Green Supply Chain Management in the Thai Automobile Industry: Focusing on Auto Part Manufacturing

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
em.o.Univ.Prof.Dr.techn.Dr.hc.mult. Peter Kopacek

Rit Sukpituksakul

0927534

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Affidavit

I, **Rit Sukpituksakul**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Green Supply Chain Management in the Thai Automobile Industry: Focusing on Auto Part Manufacturing", 126 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 12.11.2010

Signature

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ABSTRACT

It has been increasing in consciousness of the environment in the last decades. The green principle had been integrated into the concept of supply chain management. The concept of green supply chain management (GSCM) were expanded and applied in various industries including automotive industry. Thailand's automotive industry, one of major production and export base in Asia, has played important role in the country economy. Like in other countries, Thai automotive supply chain was complicated. The main purpose of this research was aimed at measuring auto part manufacturers' performance in their green supply chain by using the performance measures developed by Olugu et al 2010. The two in one chain which comprised forward and backward chains were also adopted as a framework. The study reviewed various literatures on supply chain and green supply chain management. The survey to collect data was conducted by questionnaire and interview. In the questionnaire, 16 measures with 46 metrics were used. The questionnaires were sent to staff in Thai auto part manufacturers who involved in the chain. It was found out that in the forward chain, they implemented green activities in a certain level while weak in the reverse (backward) chain. The reason was the concept of green supply chain management was not widely used among them. Original equipment manufacturers, who supplied their product to car assemblers, tended to employ the concept more than replacement equipment manufacturers (REM) since OEM's customers are more demanding. In addition, the recycling system was not well integrated in the system. The study was wrapped up with some recommendation for future research.

1 INTRODUCTION

1.1 Context

With continuous development of the automotive manufacturing circle, there is a rapid revolution due to many reasons, ranging from customer oriented products, shortening product life cycles, stake holder requirements, local and international regulatory compliances, to competitions amongst players within the industry (E.U. Olugu et al., 2010). As a result, the environmental problems are brought about together, which arouse more and more concern of people as it is against the human survival and sustainable development. For an organization to survive these challenges there is a need to devise innovative strategies which can generate a sustainable competitive edge while satisfying all the requirements from stakeholders and regulatory agencies.

The practice of extending production goals from customers to their suppliers as a means to improve overall performance in a supply chain has been a growing field of research for the past 15 years (Lamming, 1993; Krause et al., 2000; Liker and Choi, 2004). Organizations have used a range of supplier-relationship management styles to improve production processes or introduce new technologies into the supply chain (Dyer and Chu, 2003). A recent research explored the influence of a customer's relationship with its suppliers in regard to the extension of sustainability-based goals. This process, known broadly as "green-supply," is a potentially effective mechanism to improve the organization's record on corporate social responsibility, minimize reputational risks, reduce wastes and increase flexibility in response to new environmental regulations (Green et al., 1998; Bowen et al., 2001a; Melnyk et al., 2003). The customer, as a major financial stakeholder, has significant potential to force improvements to its suppliers' environmental management practices, introduce environmentally sound technologies, and collaborate with suppliers to share knowledge and jointly develop more sustainable products and processes. From the customer's perspective this may require a more hierarchical approach to the issue of supplier greening – that is, expecting that some suppliers will be more or less responsive than others. From a supplier's perspective this may present both advantages and difficulties in their attempts to meet a new and possibly under-developed set of environmental performance requirements. From a government perspective this may require a more collaborative approach to working with organizations as the challenge to meet the goals of global sustainability increases.

Much research into external pressures on the organization's derivation of environmental responsibilities from the perspective of public or institutional stakeholders or the consumer is considered. Only some researches explored the role of the major customer in a supply chain or procurement context and the implications of the nature of the customer-supplier relationship on the uptake and effectiveness of these environmentally-relevant supply requirements. That is – whether the presence of specific relationship conditions or management styles between the customer and the supplier (i.e. purchasing power, governance mechanisms or collaboration) might moderate the influence of these types of requirements.

Supply chain management is the coordination and management of a complex network of activities involved in delivering a finished product to the end-user or customer. All stages of a product's life cycle will influence a supply chain's environment burden, from resource extraction, to manufacturing, use and reuse, final recycling, or disposal. Beyond this definition with adding the "green" component, it refers to green supply chain management (GSCM) which is defined as "green procurement+ green manufacturing+ green distribution+ reverse logistics". The idea of GSCM is to eliminate or minimize waste (energy, emissions, and chemical/hazardous, solid wastes) along supply chain. Environmental issues under legislation and directives from customer become an important concern for manufacturers. As a more systematic and integrated strategy, GSCM has emerged as an important new innovation that helps organizations develop "win-win" strategies that achieve profit and market share objectives by lowering their environmental risks and impacts, while raising their ecological efficiency. Recent studies of GSCM can be separated into two ways: framework for GSCM, and performance measurement. Some frameworks propose how to improve the collaborative relationships between manufacturers and suppliers, to explore the gaps between the framework and the present state, to aid managerial decision making, or to develop general procedure towards achieving and maintaining the green supply chain. A set of performance measures is used to determine the efficiency and/or effectiveness of an existing system, to compare competing alternative systems, or to design proposed systems by determining the values of the decision variables that yield the most desirable levels of performance.

Beamon (1999b) and Linton et al. (2007) craved for the definition in supply chain management to fit the new environmental challenges which are faced in manufacturing and production operations. A major stride towards achieving this fit would be to define a new structure for the entire supply chain by incorporating environmental concerns. Supply chain performance measurement has been identified as a major stride towards an effective and efficient supply chain management (Liang

et al., 2006). Several automobile organizations have failed in supply chain management due to their inability to develop the performance measures and metrics required for complete supply chain integration and performance measurement (Mentzer et al., 2007). Therefore, it is important to establish suitable measures to assess green supply chain performance measurement in the automotive industry.

1.2 Aims and Objectives

The main purpose of this study was to evaluate the performance of the Thai auto part green supply chain by using measures and metrics recently developed by Olugu et al. Starting with the review of various literatures on green supply chain performance measurement, environmental management, traditional supply chain performance measurement, and automobile supply chain management. As automotive supply chain was so complicate, a suitable framework of two in one chain had been adopted. This two-in-one chain comprised a forward and backward chain for the automobile industry. The findings of this study suggested that the importance of all the developed measures have been substantiated.

1.3 Research Questions

As mention earlier, the focus of this thesis is to measure green supply chain performance in the current Thai Auto Part manufacturing so I formulate the following research question.

"What is the performance of GSCM in the Thai Auto part manufacturing?"

Nevertheless, I decided to make a specific scope of research into a model, which divides in forward chain and backward chain.

1.4 Structure Outline

Chapter one has introduced to the context of the study and the reason why this thesis is needed. The aims and objectives including the research questions have been presented as guidelines. The structure of the study will continue as follows.

The literature and the important foundation related to the framework will be reviewed within chapter two. This chapter will help both experienced and inexperienced readers to understand the subject within concerned framework and allow them to follow the discussion.

Chapter Three will concentrate on the presentation of the research approach adopted which describes how the research are planned to perform and why the methods are chosen.

Results of surveys are presented in chapter four, together with the before moving on to the conclusion in the later chapter.

The study will formally conclude in chapter five where research questions are answered. The finding of the study is analyzed and the thesis is finalized with the discussion of the opportunities for the further research.

2 THEORETICAL FRAMEWORK

2.1 Thailand

A unified Thai kingdom, officially known as Siam until 1939, was established in the mid-14th century. Thailand is situated in Southeast Asia. With the population of over 66 million, Thailand is the 21st most populous country in the world and 67% of its population under the age of 39 years old. The capital and the largest city of Thailand is Bangkok. The city is also known as the centre of political, commercial, industrial and cultural activities.

2.1.1 Economic Overview

Thailand is an emerging economy known as the 2nd largest of Southeast Asia and is considered as an industrialized country. With a well-developed infrastructure, a free-enterprise economy, incentive investment policies, and strong export industries, Thailand delighted in solid growth from 2000 to 2008 averaging more than 4% per year. Then the impact of the global economic crisis hit at the end of 2008. Thailand is a major exporter of manufactured goods, with export amounting to US$ 152.4 billion in 2009. The country's export value in 2010 is expected to reach US$ 183 billion, with the growth rate of 20% from the previous year. Thai exports, mostly automatic data processing machines and accessories, motor cars, parts and accessories, precious stones and jewelry, electronic integrated circuits continue to drive the economy, accounting for more than 55% of GDP.

According to the latest annual World Bank report, Thailand ranks 23th of the world in term of GDP, In addition, Thailand also ranks 13th among over 180 countries and 4th in East Asia in the ease of doing business in 2009 (see Table 2&3).

Table 1 Top 10 Exports 2010 (Jan-May)

Rank	Product	Share	Value (US$ bn)
1	Automatic data processing machines and accessories	10.07	7.56
2	Motor cars, parts and accessories	9.27	6.95
3	Precious stones and jewellery	6.11	4.58
4	Electronic integrated circuits	4.00	3.00
5	Rubber	3.86	2.90
6	Rubber products	3.27	2.45
7	Refined fuels	3.20	2.40
8	Polymers of ethylene, propylene, etc. in primary forms	3.07	2.30
9	Chemical products	2.94	2.21
10	Iron, and steel and their products	2.83	2.13
	Total		75.03

Source: Ministry of Commerce

Table 2 Thailand Economy Ranking 2006-2009

Economy	2006 Rank	2007 Rank	2008 Rank	2009 Rank
Singapore	2	1	1	1
New Zealand	1	2	2	2
United States	3	3	3	3
Hong Kong	7	4	4	4
Denmark	8	5	5	5
Thailand	20	18	15	13
Malaysia	21	25	24	20
Taiwan	35	47	50	61
China	91	93	83	83
Vietnam	99	104	91	92

Source: World Bank Group, 2009

Table 3 World GDP Ranking 2009

Ranking	Economy	Millions of dollars
1	United States	14,256,300
2	China	8,887,863
3	Japan	4,138,481
4	India	3,752,032
5	Germany	2,984,440
6	Russian Federation	2,687,298
7	United Kingdom	2,256,830
8	France	2,172,097
9	Brazil	2,020,079
10	Italy	1,921,576
11	Mexico	1,540,207
12	Spain	1,495,683
13	Korea, Rep.	1,324,383
14	Canada	1,280,279
15	Turkey	1,040,275
16	Indonesia	966,956
17	Australia	858,168
18	Iran, Islamic Rep.	843,860
19	Poland	727,086
20	Netherlands	673,066
21	Saudi Arabia	594,886
22	Argentina	586,391
23	Thailand	542,388
24	South Africa	507,571
25	Egypt, Arab Rep.	471,475
26	Pakistan	445,549
27	Colombia	404,995
28	Belgium	388,917
29	Malaysia	384,043
30	Sweden	352,593

Table: GDP Ranking 2009, PPP

2.1.2 Environmental Issue and Related Legislations

2.1.2.1 Environmental Issues Related in Automobile Manufacturing

Automobile manufacturing involves a lot of processes such as electroplating, stamping and welding of metal sheets, assembling and engines and auto parts and painting processes. More than hundred thousand parts are used to produce an automobile. These parts are made of several kinds of material. Body, engine, gear etc. are made of metal whereas bumper, dashboard, seats etc. are made of plastic, rubber or even leather. Also various kinds of chemicals are used in different steps of car manufacturing.

