



A CAUSAL MODEL OF GREEN SUPPLY CHAIN MANAGEMENT FOR MANUFACTURING INDUSTRY



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A CAUSAL MODEL OF GREEN SUPPLY CHAIN MANAGEMENT FOR MANUFACTURING INDUSTRY

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Doctor of Philosophy

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**A CAUSAL MODEL OF GREEN SUPPLY CHAIN MANAGEMENT FOR
MANUFACTURING INDUSTRY**

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this thesis entitled “A Causal Model of Green Supply Chain Management for Manufacturing Industry” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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DEDICATION

In the name of Allah, the Most Gracious, the Most Merciful and all praises to the Prophet, Muhammad S.A.W. Alhamdulillah, praise to Allah for His mercy, I have successfully completed this thesis.

I would like to take this opportunity to extend my utmost gratitude and sincere appreciations, especially to my beloved husband, *Muhamad Elias Bin Zainol Abidin* for his support and sacrifice to confront with all problems and difficulties along this journey, mentally and physically. Thanks for the patience and endless support. You were there behind me at single step that I took from the beginning of this wonderful adventure. I am so indebted to you and there is no way to repay it. Thank you, for everything. This thesis is, naturally, dedicated to our love.

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May Allah rewards all of you with a goodness and prosperity, here and hereafter.

ABSTRACT

Requirements and needs from stakeholders, government, non-government agencies and competitive market environment have urged manufacturing industries to implement the Green Supply Chain Management (GSCM) initiatives, such as increase the used environmentally friendly material, optimizing the process as well as awareness related to environmental issues and etc. in their operation. The successful implementation of GSCM is important, mainly to increase the economic performance and sustainable of business. There are various factors, external and internal, that are associated with Supply Chain Management (SCM) in planning and executing the concept of GSCM. Therefore, the awareness on its long-term effect of implementation in terms of practices, strategies and benefits can be obtain should be always prioritised. The roles of each factor and the relationship among factors is important in implementing GSCM. Lack of focus to understand these factors is perceived to increase the difficulties in implementing a better GSCM practices. Using Multicriteria Decision-Making (MCDM) method, each factor that contributes to managing GSCM practices has been studied. The results then used to evaluate the important factors in GSCM practices, mainly to give a better understanding based on causal relationship amongst the identified factors. In this research, main data were gathered from survey involving 241 manufacturing companies in Malaysia. From the survey, sixty-one (26.14%) questionnaires were returned and used for further analysis using the IBM SPSS software version 16. From factor analysis, one factor has been identified representing Work System Performance (WSP). The Work Responsive Practices (WRP) consists of three main factors, namely Quality Control (QC), Process Management (PM) and Evaluation Management (EM). While, for Strategic Environmental Practices (SEP), three factors has been identified, namely Recycling Commitment (RC), Natural Usage (NU) and Optimisation of Usage (OU). The Profits (PR) and Reputation (RP) were the two factors representing Manufacturing System Achievement (MSA). As for Green Supplier Strategy (GSS), there were two factors identified, which were Guiding Supplier (GS) and Awareness (AW). Based on all these factors, a research model was developed using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach. Through DEMATEL all these factors then used in further analysis using ten pairwise questionnaires. The interrelationship among factors has been reviewed and validated by seven experts from manufacturing firms. This research model is significant as a references in providing the specific view to understand and considering the main factors in implementing the GSCM in the most effective way. This subsequently will assist industrial player as a guidance in determining the initiatives in implementation of an efficient GSCM in their manufacturing organisation.

