, resulting in a healthier, happier and safer working environment

1.7 Definition of Key Terms

1. **Energy Management Practices** – a cyclic set of activities in a firm intended to collect, analyze, plan and implement reduction of energy consumption within the firm (Abdelaziz et al., 2011; Palm & Thollander, 2010; Gordić et al., 2010; Kannan & Boie, 2003).

2. **Energy Audit** – activities relating to the measurement, monitoring and collection of energy consumption data in the manufacturing processes, product, equipment or facilities for the purpose of identifying opportunities for improvements and establishing a benchmark for comparing energy use before and after efficiency improvement implementation (Antunnes et al., 2014; Bunse et al., 2011; Lee et al., 2011; Kanako, 2008; Zhu et al., 2008).

3. **Energy Awareness** – the ability to understand the importance and value of energy management, including the ability to identify sources of energy inefficiency and the motivation to support efforts in correcting the inefficiency (Jabbour et al., 2014; Trianni et al., 2014; Palm & Thollander, 2010; Kannan & Boie, 2003).

4. **Energy Knowledge** – the technical capability to design and implement energy efficiency improvement projects and make correct judgements when faced with competing technology, products or solutions for implementing energy efficiency improvements (Trianni et al., 2014; Plambeck, 2012; Bunse et al., 2011; Palm & Thollander, 2010).

5. **Management Commitment** – the level of support from management to allocate sufficient resources, time and manpower towards developing an energy management system plus supporting and encouraging participation in proposed energy improvement activities to ensure success (Jabbour et al., 2014; Zhu et al., 2013; Bradford & Fraser, 2008; Kannan & Boie, 2003).

6. **Green Supply Chain Performance** – a measurement of a firm's supply chain performance in terms of improvement in economic gains, reduction in environmental degradation and social contribution (Varsei et al., 2014; Zhu et al., 2013; Yu et al., 2013; Vachon & Klassen, 2008).

7. **Energy Efficiency** – changes in the total energy consumption used by a process, equipment or product after energy management practices have been applied (Martin et al., 2012; Kanako, 2011; Bunse et al., 2011; Phylipsen et al., 2002).

8. **Carbon Emission Reduction** – activities that leads to decreasing levels of CO_2 or CO_2 equivalent gases that produces the greenhouse effect that leads to global warming, climate change and degradation of human quality of life (Benjaafar et al., 2013; Schaltegger & Csutora, 2012; Soytas et al., 2007).

1.8 Structure of dissertation

This dissertation comprises of five (5) chapters. The first chapter introduces the reader with the subject and comprises of a brief background of the study, the problem statement, the research questions and objectives and ending with a glossary of key terms used in this dissertation. In Chapter 2 it presents a review of existing studies that has been conducted on energy management, energy efficiency, carbon emissions, green supply chain and the theoretical framework proposed. Chapter 3 deals with the research methodology used in this study and provide information on the measures used such as the survey instruments, sampling methods and analysis techniques used. In Chapter 4 the result of data analysis collected using methods discussed in Chapter 3 is provided, including the descriptive statistics of respondents, confirmatory factor analysis and the structural equation model results. Conclusion and implications drawn from the results are discussed and explained in Chapter 5 which also includes a brief discussion on the limitation of this study and future avenues of research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of existing literature regarding the study. It begins with a brief informatics on the current state of Malaysian manufacturing firms and their greenhouse gas emissions, followed by a review of the theory used in this study. An in-depth review of previous studies is then conducted to better understand and formulate a theoretical framework that will be tested in the later part of this dissertation.

2.2 Manufacturing Industry in Malaysia

The development of manufacturing industry in Malaysia occurred shortly after the achievement of independence in 1957, when British investment in the mid-1960s persuaded the government to switch from being a raw material exporter to a labour intensive, export-oriented manufacturing industry but significant growth did not occur until the 1970s and peaked in the mid-1980s (Jomo, 2013). As Malaysia's primary economic contributor shifted from agricultural to industrial manufacturing, energy consumption has been steadily increasing in relations to the annual gross domestic product (GDP) growth rate (Begum et al., 2015). There is evidence that foreign direct investments (FDI) has increased industrial emissions and accelerated environmental degradation however there is also evidence of a U-shaped relationship in which environmental quality worsens at lower income levels and steadily improves as income increases (Lau et al., 2014). Gan et al (2013) investigated the relationship between industrial energy consumption and GDP growth and found that energy consumption is growing at a faster rate (7.1% per annum) than GDP growth (6.1% per annum) as a result of rapid industrialization and although there are evidence that Malaysia is