Several energy supplies and utilities such as electricity, gas, oil and water are used in the automobile industries. Key issues concerning clean production in automobile industry are water pollution, solid waste, waste chemicals, air pollution, noise pollution energy loses and material recycling.

a) Water Pollution

The main sources in generating wastewater in the automobile industry are painting processes. These involve degreasing process of car bodies, chassis and metal sheet metal, surface conditioning, phosphate and electro Deposition painting. Other sources of wastewater are from office use and floor washing and general cleaning. Cleaner production need source pollutant separation systems to remove significant part of the pollutants such as Lead, Nickel, Zinc and Iron. Other than source pollutant removal systems, some automotive plants have installed process wastewater treatment plants in order to improve wastewater quality to required limit or in some case, to reuse for horticulture purposes.

b) Solid Waste and Waste Chemicals

Sources of process solid waste and waste chemicals in automotive industry are 1) packaging materials of parts and chemicals used 2) metal trimming from machining operation 3) waste steel sheet strips from stamping operations 4) rejected parts 5) janitorial waste from paint shop 6) Sludge 7) Oil and grease.

c) Noise Pollution

The noise level in some section of the manufacturing such as body welding shop, assembly process are higher than the limit (not over 118 dB-A) required by the national regulations. Being exposed to the noise higher than 80 dB for long time, workers are likely to loss of hearing. Even the ear protection gears are provided; workers generally forbear to use them while the use of equipment for protection is not strictly forced.

d) Air Pollution

Important air pollution problem of automobile industry is the emission of pain particulates due to over spraying and Volatile Organic Compounds (VOC)[1] due to evaporation of solvents and thinners into the occupational atmosphere of the production areas.

The air emissions can be classified as point and diffused emissions. The sources of point emission are such as paint spray booths, generators, heaters, boilers etc.

Main pollutants from these sources are PM (soot and dust), VOC, CO, NO_x, And SO_x (see Appendix I). The source of diffused emission are degreasing operations, welding operations, mixing of paint and thinner, application of paints and sealers etc. These types of emissions get directly into the occupational atmosphere of the production area.

e) Energy Losses

Energy wastage may occurs in some manufacturing process at the automotive plant due to several reasons such as compressed air used for cleaning and dry operation, air supplied at pressures higher than the required pressure, compressed air leakages in various pipes and pneumatic tools.

f) Material Use and Recycling

The important trend in the automotive industry is recycling of car and car parts and the more efficient use of fuel. One way to minimize fuel usage is the use of light material. Therefore manufacturers produce light car that could meet customers' interest and emission regulations. New technologies and materials are developed to help meet the demand.

Interest in environmental impact will drive further recycling of auto parts and components so material and design will be greatly driven by recyclability.

2.1.2.2 Environmental Related Regulations in Thailand

Thailand has promoted industrialization policies based on fostering foreign direct investment. Rapid economic development has brought Thailand a variety of environmental pollution problems which are of major public concern. The Thai government believed that these problems must be addressed and has demonstrated its commitment to tackling environmental issues. Development used to be the main emphasis in Thailand's five-year National Economic and Social Development Plans. The Government has adopted the philosophy of "Environmental Governance", which requires good information, disclosure of information, consent for examination or verification, and coordination with locals. An important operating tool for achieving this goal is the utilization of an emission charge measure. Also, the government tightened all the laws related to the environment. Further, environmental non-governmental organizations (NGOs) have been actively engaged in environmental work, and public awareness of the issues is growing.

Pollution problems arise from three major sources, namely, community pollution, agricultural pollution, and industrial pollution. This research concentrates on industrial sources that cause industrial pollution. In order to prevent water pollution, air pollution, and hazardous waste, factories are required to manage the environment in accordance with the provisions of law in order to prevent pollution. The environmental laws, related regulations and Notifications under these laws presented herein are cited as a basic guidance for industrial factories including auto and auto-part manufacturers in order that they can properly comply. Thai regulations are

issued with the aims to control and prevent environment problems and to encourage the environmental consciousness in the society.

a) *The Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (A.D. 1992)*

The Act is the principal instrument to address environmental issues. It promotes natural resource conservation and environmental protection. It requires the preparation of long-term environmental policies and medium-term action plans, introducing the 20-year natural resource and environmental policy and 5-year action plan. It empowers the authorities to declare environmentally unstable areas "Pollution Control Zones" or "Environmental Conservation Zones". These areas get priority in terms of financial and human resources assistance to protect natural resources and the environment. It establishes the Environment Fund to grant loans and aid money for environmental projects and programs. It grants the National Environment Board the power to issue and modify Environmental Quality Standards and set emissions standards. It requires that Environmental Impact Assessments be carried out for projects with potentially adverse impacts on the environment. It also allows entities to request financial assistance from the government for the installation of equipment, tools or procedures that benefit the environment.

b) *The Factory Act, B.E. 2535 (A.D. 1992)*

The Factory Act of 1969 (amended in 1972, 1975, 1979 and 1992) stipulates regulations for factory construction and operation, factory expansion and safety requirements. The latest revision of the Act also imposes strict controls on industrial pollution. The Act is administered by the Department of Industrial Works at the Ministry of Industry.

A factory is defined as any premise, that uses machinery equivalent to 5 horsepower or more, or that employs 7 or more workers for manufacturing, producing, assembling, packing, repairing, maintaining, testing, improving, processing, conveying, storing or destroying anything included in the classes or types of factories presently listed in the ministerial regulations. The law classifies factories according to their types and sizes into 3 categories.

Table 4 Classification of Factories under The Factory Act

Category 1	Category 2	Category 3
Factories that do not require licensing. They are allowed to start their operation immediately by the factory operator.	Factories that only require advance notification to officials before the start of operations. Operators may commence operations as soon as they receive a receipt from the Ministry, stating that their notification has been received.	Factories that require licenses prior to operation. Subject to the Ministry's discretion, operators may be granted, prior to the license, a certificate allowing them to build parts of the factory.

It is noted that the degree of government control required is dependent on the degree of environmental protection deemed necessary. The more likely a factory, based on its output, is to cause pollution, the more that type of factory is regulated.

The above categorization is made in accordance with the size and type of the factory and the severity of the impact on the environment caused by the factory operation. Category 3 factory requires supervision at every stage due to its heavy impact on the environment.

The objectives of factory control under this Act are:

I. The Factory Building: This law concerns the permission in setting up the factory and prohibition in locating in a certain area.

II. Machinery and equipment shall be strong, safe and secure. It shall not cause vibration and meet standard requirements.

III. Factory workers shall be under supervision and there shall be permanent staff members for pollution prevention system.

IV. Control of waste

i. Water discharge and polluted air shall be treated to meet standard requirements prescribed by law before discharging outside the factory. It is also required to install treatment equipment.

ii. Noise shall not exceed noise quality level as prescribed by law.

iii. Garbage, sewage and waste materials are divided into two sub-categories:

- Hazardous waste which contaminated with chemicals. It is required to be kept in safe and closed container. Disposal methods are prescribed by the Minister. This type of waste must be absolutely separated from household garbage.

- Household garbage includes office garbage and food waste. Regarding to the Ministerial Regulations No. 1, B.E. 2541 (A.D. 1998), factories within 14 specified provinces requires permission from the authority prior its transportation.

vi. Hazardous Substances. Hazardous substances under the Ministerial Regulations of the Ministry of Industry are explosives, inflammables, combustibles, poisonous materials, corrosives, abrasives, and health hazard substances. The law provides their storage methods and their factory use.

Factories are required to comply with the Factory Act, B.E. 2535 (A.D. 1992), Ministerial Regulations and the Notifications of Ministry of Industry under this Act. Failure to comply therewith will be punished by administrative measures and legal measures. Administrative penalty includes warning, restraining order, improvement order, machinery sealed off, temporary operation closure partially or wholly, factory closure or revocation of factory operating license. The worst case is revocation of professional license. Civil legal measures require factory causing damage to pay compensation or service fees for consulting fees. Criminal legal measures include imprisonment, fine and disqualification. More importantly, repeated offense will increase punishment for the architect or engineer working in the factory or being responsible for the work from which the offense arises and will be penalized as the factory operator if proved to have taken part in or to have had knowledge of the

offense. The punishment could also be from the relevant profession control committee.

However, under the virtue of this Factory Act, some Ministerial Regulations are also issued to encourage the manufacturers to improve their environmental standards such as the Ministerial Regulation No.16 B.E.2545- Exemption of annual fee for 5 years for factory certified with TIS 14001 or ISO 140001 certified or Occupational Health and Safety Management System (TIS 18001) certified by the certifying agents accredited by the Ministry of Industry, or by the system approved by the Ministry of Industry.

c) Public Health Act, B.E. 2535 (A.D. 1992)

The act directly involves public health, its good living, and good quality of life of the people which is enforced by local administrative organization. With regard to the environment, the Act could be considered as follows:

I. Management of Garbage and Sewage which include foul odor garbage, household garbage and hospital infectious garbage is under the care of local administrative organization by means of hauling, transporting and disposal thereof. The law only provides fees for hauling and transporting but not for disposing of it. However, the law is open for the same to be undertaken by private sector under the permission of local authorization under which arrangement the private sector will be able to collect fees at every stage of the operation. The law also provides maximum fees and service charges and that the operator will be required to follow the methods, procedures and conditions as stipulated therein. The local administrative agency is empowered to issue local requirements concerning prohibition to transfer, dump or discard garbage and sewage as well as requirements for provision of places for garbage and sewage and methods for collecting, hauling, and disposing thereof of the owner or the person in possession of any building or place.