MODEL PENGHUBUNGKAIT BAGI PENGURUSAN RANTAIAN PEMBEKALAN HIJAU UNTUK INDUSTRI PEMBUATAN

ABSTRAK

Kehendak dan keperluan pemegang taruh, kerajaan, agensi bukan kerajaan dan persekitaran pasaran yang kompetitif telah mendesak industri pembuatan untuk melaksanakan inisiatif Pengurusan Rantai Bekalan Hijau (GSCM), seperti meningkatkan penggunaan bahan mesra alam, mengoptimalkan proses, serta kesedaran berkaitan isu alam sekitar dan sebagainya dalam operasi mereka. Kejayaan pelaksanaan GSCM adalah penting terutama dalam meningkatkan prestasi ekonomi dan kelestarian perniagaan. Terdapat pelbagai faktor, luaran dan dalaman yang dikaitkan dengan pengurusan Rantai Bekalan (SC) dalam merancang dan melaksanakan konsep GSCM. Justeru, kesedaran tentang kesan jangka panjang pelaksanaannya dari segi amalan, strategi dan faedah yang akan diperolehi harus sentiasa diutamakan. Peranan setiap faktor dan hubungan antara faktor adalah penting bagi pelaksanaan GSCM. Kurangnya fokus dalam memahami faktor-faktor ini dilihat boleh meningkatkan kesukaran pelaksanaan GSCM dengan berkesan. Melalui penggunaan pembuat keputusan berbilang kriteria (MCDM), setiap faktor yang menyumbang dalam mengurus amalan GSCM dikaji. Dapatannya kemudian digunakan untuk menilai faktor penting dalam amalan GSCM bagi memberi pemahaman yang baik berdasarkan hubungan sebab akibat antara faktor yang dikenal pasti. Dalam kajian ini, data utama diperolehi melalui kajian tinjauan melibatkan 241 syarikat pembuatan di Malaysia. Daripada tinjauan tersebut, sebanyak enam puluh satu (26.14%) soal selidik telah dikembalikan dan seterusnya digunakan untuk analisis lanjut dengan menggunakan perisian IBM SPSS versi 16. Melalui analisis faktor, satu faktor telah dikenalpasti mewakili Prestasi Sistem Kerja (WSP). Amalan Responsif Kerja (WRP) pula terdiri dari tiga faktor utama, iaitu Kawalan Kualiti (QC), Pengurusan Proses (PM) dan Pengurusan Penilaian (EM). Manakala, Amalan Persekitaran Strategik (SEP) diwakili oleh tiga faktor telah iaitu Komitmen Kitar Semula (RC), Penggunaan Bahan Semulajadi (NU) dan Pengoptimuman Penggunaan Bahan (OU). Keuntungan (PR) dan Reputasi (RP) adalah dua faktor yang mewakili elemen Pencapaian Sistem Pembuatan (MSA). Bagi Strategi Pembekal Hijau (GSS) pula, terdapat dua faktor yang dikenal pasti iaitu Bimbingan Pembekal (GS) dan Kesedaran (AW). Berdasarkan semua faktor terlibat, model kajian dibangunkan menggunakan pendekatan makmal percubaan dan penilaian membuat keputusan (DEMATEL). Melalui DEMATEL, faktor-faktor terlibat digunakan dalam analisis lanjutan melalui sepuluh soalselidik pasangan. Hubungan antara faktor tersebut digunakan dalam membangunkan model kajian akhir. Model kajian ini seterusnya disemak dan disahkan oleh tujuh orang pakar dari firma pembuatan. Model kajian ini adalah signifikan sebagai rujukan dalam memberi gambaran secara lebih spesifik untuk memahami dan mempertimbangkan faktor-faktor utama dalam pelaksanaan GSCM dengan lebih baik. Ini seterusnya membantu pemain industri dalam merancang dan menentukan inisiatif yang diperlukan bagi pelaksanaan GSCM dengan lebih cekap dalam pengurusan organisasi pembuatan.