shifting its economic focus towards a service-based economy thus slowing down industrial growth, industrial energy consumption is still expected to be a major consumer of energy; forecasted at 44% of total demand in 2035 (Gan et al., 2013). Among the industrial sectors in Malaysia, mineral processing such cement or quicklime production is the primary contributor to energy consumption and carbon emissions due to the use of older technology and processes, followed by steel product and chemical industry (Hosseini et al., 2013). Foreign direct investment (FDI) have helped accelerate industrialization in the past but there is evidence that increased FDI investment, it was observed to also increase industrial emissions and environmental degradation (Lau et al., 2014)

2.3 Malaysian manufacturing greenhouse gas emission

The primary cause of greenhouse gas emissions in Malaysia manufacturing firms can be traced to three sources, firstly electricity consumption, secondly the direct combustion of fuels in the manufacturing process and third, fuel consumed in logistical activities (Hosseini et al., 2013). Efforts in the past to reduce carbon emissions through government sponsored programmes such as the Malaysian Industrial Energy Efficiency Improvement Project have managed to reduce 0.3% of the total industrial demand for energy but have had no lasting effect (Gan et al., 2013). Furthermore policy makers are wary of tightening regulations on emissions standards because it was found productivity growth rates were stunted when CO_2 emissions were included as part of the productivity indicator (Ahmed, 2006). Electricity generation is a primary contributor to carbon emissions due to historical availability of cheap fossil fuels in Malaysia (Begum et al., 2015) however if energy consumption continues to grow at the current rate, it is expected by 2030 the energy demand would triple (Gan & Li, 2008). It was noted however the eco efficiency among Malaysian firms with regards to energy consumption and carbon emissions vary from state to state, with higher efficiency recorded in states with free trade or industrial zones which is attributed to export oriented

manufacturers based in those locations (Ramli & Munisamy, 2015) thus there are good reasons to study the causal effect of these variations. Ramli and Munisamy (2015) proposed that these firms are exposed to foreign requirements or possibly received technology transfers which enabled their improved eco performance.

2.4 Institutional theory

In a review of organizational theories by Sarkis et al (2011), it links the application of various organizational theories to supply chain management to explain factors driving adoption of green supply chain. In this study, institutional theory has been selected as the basis of the theoretical framework design. Institutional theory establishes that external pressures influences organization actions (Hirsch, 1975), with three sub drivers within institutional theory that enables firms to take action. Coercive drivers are legitimate influence from a position of power such as governmental regulations. Normative drivers forces firms to adhere to regulations to be seen as a legitimate organization and mimetic driver enables firms to replicate successful competitors (Sarkis et al., 2011). External pressure and availability of internal resources have enabled successful implementation of environmental management (Clemens & Douglas, 2006). Several study has already established that one of the green supply chain strategy employed by large buying firms is to exert pressure on their suppliers to adopt environmental measures (Zhu et al., 2006) and the role institutional theory plays in the interaction (Zhu et al., 2010). Growing customer pressure has also influenced firms to certify themselves for ISO 14000 Environmental Management and adopting overall sustainable strategies in their business operations (Jayaram & Avittathur, 2014) to stay relevant. This is supported by the findings of Zhu et al (2013) where mimetic, competitive and normative pressure was found to significant affect internal operation improvement but at the same time by focusing the firms' resources inwards it results in poorer external collaboration efforts. The influences from customers are

mainly a result of transference of carbon emissions from foreign customers due to over restrictive emission regulations and renewed focus on transportation and supply chain carbon footprint (Lai et al., 2012). Darnall et al (2009)(2010) however cautions that external pressure does not always bring positive changes, but depending on the firm's position and situation it can be positive, negative or even neutral.