II. Nuisance. The law provides causes of nuisance. The health deteriorating nuisance carries legal punishment and the local official is empowered by the law to prohibit any person from causing any of it or to put it to stop. Failure to comply with such order by the person causing such nuisance will empower

the local official to eliminate it as necessary or do any necessary thing to prevent it at the expenses of the person causing it or any persons concerned.

Although the imprisonment and fine under this Act is not severe, it is applicable to factory causing impacts on environment in the event there is no environmental standard for specific case as no standard requirements to define any event as nuisance. Impact on public health and normal sensory perception are used as criteria therefore. For instance, the part dealing with nuisance under this Public Health Act is a proper tool to deal with a factory emitting foul odor to its neighborhood disturbing the peaceful living of the people residing in the area as there is no law dealing with odor in Thailand.

d) Navigation in Thai Waters Act, B.E. 2456 (A.D. 1913) amended in B.E. 2535 (A.D.1992)

The main objectives of this law are to regulate traffic on waterways and water usage with emphasis on preventing any activities affecting or obstructing water communication. Three Sections of this law efficiently deal with water pollution. The Harbour Officials of the Department of Harbour, Ministry of Communication, being the competent officials enforcing this Act, have taken many factories which polluted public water resources to court and won. This becomes bad news for any polluting factories since several other cases are already in court.

e) Hazardous Materials Act, B.E. 2535 (A.D. 1992)

The objective of the said Act is to put under control all hazardous materials by providing proper control regulations and procedures as well as administrative systems among agencies concerning with supervision and control of hazardous materials. This Act empowers the Minister of Industry to prescribe area or areas within which the possession, distribution, or use of many hazardous materials is prohibited in the event it is necessary to prevent danger. More importantly, the Act defines four categories of hazardous materials and the control procedure of each category varies.

The Minister of Industry with the approval of the Hazardous Material Board is empowered to identify the name of any of the hazardous materials in these four categories, or its property, its category, effective time, and responsible agencies for

the control thereof. An annual fee is payable according to the prescribed regulations and procedures.

The manufacturer shall exercise care in acquiring, determining reliable manufacturing process of such material. It shall have strong container which is safe to use, relocate, and transport. Clear and sufficient labels displaying the hazardous property of such thing must be provided. The material must be properly stored and fitness of the party to receive or anticipated to receive it must be verified. The importer shall exercise care in selection of manufacturer, quality control, suitability and accuracy of containers and labels, means of carriage and carrier. The material must be properly stored and fitness of the party to receive or anticipated to receive it must be verified. The carrier shall exercise care in the inspection of tools and equipment used in transportation including vehicles, containers and labels, suitable means of transportation, proper on-vehicle loading and placement, reliability of work carried out by its employees or its handlers or its cooperator. The party in possession of hazardous material shall exercise care in verifying the reliability of the manufacturer, the importer, the provider, the accuracy of containers and labels. The material must be properly stored and the reliability of the party to receive or anticipated to receive it must be verified.

The employer or the principal or the hirer or the business owner shall be jointly liable to the wrongful act committed by the manufacturer, the importer, the carrier, the party in possession, the seller, the person making delivery to any person, who carries or carry out the work for either of them.

With regard to the building used as a place to store hazardous material, by virtue of the Building Control Act, B.E. 2522 (A.D. 1979), the Minister, by the recommendation of the Building Control Committee, had stipulated in the Ministerial Regulations No. 4 (B.E. 2526) (A.D. 1983), the characteristics of especially strong building for the storage of inflammables, explosives, or toxic dispersal or radioactive materials under the Hazardous Materials Act. Construction materials used for such buildings must be in accordance with specifications contained in the design drawings and computation permitted. In the event there is reasonable doubt that construction materials may not have met the requirements, the licensee, the operator, or the construction supervisor is required to submit to the inspector, for his inspection, the construction materials in an appropriate amount free of charge.

f) The Enhancement of Energy Conservation Act, B.E. 2535 (A.D. 1992)

This law aims at stipulating measures for the enhancement of energy conservation or for the manufacturing of high efficiency machinery and equipment for conservation of energy. The factory operator or the owner of the building which invests and carries out energy conservation or tackling environmental problem regarding energy conservation shall be benefited from a special fee exemption or from grants from the Energy Conservation Funds, Ministry of Finance. The law provides for factory energy conservation as follows:

- Improvement of fuel combustion efficiency
- Prevention of energy loss
- Reuse of remaining used energy
- Energy type switching
- Improvement of electricity consumption by improving power factor, Reduction of maximum power demand during peak electricity demand of the system, Appropriate use of electrical equipment to suit loads and other means.
- Use of maximum efficiency machinery or equipment as well as energy conserving control system and materials
- Other means of energy conservation as provided in the Ministerial Regulations. The factory under control is required to prepare an energy conservation plan and must be the one using larger than 1000 watt/175 kilo ampere power meter or using electricity from thermal power system with the energy equivalent to over 20 million mega joules.

The duties of the owner of the factory under control are to:

- Arrange to have at the factory one person responsible for energy with qualifications as stipulated by law.
- Submit information on production, energy consumption and conservation to the Department of Energy Development and Enhancement.
- Arrange to have records of energy consumption, the installation or change of machinery or equipment which affects energy consumption and energy conservation.
- Set energy conservation targets and plan for the factory under control and submit the same to the Department of Energy Development and Enhancement.
- Examine and analyze the achievement of the energy conservation targets and plan.

The above implementation shall follow the criteria, process and period of time as prescribed in the Ministerial Regulations issued by the Minister of Science, Technology and Environment by the advice of the National Energy Policy Board.

g) The Industrial Estate Authority of Thailand, B.E. 2522 (A.D. 1979)

As Thailand's development policy emphasizes and relies on industrial development to generate her income, it also brings pollution harmful to the environment. It is therefore necessary that factory operation be under control and the same would be effective if factories are located in the same area. This Act provides that, as a juristic person, the Industrial Estate Authority of Thailand (IEAT) controls and oversees all factories situated in the IEAT's industrial estate and the said factories shall enjoy certain privileges such as exemption for special fees, import/export duty or tax exemption under Investment Promotion law.

Factories located within IEAT are required to comply with IEAT's regulations issued by the Board of the Industrial Estate Authority of Thailand to regulate the operation of the industrialists. Factories setting up within IEAT require permission in writing from IEAT's Governor or his authorized representative.

IEAT's competent officials are empowered to enter the industrial premises during working hours to make inquiries or to inspect any document or thing related to industrial activities or other activities from any person in that premises as necessary. The factory operator is obligated to reasonably facilitate such visit.

With regard to wastewater treatment, each IEAT site will provide central wastewater treatment plant which could be joined by any factory. However, if preferred, a factory may construct its own wastewater treatment plant.

All the above-mentioned environment related laws are major provisions. Factories are required to comply. However, many companies may implement more than it is required by law depending on their environmental responsible attitudes and intense interest.

2.1.3 Automobile Industry Overview

The Thai automobile industry was originally developed with the aim to substitute imports, and large automotive manufacturers initially established themselves in Thailand in order to boost their domestic sales, with exports as a secondary target. The trend began in 1962 when Board of Investment (BOI) first promoted automobile assembly, which lured Nissan to enter the market. In 1997, how things changed abruptly in the wake of Thailand's economic crisis. There was a sudden and disastrous drop in domestic demand for cars, together with a dramatic devaluation of Thai currency (Baht). The solution for excess production capacity is export. The country's export of car jumped from 14,020 units in 1996 to 333,057 units in 2004. It is almost 24 times over the period of 9 years. Presently, the industry is the third largest in Thailand with the total workforce around 300,000 people. It also generated annual revenue from export over 379 billion baht in 2009. Aspiring to become the "Detroit of Asia", Thailand is the second largest producers of 1 ton pick-up trucks after the United States and the fifth largest automotive assembler in APAC region with an annual production capacity around 1.89 million vehicles in 2008. Over 15 different makers now assemble cars in the Kingdom, including leading Japanese makers as well as BMW, Mercedes Benz, General Motors, Ford, Volvo and Peugeot along with legions of suppliers. The total investment of automotive assemblers in Thailand in 2008 valued at 77 billion Baht with 251 projects being current undertaken at present making Thailand the largest automotive producer in Southeast Asia.

Compared to other car producing countries, Thailand has developed high level of infrastructure and proximity to Asia's biggest markets and become a regional logistics hub.

Vehicle production in Thailand is expected to increase from 1.2 million units in 2006 to approximately more than 1.6 million (including eco-cars) at the end of 2010, 60 percent more than last year and 2.5 million units in 2016. This will increase demand for another 200,000 workers.

Major automakers such as Toyota, Isuzu, Mitsubishi and Honda are likely to increase their production capacity in 2016, altogether accounting for over 75% of total country capacity.

Table 5 Annual Production Capacity by Major Car Assemblers

Assembly Plants	Capacity (units) in 2008	Capacity (units) in 2016
Toyota Motor Thailand	550,000	730,000
Isuzu Motor (Thailand)	220,000	265,000
MMC Sittiphol	206,000	208,000
Honda Automobile (Thailand)	120,000	273,000
General Motor Assembly Center	160,000	250,000
Auto Alliance (Thailand)	155,000	275,000
Siam Motor and Nissan	139,000	212,000
Others	75,000	120,000
Total	1,625,000	2,333,000

Source: Department of Export Promotion, 2009

Thai automobile industry infrastructure, combined with current market size, market growth potential, trade and investment policy, has made Thailand to become one of the most attractive country for automobile investment. Moreover, the country's automotive industry shows no signs of slowing down.