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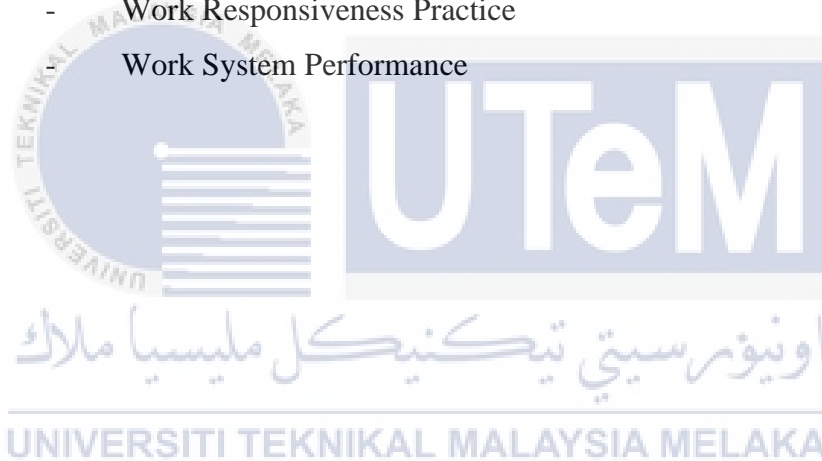
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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
AW	-	Awareness
DEMATEL	-	Decision Making Trial and Evaluation Laboratory
EE	-	Electronic Engineering Industry
EM	-	Evaluation Management
ERP	-	Extended Production Responsibility
ERP	-	Enterprise Resource Planning Systems
GS	-	Guiding Suppliers
GSCM	-	Green Supply Chain Management
GSS	-	Green Supplier Strategy
HCSC	-	Health Care Supply Chain
IRENA	-	International Renewable Energy Agency
ISM	-	Interpretive Structural Modelling
IT	-	Information Technology
KeTTHA	-	Minister of Energy, Green Technology and Water
KMO	-	Kaiser-Meyer-Olkin Measure
MCDM	-	Multi Criteria Decision Making
ME	-	mechanical engineering
MGTC	-	Malaysian Green Technology Corporation
MID	-	Minister Industry Dialogue
MSA	-	Manufacturing System Achievement
MW	-	megawatts
NU	-	Natural Usage
OEE	-	Overall Equipment Efficiency
OU	-	Optimization of Usage

PM	-	Process Management
PR	-	Profits
QC	-	Quality Control
R&D	-	Research and Development
RC	-	Recycling Commitment
RP	-	Reputations
SC	-	Supply Chain
SCM	-	Supply Chain Management
SEP	-	Strategic Environment Practices
SPC	-	Statistical Process Control
TPM	-	Total Productive Maintenance
TQM	-	Total Quality Management
WRP	-	Work Responsiveness Practice
WSP	-	Work System Performance



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Journals:

1. Norhafiza Mohamed, Wan Hasrulnizzam Wan Mahmood, Muhamad Zaki Yusup, 2023. Strategic Environment Practices Model for Green Supply Chain Management Using The DEMATEL Method. *Journal of Sustainability Science and Management*, 18(1), pp. 86-101.
2. Norhafiza Mohamed, Wan Hasrulnizzam Wan Mahmood, Mohd Razali Muhamad, Muhamad Zaki Yusup, 2020. Initial Study of Factors on Green Supply Chain Management, Green Supplier Strategy and Work System Performance. *The International Journal of Integrated Engineering*, 12(5), pp. 178-184.
3. Norhafiza Mohamed, Wan Hasrulnizzam Wan Mahmood, Mohd Razali Muhamad, Muhamad Zaki Yusup, Rahayu Tukimin, 2019. Development of Sustainable Supplier Selection Model using DEMATEL for Manufacturing Industry. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(4), pp. 11003-11006.

4. Norhafiza Mohamed, Wan Hasrulnizzam Wan Mahmood, Mohd Razali Muhamad, Muhamad Zaki Yusup, 2017. The Influence of Environmental Actions and Customer Activities in GSCM on Operational Performance. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 6(1), pp. 20-27.

5. Wan Hasrulnizzam Wan Mahmood, Norhafiza Mohamed, Mohd Razali Muhamad, Muhamad Zaki Yusup, 2014. A Review on The Interaction Component In Formulating Sustainable Supply Chain Management. *Special Issue. Science. International (Lahore)*, 26(5), pp. 1631-1634.

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1. Norhafiza Mohamed, Wan Hasrulnizzam Wan Mahmood, Mohd Razali Muhamad, Muhamad Zaki Yusup, Rahayu Tukimin, 2019. Development of Sustainable Supplier Selection Model using DEMATEL for Manufacturing Industry. *International Innovation Technology Exhibition & Conference 2019 (i-Tec '19)*. 24-25 September 2019. Terengganu, Malaysia.

2. Norhafiza Mohamed, Wan Hasrulnizzam Wan Mahmood, Mohd Razali Muhamad, Muhamad Zaki Yusup, Rahayu Tukimin, 2018. Interaction between Work System Performances with Process of Greening the Supplier. *Innovative Research and Industrial Dialogue '18 (IRID 2018)*. 18 July 2018. Malacca, Malaysia.

