



UNIVERSITI PUTRA MALAYSIA

***DEVELOPMENT OF EVALUATION MODEL TO IMPROVE GREEN
SUPPLY CHAIN MANAGEMENT BY APPLYING DEMATEL TECHNIQUE***

ELHAM FALATOONITOOSI

FK 2013 92



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By

ELHAM FALATOONITOOSI

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfillment of Requirements for the Degree of Master of Science**

April 2013

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DEDICATION

I thanked form ALLAH for everything that I have in my life

This research is dedicated to people whom I love so much

*Especially to MY MOTHER who love me strongly more than everything in the world
even more than herself and support me during all moments of all my life*

To my supervisor Prof ZULKIFLLE BIN LEMAN

*To my best friend Dr SHAHRJAR SOROSHTIAN how have helped and guide me
to achieve my goal*

And

Those who have helped me

2012

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirements for the degree of Master of Science

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April 2013

Chairman : Associate Professor Zulkiflle b. Leman, PhD

Faculty : Engineering

Green supply chain management (GSCM) has become a practical approach to develop environmental performance. Under strict regulations and stakeholder pressures, enterprises need to enhance and improve GSCM practice, which are influenced by both traditional and green factors. The aim of the study was to develop a framework to improve green supplier selection by considering on green supplier selection. Indeed the essential gap in previous studies was lack of formal models to help improving green supplier management especially green supplier selection development. Also in many studies, there was not any consideration to complex causal relationship between criteria of the system consists of dependences and feedbacks among criteria and alternatives simultaneously. Consequently, a finding of this study is an evaluation framework to select the most eligible green suppliers by examining the influential and important factors among twenty-one elements of five main GSCM practices, namely Green Logistics, Organizational Performance, Green

Organizational Activities, Environmental Protection and Green Supplier Evaluation. In fact, this model enables enterprises to figure out the main aspects for evaluating green suppliers and indicates that which one of these aspects are more important or have more impact to other aspects. Another finding of the study is related to the results of the calculations that assist automotive companies by two ways. First, company tends to select new suppliers or organize their suppliers according to the green image for being successful in today competitive market. Results show which factors are more effective and important for being green as a suppliers. Second, the results of proposed model enables manufacturers who are supplier for other companies to become a green supplier and produce based on green practices.

The nature of supplier selection is a complex multi-criteria problem including both quantitative and qualitative factors, which may be in conflict and may be uncertain. So, Multi Criteria Decision Making (MCDM) methods are required to handle and solve the problem effectively. Consequently, decision-making trial and evaluation laboratory technique (DEMATEL) has been applied in this study to obtain direct and indirect influences between criteria and calculate the causal relationships and strength among criteria. By this way, structural relationship between system elements is better understood and finding ways to solve complicate system problems is possible. Consequently, all factors have been divided into cause and effect groups and elements are ranked based on the most important and most influential aspects. Factors that belong to the cause group have significant impact on factors of effect group. It means that if the factors in cause group improve, the factors of effect group will be improved automatically and it cause to have reduction waste on time, energy and resources.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**RANGKA KERJA PENILAIAN MENINGKATKAN PENGURUSAN
RANTAIAN BEKALAN HIJAU OLEH MENGGUNAKAN TEKNIK
DEMATEL**

Oleh

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Pengurusan rantaian bekalan hijau (GSCM) telah menjadi pendekatan yang praktikal untuk membangunkan prestasi alam sekitar. Dibawah undang-undang dan peraturan yang ditetapkan pihak tertentu, perusahaan perlu untuk meningkatkan dan memperbaiki amalan GSCM, yang dipengaruhi oleh kedua-dua faktor tradisional dan hijau. Sesungguhnya jurang yang penting dalam kajian sebelum ini adalah kekurangan model formal untuk membantu memperbaiki pengurusan pembekal hijau pembekal pembangunan terutama pemilihan hijau. Juga dalam banyak kajian, tidak ada apa-apa balasan untuk sebab-sebab hubungan kompleks antara kriteria sistem terdiri daripada kebergantungan dan maklum balas di kalangan kriteria dan alternatif serentak. Oleh itu, dapatan kajian ini, Tujuan kajian ini adalah mengkaji faktor-faktor yang berpengaruh dan penting di kalangan 21 elemen dan 5 amalan GSCM yang utama, iaitu Hijau Logistik, prestasi organisasi, aktiviti organisasi, perlindungan Alam Sekitar dan Penilaian pembekal Hijau.. Malah, model ini membolehkan perusahaan untuk mengetahui aspek-aspek utama untuk menilai pembekal hijau dan menunjukkan salah satu daripada aspek-aspek ini adalah lebih penting atau mempunyai kesan yang lebih kepada aspek-aspek lain. Yang pertama, syarikat cenderung untuk memilih pembekal baru atau menganjurkan pembekal