Table 6 Vehicles Production in Thailand (2005-2010) (Unit: Vehicles)

Year	Total	Passenger Car	OPV	Van & Micro Bus	Bus	Truck
2005	1,125,316	277,603			412	847,301
2006	1,193,885	298,819			272	894,794
2007	1,301,149	329,223			578	971,348
2008	1,391,728	399,435			376	991,917
2009	999,378	313,442			458	685,478
2010 (January-June)	768,994	244,761		120	196	523,917

Source: The Thai Automotive Industry Association

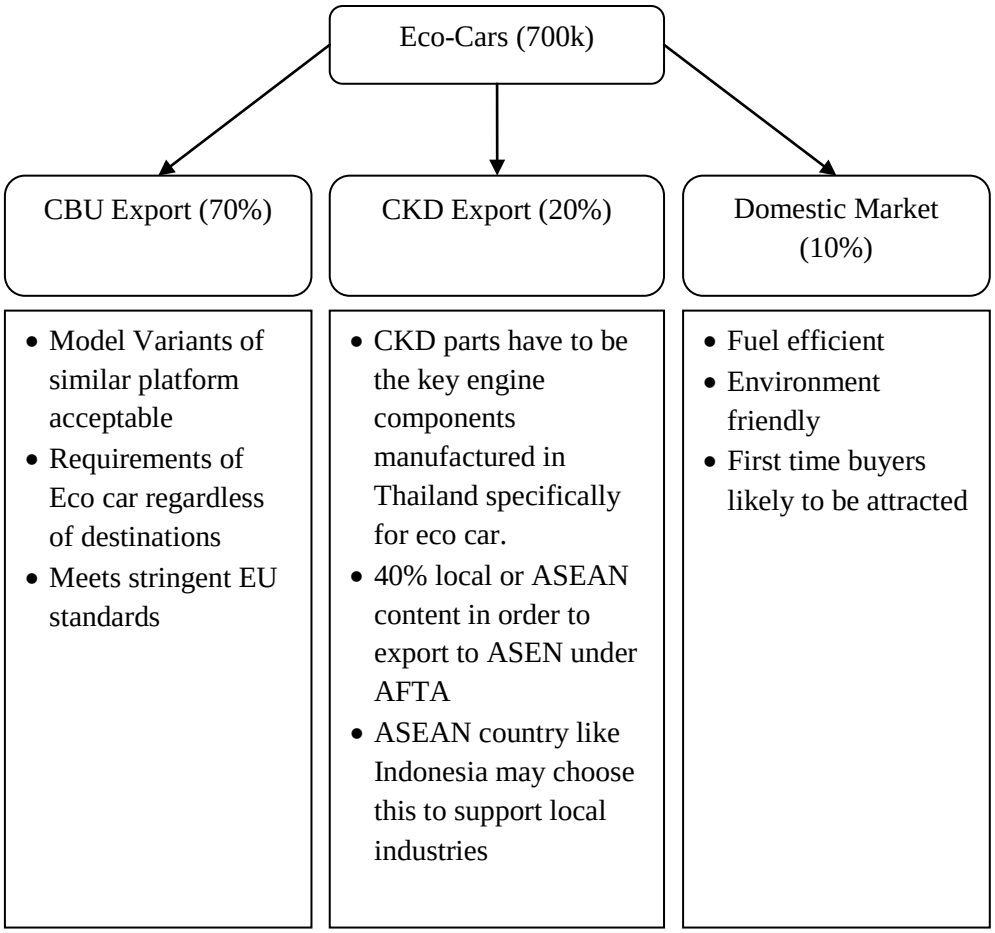
2.1.4 Automobile Policies

2.1.4.1 Eco Car: Strategic Initiative from Thailand

The concept of Eco car was created firstly in Thailand in 2007 with aim to reduce energy consumption, preserve environment and lessen the dependence on foreign oil. This policy is to be a showcase that Thailand will be the next generation production hub for environmental friendly cars as well as alternative fuel cars and hybrids which also meet the European emissions standards. Seven manufacturers including Honda, Suzuki, Toyota, Nissan, Mitsubishi, Mazda, and Tata (Whose pick-ups are the first driven by compressed natural gas) have expressed their commitment to invest millions of US dollars in eco-car assembly and production of engines and parts in Thailand, primarily for exports. It is expected that the annual production capacity of eco-cars will reach 700,000 units by 2015.

Eco-cars for export even to less developed markets have to comply with the eco-car specifications to enable manufacturers to receive incentives. The Ministry of Finance allows eco-car manufacturers to pay reduced exercise tax of 17 percent on cars with engines smaller than 1,300 cc for petrol-powered cars and 1,400 cc for diesel-powered cars. The actual production capacity must not be lower than 100,000 units per year from the fifth year of the projects operation. OEMs have to cater to certain regulations to get incentives from the Royal Thai Government. The main regulation specified that the eco-cars should be fuel efficient, consuming not over 5 liters per 100 kilometers and should have a minimum pollution standard of EURO4 or higher, emitting no more than 120 grams of carbon- dioxide per kilometer. The car should also satisfy passenger safety standards for both front and side impact as specified by UNECE Reg. 94 and Reg.95 respectively.

Figure 1 Eco-Cars; Frost & Sullivan (2009)



As for E-85 gasohol vehicles, the Ministry of Finance is offering a 3-year exemption of import duties on auto parts used to make vehicles E-85 ready. The Ministry has also reduced excise taxes on cars using E-85 to 25, 30, and 35 percent depending on the size of the engine.

2.1.4.2 Thailand Automobile Industry Master Plan

Thailand Automobile Industry Master Plan had been launched with the aim to create a predictable environment for Thai automobile industry. Positioning the country to be the production hub in Asia, it will add more value to the country in term of having strong domestic supplier base in 2011.

Details of the Master Plan are divided into 3 sections as follows:

- Automotive
  - Produce vehicle more than 2 million units per year in 2011
  - Export market to be more than 55%
  - Production value of than 1 trillion Baht
- Motor cycles
  - Production of more than 4 million units per year
  - Export of more than 2 million units
- Auto-parts
  - Produce OEM &REM parts with high quality standards and reach an export value of more than 400,000 million Baht per year.
  - Auto parts suppliers use at least 70 percent local content
  - Develop capacity in design and R&D

2.1.4.3 Attractive Investment Incentives

Since the automobile and auto parts industry is a key strategic driver of the country's economic growth, the Board of Investment (BOI) and the Ministry of Finance offer many compelling tax and non-tax incentives to investors.

Non-tax incentives include: land ownership rights for foreign investors; permission to bring in foreign experts and technicians; and work permit and visa facilitation for expatriate employees.

Tax incentives include: corporate income tax holidays of up to 8 years; reduction of or exemption from import duties on machinery and raw materials; and other zone dependent incentives such as permission to doubly deduct utility and transport costs from taxable income for up to 10 years.

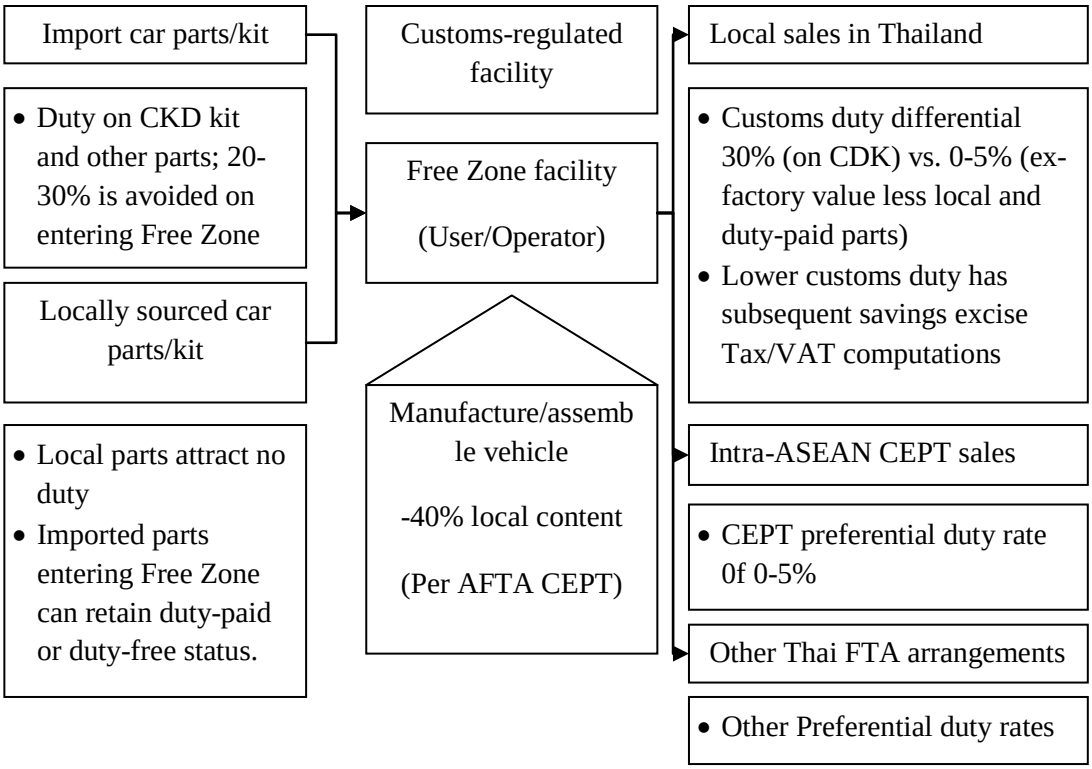
Additionally, the BOI offers several customized incentives for R&D and testing activities as follows:

- ABS braking systems
- Substrates for catalytic converters
- Electronic fuel injection systems
- Molds and dies
- Jigs and fixtures
- Integrated electrical parts

2.1.4.4 Thailand Free Trade Agreement with Other Countries

The country benefits from open trade area. An ongoing growth in the auto markets are aiding global players to set up their production, assembly, retail base in Thailand. Therefore, with the Free Trade Agreement (FTA), the Thai government has been successful in boosting the country's bilateral economic relations with other nations such as ASEAN, Australia, China, India, New Zealand, South Korea and Japan. In addition, the Thai government has been looking to pass much-awaited trade agreements with BIMSTEC, ASEAN+3, ASEAN+6, and EU.

Figure 2 Free Zone Arrangement; Frost & Sullivan (2009)



According to Kasikorn Thai Research Center Report on 29 July 2010, AFTA with 0% of import duties, on passenger car, effective on 1 January 2010, will facilitate the growth of car export to other ASEAN members. It is expected that it will expand 86-91 % in 2010 which is accounted for 3,300 -3,400 Million US$.