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CHAPTER 1

INTRODUCTION

1.1 Background

With the implementation of better innovations, the production process has evolved. The world is now focusing in sustaining the environment and increasing profits. In improving the profits, some disadvantages that affect the environment occurred, such as impact of solid wastes, pollution of water, air, and land. Figure 1.1 shows the statistics from 2013 to 2020. It showed that scheduled wastes recorded 4.0 million tonnes from the healthcare services industry, which indicated an increase of 7.5%.

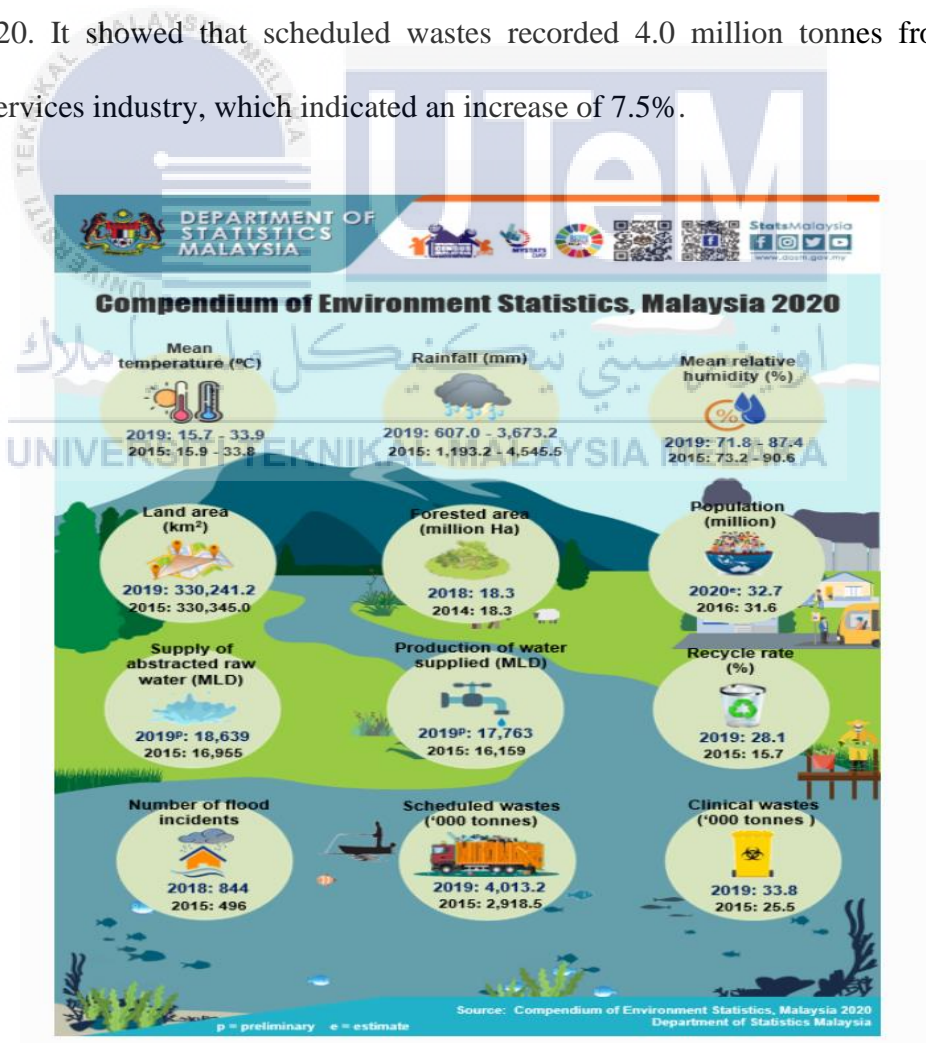


Figure 1.1: Compendium of Environment Statistics, Malaysia (Department of Statistics Malaysia Official Portal, 2020)

For this reason, Malaysia is committed and realises the benefits and opportunities created by energy efficient development with consideration to optimise the usage of waste management. The Minister-Industry Dialogue (MID), for example, provided a venue for high-level governmental and business players to address energy efficiency and sustainability. The Minister of Energy, Green Technology, and Water (KeTTHA) presided over the MID, which focused on the energy ecosystem and how to maximise the effect of energy-efficient and sustainable initiatives across the board. The programme included feedback and questions from several industry executives who were present in the audience, in addition to a debate among the panellists (International Investor Malaysia, 2018). This ensured that the MID took a dynamic and comprehensive approach to address the key issues facing leading economic sectors in relation to energy efficiency and sustainability.