mereka mengikut imej hijau untuk menjadi berjaya dalam pasaran hari ini yang kompetitif. Keputusan menunjukkan faktor manakah yang lebih berkesan dan penting untuk menjadi hijau sebagai pembekal. Kedua, keputusan model yang dicadangkan membolehkan pengeluaran adalah pembekal bagi syarikat-syarikat lain untuk menjadi pembekal hijau dan menghasilkan berdasarkan amalan hijau. Sifat pemilihan pembekal adalah kompleks pelbagai kriteria masalah termasuk kedua-dua faktor kuantitatif dan kualitatif, yang mungkin bercanggah dan mungkin tidak menentu. Jadi, Multi Kriteria Membuat Keputusan (MCDM) kaedah yang diperlukan untuk.

mengendalikan dan menyelesaikan masalah dengan berkesan. Oleh itu, membuat keputusan percubaan dan penilaian teknik makmal (DEMATEL) telah digunakan dalam kajian ini untuk mendapatkan pengaruh secara langsung dan tidak langsung di antara kriteria dan mengira hubungan sebab-sebab dan kekuatan di kalangan kriteria. Dengan cara ini, hubungan antara unsur-unsur sistem struktur lebih mudah difahami dan mencari jalan untuk menyelesaikan masalah sistem merumitkan adalah mungkin. Oleh itu, semua faktor-faktor yang telah dibahagikan kepada punca dan kumpulan kesan dan unsur-unsur yang disenaraikan berdasarkan aspek-aspek yang paling penting dan paling berpengaruh. Faktor-faktor yang tergolong dalam kumpulan punca mempunyai impak yang besar ke atas faktor-faktor kesan kumpulan. Ia bermakna jika faktor dalam kumpulan punca diperbaiki, faktor kumpulan kesan akan dipertingkatkan secara automatik dan ia menyebabkan pengurangan sisa pada masa, tenaga dan sumber.

ACKNOWLEDGEMENTS

During my graduate studies at the University Putra Malaysia, I have had a good fortune to interact with many wonderful people such as the students and staff in engineering faculty.

Firstly, I would like to thank Prof ZULKIFLLE BIN LEMAN for his guidance, advice and support during my research and writing of this thesis. The knowledge and experience that I have gained working under his supervision will be of great value for me throughout the rest of my life. In addition to her huge knowledge and experience, I enjoyed her support and patience during the very tough moments of research work and writing of the thesis.

I would like to express my gratitude to my first co supervisor Dr MOHD KHAIROL ANUAR BIN MOHD ARIFFIN for his individual comments, guidance, consultation and support throughout the thesis.

In addition, I would like to acknowledge the enthusiastic supervision gratefully of my second Co supervisor Dr. SHAHRIAR SOROOSHIAN during this work. He inspired me greatly to work in this research. His willingness to motivate me contributed tremendously to my thesis and for his co-operation in being member of my committee, his advices and feedbacks and taking the time to review my thesis and share his ideas.

I would like to deeply acknowledge and thank again to my dissertation supervisor and committee members who without their support and helps I would not able to complete my master degree.

Last but certainly not least, especially thanks to my Mother for being supportive, understanding and loving all my years as a student.



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LIST OF ABBRIVIATIONS

GSCM	Green Supply Chain Management
GSC	Green Supply Chain
AHP	Analytical Hierarchy Process
MCDM	Multi Criteria Decision Making
SCC	Supply Chain Council
ESCM	Environmental Supply Chain Management
CSR	Cooperate Social Responsibility
JIT	Just In Time
LCA	Life-Cycle Assessment
ISO	International Organization Standardization
EPA	Environmental Protection Agency
GATT	General Agreement on Tariffs and Trade
EPP	Environmentally Preferable Purchase
MP	Mathematical Programming
MUAT	Multi-Attributes Utility Theory
ANP	Analytical Network Process
TOPSIS	Technique for Performance Order by Similarity to Ideal Solution
IA	Artificial Intelligence
HSM	Hazard Substance Management
DEMATEL	Decision Making Trial and Evaluation Laboratory
NRM	Network Relationship Map
IRM	Impact Relation Map
GL	Green Logistics
OP	Organizational Performance
EP	Environmental Protection
GOA	Green Organizational Activities
GES	Green Evaluation Supplier
IRM	Impact Relationships Map

CHAPTER 1

INTRODUCTION

This chapter discusses the background of the study, problem statement, the purposes, and the significant of the study.