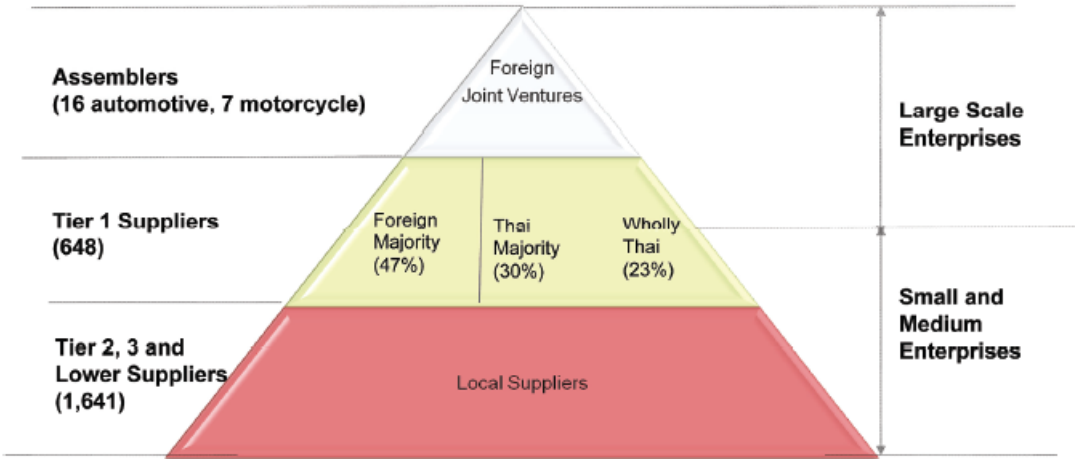
Table 7 Thailand Free Trade Agreement with Other Countries

Country	Signing Date	Effective Date	Consequence
Thailand-ASEAN	January 1992	January 1993	Autos and auto parts components exports were valued at US$ 1.5 billion to ASEAN region from Thailand. ASEAN's pursuit of FTAs with major trading partners, Thailand and its foreign investors may gain access to new markets such as South Korea, Japan and India.
Thailand-India (ITFTA)	October 2003	September 2004	Indian component manufacturers expected to set up bases in Thailand to serve domestic and regional economies. FTA also aids in Thailand aftermarket parts to penetrate Indian automotive market.
Thailand-Australia (TAFTA)	July 2004	Jan 2005	Thai auto components for cars, UVs and commercial vehicles, to be cheaper in Australia, with consumers having wider choice
Thailand-New Zealand (TNZCEP)	April 2005	July 2005	Foreign manufacturers in Thailand, who have set up plants, to have access to New Zealand market in future, mainly for pick-up trucks initially and other vehicle subsequently as the FTA develops
Thailand-Japan (JTEPA)	April 2007	November 2007	Increasing automotive investment and auto parts exports resulting Thailand's position as a regional Automotive hub for the Japanese investment network in the region.
ASEAN-South Korea (AKFTA)	February 2009	January 2010	Expanding an opportunity to select suppliers since most of Thai imports from Korea are auto parts and raw materials.

Source: http://www.ThaiFTA.com/, Frost & Sullivan (2009)

2.1.5 Automobile Industry Supply Chain Structure

Figure 3 Thai Automobile Industry Structure; Thailand Automotive Industry Directory (2005)

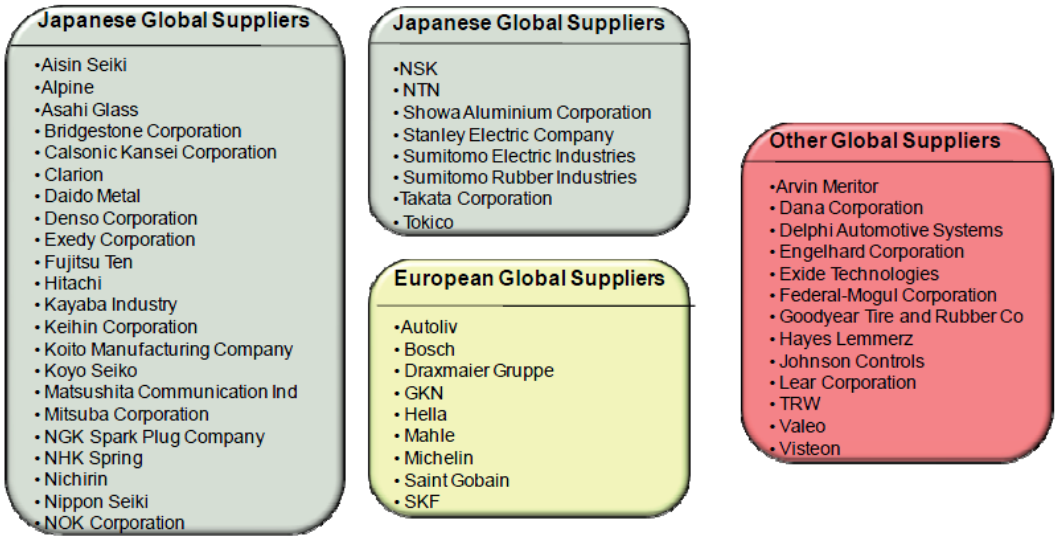


Thailand has about 16 automotive and 7 motorcycle assemblers at the top of the supply chain that is driving the growth in the automotive sector. Vehicle assemblers are all large scale enterprises that are joint ventures or foreign owned. Furthermore, the value chain consists of around 648 large, medium and small scale tier- 1 suppliers that are either foreign majority-owned company, Thai majority-owned company or wholly Thai owned company. Foreign majority-owned suppliers contribute the bulk of Tier-1 suppliers with a percentage share of approximately 47% while Thai majority-owned companies account for around 30% and wholly owned Thai companies share is minimal with 23% in Tier-1 supplier category.

Almost 80% of foreign majority-owned Tier-1 suppliers are Japanese firms belonging to keiretsu groups since assemblers at the top of the value chain are mostly Japanese OEMs. Japanese tier-1 companies can be categorized into three groups: a member in Japanese family companies, a joint venture with Japanese technology owners, and a company having technical assistance or licensing agreements with Japanese firms. At the bottom end of the value chain, in Tier 2 & Tier 3, there are more than 1,100 small and medium local Thai enterprises producing replacement parts (REM). These groups of suppliers are Thai owned. They supply raw material to OEM in Tier 1 or produce for replacement auto part market. The market depends mainly on used cars which need spare part to replace the worn outs.

It is noted that these two groups of auto part suppliers, OEMs and REMs, have different markets and customers as well as different market requirement.

Figure 4 Global Suppliers; SVI (2009)



In term of technology transfer and development, it can be transferred efficiently from the parent company to Joint Venture Company (JV). They will get financial support, high technology machines, research activities, and development programmes to continuously improve products and production quality. Some local part manufacturers have technical assistance agreement (TA) with foreign companies. Foreign companies offer technical support on product by product basis. For pure Thai companies are Thai manufacturers without any supports from any foreign company. Production technology and management style are originated within the organization. Due to recent financial crisis some Thai companies have been transferred into JV and TA companies.

According to the Japan Automobile Manufacturers Association (JAMA), the quality of automotive parts in Thailand is the highest of any ASEAN nation. The past few years has seen an increase in the number of non-Japanese auto parts manufacturers because of investments from General Motors in Thailand's automotive industry. The American assemblers have brought a number of their own Tier-1 suppliers to Thailand. In addition, Auto Alliance Thailand, a joint venture between Ford and Mazda, now has plant in Thailand; currently purchased components from 177 suppliers which 90% are local suppliers. Many new overseas joint ventures

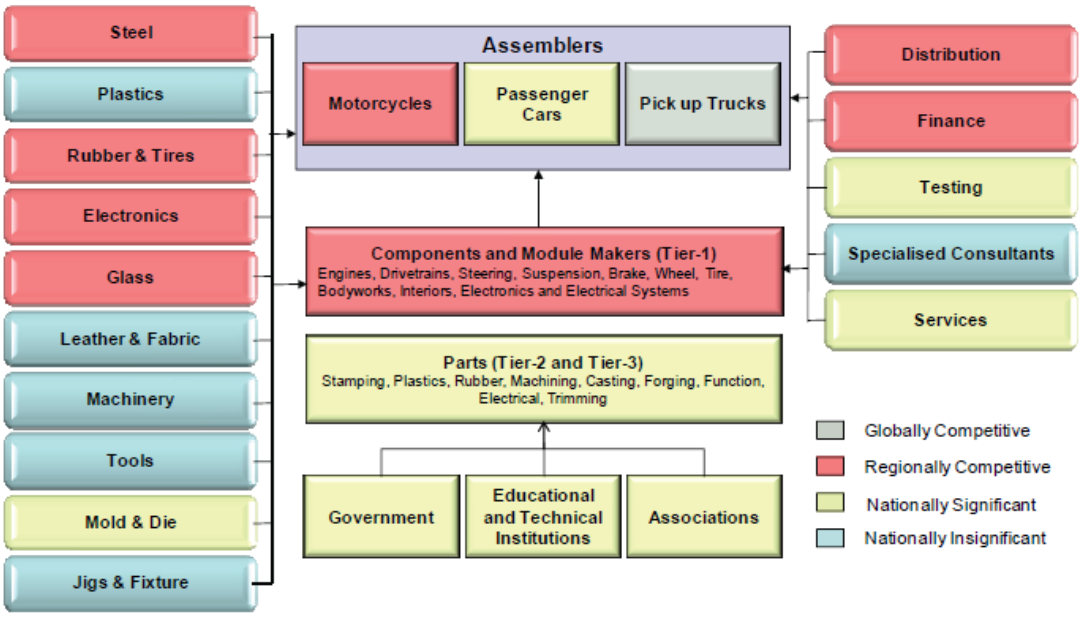
companies were set up to supply parts and accessories to the global manufacturers. The replacement market (REM) has greater volume consumption from independent Thai companies while the rest of the output is consumed by original equipment manufacturers (OEM). The local part manufacturers supply approximately 80% of all parts used for assembly of pick-up trucks, around 55% is supplied for passenger cars and nearly 100% for motorcycles manufacture and assembly. Locally produced or assembled parts include engines, suspension control and spring, axles, hubs, propellers shaft, brakes, clutches, steering system, body parts, electronic parts, air conditioning, tires, wheels, internal and external trim components and glass. Though European assemblers have entered the Thai market earlier, they tend to have fewer local part suppliers due to their small assembling volume.