2.5 Carbon Emissions

Carbon dioxide (CO_2) is the most prolific greenhouse gas produced from human activities (IPCC, 2005) and represents a type of environmental cost that is paid for by adverse climate change (Lam et al., 2010). To address growing concern with ever rising carbon emissions levels, recent actions by both governmental and non-governmental actors have changed corporate behaviour from lobbying against tightening environmental policies to adoption of voluntary firm-specific climate management strategies (Okereke, 2007). Plambeck (2012) suggests firms do so because they believe are cost reduction benefits while providing reputation benefits with stakeholders and leverage with governments to affect regulation policy setting. Furthermore Bunse et al (2011) explains that rising energy prices and changing customer demands for environmentally friendly products have created a need for firms to adapt to changing market perception. Okereke (2007) also explains that stakeholder fiduciary management requires planning for sustainable business development as investors become more aware of the negative impact of environmental risk and seeks firms who are proactive at minimizing business loss resulting from inaction on environmental issues. He also considers it the ethical responsibility of the firm to ensure their operation does not impact future needs. On the other hand, greenhouse gas emission levels are still rising despite ambitious targets set in countries with strict emissions standards because such regulations are creating pressure for firms to shift responsibility towards imported goods from counties with lax regulations (Larsen et al., 2012). In such a case, the escalating energy

demands for sustaining rapid economic growth will continue to worsen CO_2 emission levels as long as fossil fuels remain the primary fuel mix for energy production (Oh & Chua, 2010). Plambeck (2012) goes on to explain that rising greenhouse gas emissions are related to variability of demand called the "bullwhip effect" where a small change in consumer demand leads to a great fluctuation of demand on upstream manufacturers, especially for basic material production.

While Soytas et al (2007) has empirically proven that reducing energy consumption will lead to a decrease in carbon emissions without any long term harm to business growth prospects but difficulties in quantifying the value of carbon emissions to firm performance in real world measurement have delayed implementation of carbon management as business managers have not been wholly motivated to take an interest in environmental issues and may lack awareness without direct external stakeholder pressure (Bradford & Fraser, 2008). Saboori et al (2012) supports this finding and offers that current literature and research focuses on providing general understanding of how each of the variables are related but does not offer sufficient guidance on reducing carbon emissions. The large number of possible sources of carbon emission further muddles decision makers as alternatives such as material selection, energy mix, technological advancement and process improvements are all viable alternatives which require deep understanding of each alternative (Ball et al., 2009). Researchers themselves are split in terms of viable alternatives where Zhang and Cheng (2009) strongly recommends technological change as the method of reducing energy intensity while Benjaafar et al (2013) shows carbon reduction can be achieved through operational adjustment alone without costly technological changes. Plambeck (2012) suggests using knowledge collaboration between firms improve best practices due to shortages in knowledgeable professionals but on the other hand Ball et al (2009) argues that interdisciplinary cooperation internally can provide effective solutions and in Benjaafar et al (2013) states that collaboration reduces costs but does not always lead to lower total emission levels. Clearly there are many future directions for further research to improve

upon for a holistic solution. Bunse et al (2011) offers that standardization of management system such as ISO 14001 will lead to improved transparency of internal processes that improves stakeholder's understanding and helps convince them to commit to further improving environmental performance. The opposite is offered by Rondinelli and Vastag (2000) where it is found that certification does not actually assess the real environmental performance of the firm but assumes the controls used by the firm will somehow mitigate its environmental impact.

In terms of industrial support for emissions reduction, Tanaka (2011) postulated that industrial coverage on energy and carbon management is proportional to the motivational power provided by rewards or penalties. The sparse number of literature on long term value of carbon emission reduction coupled with general lack of governmental direction and in the absence of strong policy creates uncertainty for firms to adopt carbon management and where the market demands environmentally friendly product, it is not a mature market; fraught with uncertainty whether the market will respond favourably to a new product (Okereke, 2007). Plambeck (2012) also expounds on the lack of literature on climate change from the viewpoint of operation or production management, instead the current literature tries to quantify disruption as a result of climate change or effect of costs in terms of taxation and penalties on motivating changes. Current prescribed reduction methodologies are also impractical for many firms to comprehensively address energy efficiency (Bunse et al., 2011) and data aggregate methods for measuring carbon footprint does not allow for detailed analysis of individual firms (Benjaafar et al., 2013). It is also hard to prove empirically the link between carbon emissions and economic benefits at this time (Saboori et al., 2012). In this sense the researchers suggests a need for to develop a new quantitative model that accounts for carbon emissions in determining how operation decisions will lead to financial benefits for the firm. Meanwhile Ball et al (2009) also agrees that lagging awareness to the cost of carbon emission is preventing manufacturing systems which focuses on efficient flows and performance metrics from adopting additional emission measures.