1.1. Background

Environmental protection is becoming more and more important for enterprises because of stronger public awareness, competitors and communities and government regulations. For this purpose, some programs become more popular for environmentally aware performing including total quality environmental management, ISO 14000 standards and green supply chain management. Reducing the environmental pollution from upstream to downstream during the procuring of raw materials, producing, distribution, selling products and products depreciate is the most important goal of Green Supply Chain Management (GSCM).

Supplier selection is a fundamental issue of supply chain area which heavily contributes to the overall supply chain performance (Sanayei et al., 2010). Suppliers' development is a critical function within supply chain management. Green supplier improvement is also essential for effective green supply chain management.

Supply Chain managers could minimize the products' environmental impact based on the some related environmental criteria. It harmonizes the economic, customer-value,

manufacturability and other factors that may also be evaluated. Additionally, buyer–supplier relations play an increasingly important role in addressing environmental issues. The third concern is that firms should change their environmental performance methods in order to incorporate environmental concerns of external sources. Therefore, a system analysis is needed to integrate environmental management with the greening of the Supply Chain. Supply chain managers must consider the complete environmental impact of a product during its entire life cycle, including raw material, manufacturing/assembly processes, distribution, use and disposal. The environmental effects include material, energy, air, water, and solid waste pollution (Stadtler, H, 2008).

The recent shift from buying products to purchasing sets of services makes the re-use of recovered materials, parts and products desirable. In response to heightened governmental regulations and rising public awareness of the effect of industrial production on the environment, many organizations are now undertaking major initiatives to transform their supply chain processes (Srivastava and S. K. 2007). In contrast with the reverse logistic models, the green supply chain (GSC) is a broad concept that refers to a variety of methods by which companies work with their suppliers to improve the environmental performance of their products or manufacturing processes of the suppliers, customers or both. Two primary goals of GSC include: (1) consistently meeting specified environmental performance criteria among the participants in the supply chain, and promoting responsible corporate environmental

behavior among all the suppliers/ in the chain of products and services, and (2) helping suppliers to recognize the importance of resolving environmental issues and support them in installing their own improvement initiatives. The emergence of GSC is one of the most significant environmental developments in the past decade, offering the opportunity for companies to align their supply chains in accordance with environmental and sustainability goals (Buyukozkan and Cifci, 2011).

The main and basic challenges in the green supply chain are modeling a strategy to manage the resources and meet the demands. Select the green suppliers that will deliver the goods and services that are required to manufacture the product, deliver the product the customers environmentally and arranging for return of the product for servicing through customers, if there is any fault in the product. This thesis study concentrates mainly on the supplier selection problem. Selecting suitable suppliers for purchasing the raw materials is an important part of the operation (Seuring et al., 2008)

The decision of selecting the right supplier is prone to errors. The right supplier is the one who will meet and complement the organization's needs from its corporate culture to long-term future requirements. Several suppliers that meet various selection criteria may fail in some other criteria; For example, the supplier selected may meet the "price" criteria but the company might have to compensate on the quality of the product as well as lead-time. Choice of suppliers depends on different criteria. In recent years, with the increasing of worldwide awareness in environmental protection and sustainable development within organizations, the green issue and green production

have become important concerns in supply chain management and for approximately every company and will determine the sustainability of a manufacturer in the long term. (R.J. Kuo , et al. 2010). Today, buyers are willing to purchase products and services from suppliers that manage to provide them with high quality, low cost, short lead-time with environmental responsibility at the same time because of increasing environmental attentiveness. On the contrary, a number of criteria are quantitative such as “price of the product,” “lead-time for delivery,” “transportation cost,” etc (Buyukozkan and Cifci,2011); whereas some like “pollution control,” “reducing the waste,” “quality of service,” etc., are qualitative. No single methodology appears to be dominant in solving the supplier selection problem. In this study multi-criteria decision making methodologies are applied to select the qualified suppliers by prioritizing various criteria (elements) and mapping causal relationships to find a effective factors to improve green supply chain. The basics of the supply chain and green supply chain and fundamental of supplier selection are discussed in Chapter 2, Literature Review. In addition, based on previous studies the most important criteria and sub-criteria are introduced in second chapter for applying them in proposed evaluating framework to select green supplier selection in Chapter 3, and finally various methods, which have been provided in green supplier selection, are reviewed. In Chapter 3, Methodology, Multi Criteria Decision Making problem and then Decision-making Trial and Evaluation Laboratory are discussed and finally the evaluation framework for selecting green supplier for automotive companies is proposed. All results are analyzed in

Chapter 4 and all criteria and elements are prioritized according to relations. Finally, in Chapter 5, Conclusion, the most important and effective criteria are discussed and solution for improving green supply chain are studied.