Most of the suppliers in Thailand are certified with QS 9000 certification for quality. Systems used in auto-parts assembling, parts and servicing are certified with ISO 9000. Surveillance audits are conducted every 6 months to make sure for the quality compliance. In order to develop the outlook of the industry, auto-parts suppliers in Thailand are trying to comply with non-quality standards include ISO 1400 (Environmental – most of assemblers and component suppliers have been certified in Thailand), OHSAS 18001 (Operational safety aspects which is still at nascent stage), SA 8000 (Social aspects – child labor law, labor law compliance) safety and emission test compliance. Regarding the product quality, end users are the principal enforcer of product standards.

2.1.6 Automobile Cluster

A cluster is a geographical concentration of businesses and institutions that are inter-linked to fulfill a defined economic goal. It covers a network of various branches that are all working towards creating a competitive advantage for the group as a whole. Thai Automotive Cluster, shown in figure, includes assemblers, components and module makers, parts suppliers, associations, government, educational and technical institutions with support in terms of distribution, finance, testing, specialized consultants and services.

Figure 5 Thai Automobile Cluster; Team revision of Christian Ketels, “Thailand Competitiveness: Key Issues in Five Clusters”, ISC/HBS



Currently, the pickup truck is the only segment in Thailand that is globally competitive in the automotive sector. However, the Thai automotive cluster is trying to address some of the issues in terms of scarcity of skilled workers and low management abilities in the area of quality control to match international standards. Another major issue facing the cluster is the inability of Thai parts companies to compete with international firms in terms of technology and quality standards. Some of the issues faced have been solved with the support of foreign automotive companies in Thailand. For example, Toyota has engaged more local suppliers and helped them move upwards in value chain. Thailand has already started moving in this direction by leveraging the existing presence of MNCs to deepen its cluster by inviting them to set up more local R&D facilities, product development and marketing activities thereby improving the skill sets of employees and hence projecting Thailand as an attractive destination for setting up automotive assembly, parts and service centers in the Asia Pacific region.

In 2007, the Thailand Automotive Institute has developed a US $217.5 million plan to support five majors projects in order 1) to develop human resources, 2) to dispatch automotive experts to build industry cluster and upgrade the auto parts manufacturing technology, 3) to establish the research and development centers, 4)

to analyze industry trend by setting up an information technology center, 5) to establish an automobile export promotion center. With these plans, Thailand is currently one of the top worldwide automotive producers.

Automotive Industry Trends in Thailand

- The campaign for energy saving and the development of renewal energies both in car and in the industries for example Bio Diesel, Eternal, Natural gas etc.
- Car production should maintain the environment and safety.
- The standard development and more researches for value added

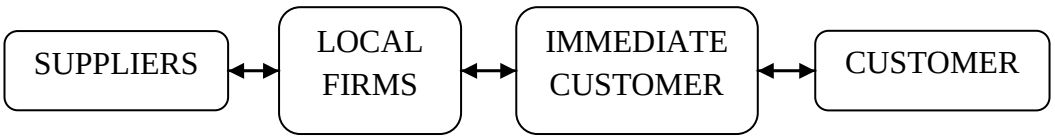
2.2 Green Supply Chain Management

2.2.1 Concept of Supply Chain and Supply Chain Management

In defining Supply Chain Management by Mentzer et al, 2001 gave the definitions and the development of supply chain according to the complexity of the business shown in figure 6, 7, and 8.

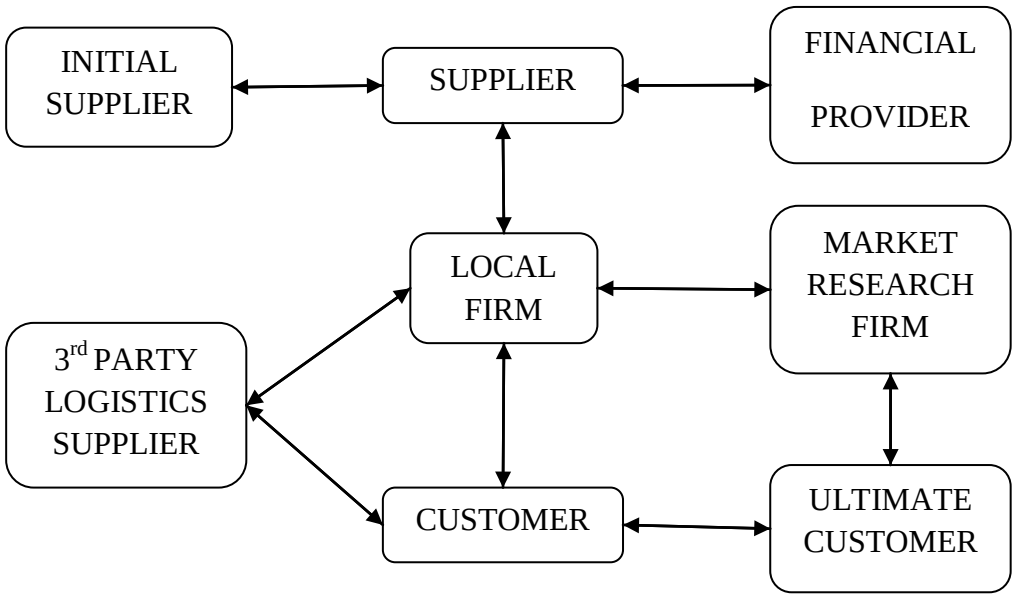
Figure 6 Definition of a Basic Supply Chain; Mentzer et al, (2001)

Figure 7 Definition of Extended Supply Chain; Mentzer et al, (2001)



"A supply chain is a set of three or more companies directly linked by one or more of the upstream flows of products, services, finances and information from a source to a customer"

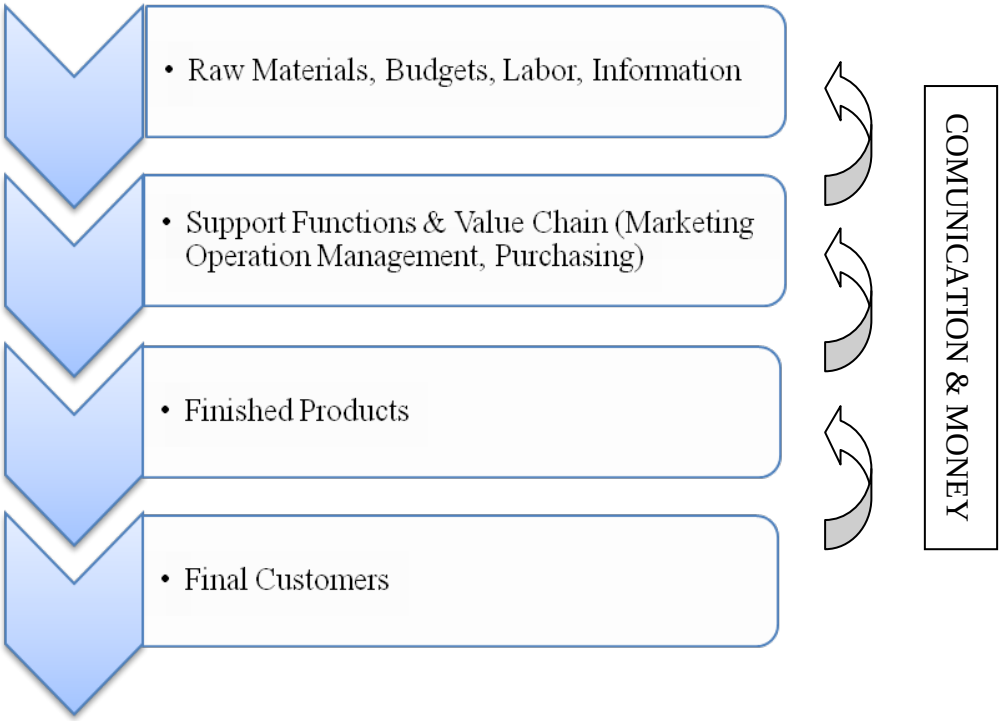
Figure 8 Definition for an Ultimate Supply Chain; Mentzer et al, (2001)



"An ultimate supply chain includes all the companies involved in the upstream flows of products, services, finances, and information flow from the initial suppliers to the ultimate customer"

Supply Chain is also defined as "processes from the initial raw materials to the ultimate consumption of the finished product linking across supplier-user companies" or as "functions within and outside a company that enable the value chain to make products and provide services to the customer (APICD Dictionary). The dictionary also defines **the value chain** as those functions within company that add value to the products or services that organization sells to customers and for which it receives payment. The definitions of **Supply Chain** and **Value Chain** are different**.**

Figure 9 Supply Chain Process



The above figure shows that the supply chain involves activities starting from raw materials stage to the final customers. Each arrow in the supply chain represents an individual firm which has its own value chain. The value chain in one firm means series of value added by internal functions of the firm. These functions are purchasing, marketing, operation management and so on. These are internal functions of the firm and they occur in every firm that is a member of a supply chain.

The figure also illustrates that the supply chain comprises more than the movement of physical goods between firms. It also involves flows of communication, information and of course, money.

Supply Chain Management (SCM) represents a significant change in how most organizations view themselves. Traditionally, companies view themselves as having customers and suppliers. Historically, a company did not consider the potential for either its suppliers or its customers to become a partner. In many industries each company was very competitive with its suppliers and customers, fearing that they

would be taken advantage of by them. However, in the year 1960s and 1970s companies began to view themselves as closely linked functions whose joint purpose was to serve their customers. This internal integration was called “material management”. The material flows were grouped together. Companies integrated their purchasing, operation, distribution functions to improve customer service while lowering the costs.

Severe competition in the market has forced companies to focus their performance on customer value of products and services. They have been invested in Supply Chain Management (SCM) to control the supply chain so that they can utilize limited resources for customer value creation.

Interest in Supply Chain Management has steadily increased since the 1980s when firms saw the benefits of collaborative relationships within and beyond their own organization. Firms are finding that they can no longer compete effectively in isolation of their suppliers or other entities in the supply chain.

A number of definitions of Supply Chain Management have been proposed in the literature and in practices (Lummus and Vokurka, 1999).

Supply Chain Council defined “Supply Chain” as a process of efforts involved in producing and delivering a final product from the supplier’s supplier to the customer’s customer. These efforts are planning, sourcing, making and delivering which include manage demand and supply, sourcing raw materials and parts, manufacturing, inventory tracking and warehousing, managing orders as well as distributing and delivering products , services and value to customers.