To replace non-renewable and polluting technologies, it is crucial to support the use of renewable energy resources, as well as to reduce energy consumption (Hou et al., 2020). Therefore, Malaysia supports the requirement in renewable energy. This was proven based on the Renewable Capacity Statistics report by the International Renewable Energy Agency (IRENA) in 2021, whereby Malaysia's total renewable energy increased throughout the years. Figure 1.2 shows the statistics of total renewable energy from 2011 to 2018 in megawatts (MW). The energy consisted of hydropower, marine energy, wind energy, solar energy, bioenergy, and geothermal energy that meets the green supply chain management (GSCM) requirements that used a natural source (IRENA, 2021).

According to Vanwalleghem and Mirowska (2020), the market share of sustainable investments had grown in recent years. This means that sustainability is crucial for all businesses, across all industries. Sixty-two percent of executives considered a sustainability strategy is necessary to be competitive today, and another 22% considered it for future undertakings (Haanaes, 2016). Briefly, sustainability is a business tactic to form long-term

values by taking into consideration how a certain business works in the ecological, social, and economic environment. Sustainability is constructed on the supposition that developing such approaches encourage a company's resilience.

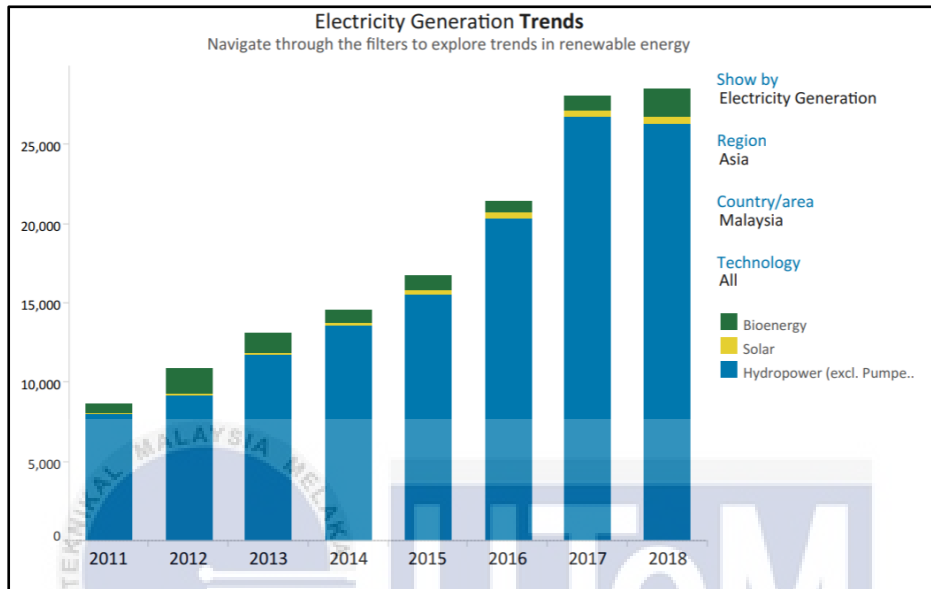


Figure 1.2: Total Renewable Energy in Malaysia (IRENA,2021)

The Supply Chain Management (SCM) was conceived as a result of the changes in this revolution. SCM is the integration of significant decisions from end-users to original suppliers that offer products, services, and information to customers and other stakeholders (Esper, 2021). For the purpose of securing the environment, “green” terms were adopted in the SCM and it was later named as the green supply chain management (GSCM).

The GSCM is a popular concept worldwide. For many organisations, it is a way to show their genuine commitment to environmental sustainability (Mahmood et al., 2012; García et al., 2020). A balance between economic growth and environmental quality is very important to achieve this. Al-sheyadi et al. (2019) believed in order to achieve sustainable development, green initiatives had to be immediately implemented across diverse industries to mitigate and reduce the negative environmental impact. In 1992, the International Institute