1.2. Statement of the Problem

In the last century, the most important challenge for enterprises have been integrating social, environment and economic performance to obtain sustainable improvement (Verghese and Lewis, 2007), in other words, firms wants to survive in the global market cannot disregard environmental issues. In spite of traditional supplier selection that focused on price, quality and delivery on time (Lee et al., 2009) or concentrated only on the requirements of single organizations and lose to consider the whole supply chain (Chen, 2011), green supplier selection processes has to focus on improving environmental factors in whole supply chain through organizational performance and activities, consumption, logistics, customer service and financial performance concurrently (Sarkis, 2003; Linton et al., 2007). Likewise, many adverse environmental impacts are made during the each supply chain because of raw materials including harmful substance that are provided by suppliers (R.J. Kuo et al., 2010). Therefore, to have an effective green supply chain management, organizations need to develop their supply chain by selecting appropriate suppliers based on green issues and identifying an efficient model based on green values.

Nowadays most of organizations tend to their suppliers generate production consider to environment protection because they do not want to ignore environmental protection

and they started to evaluate supplier's environmental performance. In spite of traditional supply chain system which criteria of supplier selection only includes cost, time and quality, in recent years the environmental protection issues is become one of the most concerns in supplier selection (Humphreys et al., 2003; Wei-Chang et al. 2011). Three problems are defined in this research:

1. One of the most obvious gaps by considering to previous studies is large number of quantitative models that have been applied for selecting green suppliers such as AHP (Analytic Hierarchy Process) technique (Pi Wei-Ning et al., 2006; Wen and Chi, 2010), fuzzy comprehensive evaluation (Amid A et al., 2006), comprehensive grade model (Choy et al. 2004) and grey widespread evaluation (Sue J et al., 2005), etc. In fact, the nature of supplier selection is both quantitative and qualitative; therefore, the quantitative models could not be reliable enough. On the other hand, some of these quantitative methods have complicated calculation, while others cannot avoid subjective presumption.

2. Another critical deficiency in researches are that many studies are working in green supplier selection combined with traditional supply chain management, although rarely developing practical methods that mix traditional and green supplier selections. Most of previous and recent studies have not considered to other essential traditional and non-environmental concepts and they have only focused on environmental perspective.

In contrast, most of them have concentrated only on traditional aspects in green supplier selection. Therefore, the essential gap in researches is lack of formal models

virtually to help improving green supplier management especially green supplier selection development, which is combination of both traditional aspects in supply chain management system and environmental protection issues. (Bai and Sarkis, 2010). To find the most appropriate suppliers that perform well in important view points, all predictable and conventional features, on top of environmental concerns, have to be integrated together. By this way, a comprehensive green supplier selection model will be designed.

3. Finally, in many studies there is no consideration to the complex causal relationship between criteria of the system along dependences and feedbacks among criteria and alternatives simultaneously (Yang et al., 2011). Therefore, interactions between main features of green supplier selection could not be considered and any evaluation wouldn't be accurate and reliable.

1.3. Objective

The aim of the study was to improve supply chain management by proposing a model to develop a green supplier selection with respect to both criterions of traditional supplier selection and green approaches consist of environmental protection and regulations. Also owing to the nature of supplier selection problem, which is a complex Multiple-Criteria Decision Making (MCDM) problem, an integrated MCDM technique based on DEMATEL (Fontela and Gabus, 1976), will be used.

The specific objectives of the study were:

1. To develop an evaluation model for green supplier selection, that consists of both qualitative and quantitative dimensions.
2. To develop an evaluation model that combine both traditional and environmental perspective together.
3. To examine the relationship and interactions between GSCM factors including their direct and indirect effects by using DEMATEL technique

There are numerous opportunities for enterprises that apply green supply chain management and select green suppliers like improve financial and social performance, reduce waste, develop recycling and minimize legal and environmental risks, decrease adverse health effects during the chain procedure from up-stream to down-stream and improve product design with consideration to environmental protection due to increase customer satisfaction and public consent have advantages. (Gilmore, 2006; Yeh and Chuang, 2011).

1.4 Scope and Limitation of the Study

The scopes of the study are Automotive Companies in Iran. The current research develops an evaluation framework to improve green supply chain in automotive industries by selecting the most eligible suppliers. For this purpose, 10 supply chain experts have been surveyed by semi-structural interview in 2012. The limitations of this study are only usable in automotive industries in Iran because of different economic, political and climate conditions.

Finally, this chapter detailed the problem statement, purposes and limitations of the study. In the next chapter, according to pervious researches on green supplier selection and green supply chain management, five main criteria and own their elements will be discussed and the importance of each of them will be described.



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