Stevens (1989) defined SCM as the integration of business functions involving the flow of materials and information from inbound to outbound ends of business.

Oliver and Weber (1982) discussed the potential benefits of integrating internal business functions of purchasing, manufacturing, sales and distribution into one cohesive framework.

All definitions reflected different insights and perspectives of SCM.

In Early 1990's, Supply Chain Management evolved dramatically with the increasing importance of the relationship with other suppliers (Harland 1996). The emergence of global markets was the reason for this change. The organizations were required to be more actively responsive to the need of customers. It was observed by Power (2005) that speed in delivering customer demand and leanness (doing more with less) contributed to the firm to be more competitive. It was obvious that firms were becoming more integrative to their supply chain partners. Just in time management has added factors that helped the operational processes of the supply chain. Herrison and Van Hoek (2001) stressed that SCM involves not only capabilities of supply chain partners to deliver superior value to the end customers but also operation at less cost in the supply chain as a whole.

Tarn et al (2002) pointed out the 6 major benefits from successfully applying Supply Chain Operations Reference model(SCOR): 1) help them manage the business by providing visibility of how work actually get done 2) help firms compete more effectively through the system of metrics that linked to business processes. 3) help focus points that need real process improvements, not just move bottleneck from one place to another 40 help improve cost, cycle time and reliability 5) help steamline and accelerate business change by mapping out the process improvement cycle and 6) help promote team building.

The benefits of SCM will be recognized in immediate, medium term as well as long term impacts.

Immediate benefits are

- Lower inventory risk/cost.
- Reduction in warehousing cost
- Reduction in distribution cost
- Reduction in transportation cost.

Medium term benefits are

- Sustainable cost saving through increased productivity and make business processes more efficiently in procurement and purchasing, order fulfillment, payment and exception management.
- Reduced times in product delivery.
- More efficiency in product development
- Reduction cost of product manufacturing

Long term benefits are

- More flexibility especially when market changes.
- Improve customer responsiveness/ satisfaction.
- More opportunity to retain customers.
- More effective marketing.

The most important factor for success SCM is collaboration from all parties involved in the value chain. Fundamental attributes of an SCM network are such as

- Open and low cost connectivity
- Flexibility
- System and channel integration
- New e- commerce capability
- Intelligence gathering and analysis

SCM was never a strategic issue in the past, when sourcing and delivery of logistics took a back seat to manufacturing. However, the emergence of new information technologies changed the business landscape. They become necessary tools to do business faster rate. Companies which are unable to move their goods and information quickly enough cannot survive since their competitor can do faster.

There are two forces driving supply chain management. First, is that there are new communication technology available now that allows management to actively manage a supply chain. Second, customers are demanding lower prices and better products and services. To meet the customer demand, the companies are optimizing the whole supply chain. Supply chain management allows all companies in a supply chain to look beyond their own objectives to the objective of maximizing the ultimate customer satisfaction. The payoff for supply chain players that can do this is increased profits for their shareholders.

Mezher and Ajam (2006) agreed with Horvath 2001 that e-commerce become essential attributes in the SCM network. These capabilities can affect the reduction of cost and increase of process speed. The collaborative SCM infrastructure will incorporate innovative financial arrangements, such as electronic billing and payment, automatic progress payments and expensive engineered products. Modern electronic practices began to displace the traditional forms of data and information interchange. In fact, e-commerce acts as a backbone facility for SCM. It helps to integrate collaboration of all players involved in the chain through the virtual space, thus reducing time and cost. It also provides interactive way of communication among parties.

Madmaiy (2010) suggested that the company may apply 5s Concept in productivity and quality improvement plus Kaizen, the Japanese strategy of continuous improvement to support efficient SCM.

5s concept comprises of

- Seiri – Seperation of wanted materials from unwanted ones and disposal the unwanted.
- Seiton- Arrangement of all stuff to make the workplace to be in order, convenient and safe.
- Seiso –Cleansing all equipments, machines and workplace.
- Seiketsu – Maintaining healthy atmosphere in the workplace.
- Shitsuke – Implement 5s concept strictly as disciplines.

Kaizen Strategy calls for never ending effort for improvement involving everyone in the organization.

Management has two major components:

- Maintenance, and
- Improvement

The objective of the maintenance function is to maintain current technological, managerial, and operating standards. The improvement function is aimed at improving current standards.

Under the maintenance function, the management must first establish policies, rules, directives and standard operating procedures (SOPs) and then work towards ensuring that everybody follows SOP. The latter is achieved through a combination of discipline and human resource development measures.

Under the improvement function, management works continuously towards revising the current standards, once they have been mastered, and establishing higher ones. Improvement can be broken down between innovation and Kaizen. Innovation involves a drastic improvement in the existing process and requires large investments. Kaizen signifies small improvements as a result of coordinated continuous efforts by all employees.

5s concept together with Kaizen strategy will promote productivity and working efficiency in the company because of

- Decrease of complicate work
- Decrease of waste in processes such as waste of unnecessary movement due to inappropriate design of workflow etc.
- Pleasant, clean and safe workplace
- Decrease in delivery time
- Decrease of accident in workplace.

Suharitdumrong (2010) proposed that 7 habits of Highly Efficient Supply and Demand Chain developed by Jim Tompkins also help manage supply chain in the organization. These habits are:

a) Communicate

The first is "Communicate," and the best practice here is to communicate to ensure that all the departments within your company and all the links within your supply chain have a common understanding of what "supply chain" means and what the objectives are, and that everyone has a common understanding of the "what, why, who and where." There should be no surprises as to what you're trying to accomplish.

b) Benchmark

The second best practice is Benchmarking. As a first step toward identifying opportunities for supply chain improvement, it is important to know what our competitors are doing, what our industry is doing, what the best-in-class companies are doing, so that it will be a framework against which to establish improvement. It is also important to identify weak point and see how the company doing by comparing them to the industry, competitor and best in class companies.

c) Assess and Partner

The third is a combination of assessment and partnership. For assessment, after the benchmarking is done the opportunities for improvement will be recognized, the company needs to ensure the readiness to move forward. Six levels of Supply Chain Excellence are identified (see Appendix II).

d) Prioritize

The next best practice is Prioritize. In this step, make benchmarking and assessment activities and use them to identify the specific processes and tasks need to be improved

e) Lead, Don't Just Manage

The next best practice has to do with Leadership. It is important to understand the difference between leadership and management. Management is an important task. But, unfortunately, plenty of management is in most companies, plenty of people to measure and control and perform tasks. What is more important is leadership. In most organizations today, it is found that they’re about 95 percent management and only 5 percent leadership. More balance like fifty/fifty would certainly be good.

f) Add Value by Focusing on Core Competencies

The next best practice addresses Core Competencies. It needs to focus on the things that truly add value to the customer and therefore give us market position. Focusing on the core competencies and do not to try to do it all, the company will have time to improve, provide leadership and go peak-to-peak on the things that are really important to the customer.

g) Continuously Improve

The last of the seven habits needed to adapt for the overall supply chain is Continuous Improvement. Do not stop pushing for the next level of performance. The company needs to continuously go through these other six habits of understanding how it communicate, benchmark, assess, prioritize, provide leadership and focus on the core competencies, and then do it again and again and again. Step 7 would be, return to Step 1 and do it again.

❖ *Tools for Supply Chain Management*

- *SCOR Model*

SCOR or The supply chain operations reference model is a management tool used to address, improve, and communicate supply chain management decisions within a company and with suppliers and customers of a company (1). The model describes the business processes required to satisfy a customer's demands. It also helps to explain the processes along the entire supply chain and provides a basis for how to improve those processes.

The SCOR model was developed by the supply chain council (www.supply-chain.org) with the assistance of 70 of the world's leading manufacturing companies. It has been described as the "most promising model for supply chain strategic decision making." The model integrates business concepts of process re-engineering, benchmarking, and measurement into its framework. This framework focuses on five areas of the supply chain: plan, source, make, deliver, and return. These areas repeat

again and again along the supply chain. The supply chain council says this process spans from “the supplier’s supplier to the customer’s customer.”

Supply Chain Management System has five components. There are 1) the plan - the overall strategy of the SCM program including the development of SCM metric to monitor. Demand and supply planning and management are also included in this first step. Elements include balancing resources with requirements and determining communication along the entire chain. This includes determining business rules to improve and measure supply chain efficiency. These business rules span inventory, transportation, assets, and regulatory compliance, among others. The plan also aligns the supply chain plan with the financial plan of the company. 2) The source – the suppliers who provide the company with goods and services necessary to run business. This step describes sourcing infrastructure and material acquisition. It describes how to manage inventory, the supplier network, supplier agreements, and supplier performance. It discusses how to handle supplier payments and when to receive, verify, and transfer product. 3) The make – the execution of processes needed to produce, test, and pack the products or services. This step emphasize on Manufacturing and production. Is the manufacturing process make-to-order, make-to-stock, or engineer-to-order? The make step includes, production activities, packaging, staging product, and releasing. It also includes managing the production network, equipment and facilities, and transportation. 4) The delivery – the system for, warehouses, getting the products and service to the customers, invoicing customers and getting paid from them. Delivery includes order management (receiving orders from customers and invoicing them once product has been received), developing a network of warehousing, and transportation. This step involves management of finished inventories, assets, transportation, product life cycles, and importing and exporting requirements. 5) The return – the system used to process customer returns and/or to support customers with problems. Companies must be prepared to handle the return of containers, packaging, or defective product. The return involves the management of business rules, return inventory, assets, transportation, and regulatory requirements.

The SCOR model developed by Supply Chain Council can be used as a reference model. To apply this model to the specific organization, the management should study in details thoroughly.

- *How SCOR Helps Companies Perform*

Better SCOR helps manage a common set of business problems through a standardized language, standardized metrics, and common business practices which accelerate business change and improve performance. Applying SCOR streamlines communication and dramatically improves the overall effectiveness of daily management and targeted improvement initiatives. As demonstrated by the SCOR index, companies that use SCOR are consistent top performers in their industries.

- *Benefits of Using the SCOR Model*

The SCOR process helps companies understand how the 5 steps repeat over and over again between suppliers, the company, and customers. Each step is a link in the supply chain that is critical in getting a product successfully along each level. The SCOR model has proven to benefit companies that use it to identify supply chain problems. The model enables full leverage of capital investment, creation of a supply chain road map, alignment of business functions, and an average of two to six times return on investment. SCOR helps managers address perennial supply chain challenges:

Customer Service – SCOR helps evaluate cost/performance tradeoffs, develop strategies for meeting customer expectations, and respond to domestic and global market growth.

Cost Control – SCOR metrics are used in conjunction with supply chain performance attributes, making it possible to compare different supply chains, industries, and strategies.

Planning and Risk Management – Using SCOR leads to faster implementation, more comprehensive identification of potential risks, and easier coordination with customers, suppliers, and stakeholders. It helps a company analyze its supply chain. It gives companies an idea of how advanced its supply chain is.

Supplier and Partner Relationship Management – SCOR provides a common language for supply chain classification and analysis across organizational boundaries.

Talent Development – The release of *SCOR 10.0* adds a strategic talent framework that complements SCOR metrics, process, and practice components.

CSCMP Supply Chain Process Standards created by Supply Chain Visions for the Council of Supply Chain Management Professionals is a guide which presents an outline or framework of processes that are typically found to be involved in performing supply chain related activities, and a set of standardized activities described in 2 levels of maturity - "Suggested Minimum" and "Best Practice" for each process. The Standards were created for by; a supply chain process and measures consulting firm.

The intent of the "Standards" is to provide
practitioners, educators, and consultants with a reference tool to help companies identify potential gaps across a broad spectrum of their supply chain processes. Practitioners can use this tool to identify process strengths and weaknesses, and then focus their attention on those areas where improvement efforts will drive the most benefit. Results can be shared and compared (with discretion) with other organizations in your supply chain to improve overall effectiveness.

However, even though these two tools are mainly similar, there are subgroups of each different process. These standards are also included as in SCOR Model.

Table 8 Supply Chain Management Standard by CSCMP

Main Process	Process Subcategory
Plan	1) Supply Chain Planning 2) Supply/Demand Alignment 3) Inventory Management
Sources	1) Strategic Sourcing 2) Supplier Management 3) Purchasing 4) Inbound Material Management
Make	1) Product Engineering 2) Partnership and Collaboration 3) Product or Service Customization 4) Manufacturing Process 5) Lean Manufacturing 6) Make infrastructure 7) Support Processes
Delivery	1) Order Management 2) Warehousing/Fulfillment 3) Customization/Postponement 4) Delivery Infrastructure 5) Transportation 6) E- Commerce Delivery 7) Management Client/Customer Partnership 8) Post Sales Technical Support 9) Customer Data Management
Return	1) Receiving & Warehousing 2) Transportation 3) Repair & Refurbishment 4) Communication 5) Customer Expectation Management
Enable	1) Strategy & Warehousing 2) Competitive Benchmarking 3) Product/Service Innovation 4) Product/Service Data Management 5) Process Variability and control 6) Measurement 7) Technology 8) Business Management 9) Quality 10) Security 11) Industry Standard

2.2.2 The Development of the Concept of Green Supply Chain Management

Nowadays, environment change is upon everyone. The world is being disturbed by turbulent weather such as heat waves, rain, snowfall and hurricanes. According to Jay Lawrimore, Chief, the Climate Monitoring Branch of the National Oceanic and Atmospheric Administration, "The burning of oil and fuels creates carbon dioxide which raises the blanket of the earth and traps heat." It is believed that environmental pollution may lead to the potential of extinction of mankind on earth. Among various kinds of pollution, air pollution is one of problems that need urgent solve. The amount of carbon dioxide has reached the level of 380 parts per million and its rise has accelerate.

The world also faces the problem of resource depletion. As World Bank Report, approximately 80 countries around the world have the problem of water shortage. It is forecasted that the world will run out of natural resources by the end of the next century, if they have been used at the present rates.

There were some efforts to initiate international cooperation. International negotiations took place and Kyoto Protocol, effectively on 16 February 2005. The developed countries are required to reduce their collective emission by 5.2% of its level in 1990.

The traditional supply chain comprises five important parts: raw materials, industry, distribution, consumer and waste. Each part can create pollution, waste and hazards to the environment in different degree. For raw materials, a company can choose to use environmentally harmful materials and put pressure to suppliers to choose more environmental friendly material and process.

Oil is a major source of energy consumed by the industries and consumers at various stage of supply chain. It is used in many processes such as power generation, engine running, transportation etc. Oil consumption causes the emission of green house gases. The more oil was consumed, the more emission of unwanted gases.

It has been increasing awareness of the world's environmental problems. Several organizations responded to the problems by applying green principles such as using environmental friendly raw material, using recycle paper for packaging etc. Then the

principles expanded to other departments including supply chain. The very first green supply chain came to the context in 1989 according to Kelle and Silver 1989. They developed an optimal forecasting system for organizations to use to forecast products that can be potentially be reused. Green supply chain management involves every stage in manufacturing from the first to the last stage of product life cycle. Actually not only manufacturing but GSCM can be applied in other organization types such as government, education and services.

Duber- Smith (2005) identified reasons why the company should adopt green supply chain. They are target marketing, brand reputation, lower cost/ increased efficiency, sustainability of resources, competitive and supply chain pressures, product differentiation, competitive advantages, adapting to regulation and reducing risk, return on investment, employee morale and the ethical imperative.

In many cases they are forced by government regulations and laws. Different industries are controlled by different regulations depending on industrial characteristics and resources needed. Important regulations and guidelines are Environmental Protection Laws, ISO 14000, and European's regulation of Restriction of Hazardous Substances.

In addition, competition may force companies to apply GSCM. In strong competitive business environment, companies have to try to make customers impress by making them to be outstanding among competitors. Being environmental friendly is one way to differentiate from their competitors. Customers do affect to the company's decision to adopt GSCM. Customers may require special treatment or special products. It forces the company to make changes to make them satisfy.

Driver to apply GSCM may come from the company itself. Several studies support that adopting GSCM can reduce cost (Duber- Smith, 2005)(Stevels 2002)(Gunther 2006). Other reasons such as increasing efficiency, eliminating waste and pollution and generating brand reputation are also drivers. However, factors and drivers to adopt GSCM in different industries were different. The result of Zhu, Sarkis and Lai's Survey in 4 industries in China showed that the automobile industry has applied GSCM behind other industries. It may be because of its high level of complexity of the industry itself that delayed its adoption of GSCM practice.

2.2.3 Green Supply Chain Model and its Activities

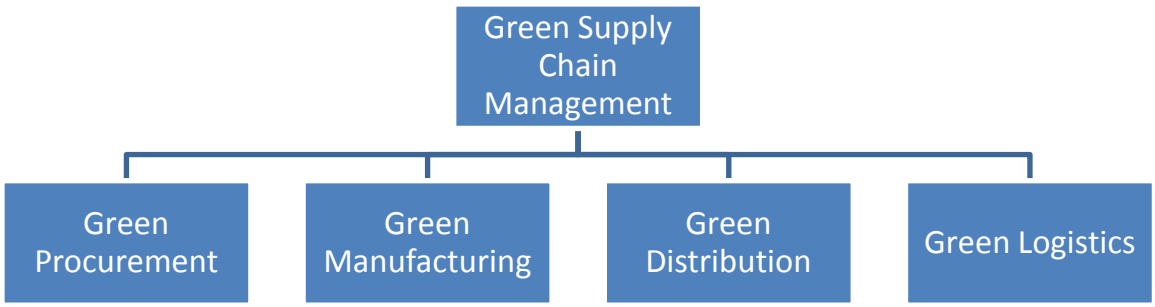
❖ GSCOR Model

Supply Chain Operations Reference Model (SCOR Model), developed by Supply Chain Council, is a standard model that broadly use as a reference. SCOR-model provides a unique framework that links business process, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities. The reference model consists of 4 key pillars:

- Performance; Metrics help to describe the performance of the supply chain
- Processes help explain how the supply chain is configured (what activities are taking place)
- Practices are unique ways to configure supply chain processes
- People; Assess needs, availability and gaps of skills in the supply chain workforce

Green supply chain management involves traditional supply chain management practices by integrating green aspect throughout the entire process. GSCOR model consider green manufacturing in the original SCOR model. It requires supply chain designers in the design process, fully consider all the factors, including the quality, the cost, the progress schedule, the user's needs, the resources optimized use, as well as recycling from the very beginning in the product entire life cycle and put green design as an important content through each aspect. As a whole, the green supply chain is divided into four main parts: green procuring, green manufacturing, green distribution and green recycling. During each task, follows the green manufacture concept and takes the entire supply chain as a green system to manage.

Figure 10 GSCOR Model; Supply Chain Council (2010)



a) Green Procurement

Green Procurement is defined as an environmental purchasing consisting of involvement in activities that include the reduction, reuse and recycling of materials in the process of purchasing. Salam (2008) pointed out that a solution for environmentally concerned and economically conservative business and a concept of acquiring a selection of products and services that minimizes environmental impact is beside green procurement. The process starts with supplier selection. The manufacturers may purchase materials or parts only from "green partners" who acquire environmental quality standards and pass an audit process related environmental aspects. They may consider suppliers who get ISO 14000, OHSAS 18000 and/or RoHS Directives. Some suppliers who also control hazardous substances in their companies and achieve green certificates are also selected. The organizations are required to implement supplier Relationship Management (SRM) Monthatipkul (2010). A relationship between supplier and manufacturer can lead to innovation and cost effective end- products. A recent study by Lewis (2000) found that Japanese automakers were operating on productivity twice as that of the U.S. counterparts. The main differences in Japanese productivity are lean manufacturing systems, reducing lead-time while increasing quality. However there are sometimes contrasts between suppliers and manufacturers in dealing with GSCM. Suppliers are generally concerned with cost, quality and delivery and take "environmental safety" as a low priority while manufacturers may concern environmental safety and improvement as high priority. Therefore, manufacturers may need to consider their own environmental goals, social responsibilities and reputation to consumers.

Involvement of suppliers in manufacturer's plant and manufacturers in suppliers' plant helps communication between them more efficient while creates trust. It can

also let them concentrate on each individual process and part to achieve a desired environmental rating for a product. The study by Geffen and Rothenberg (2000) showed that the greatest success between suppliers and manufacturers was fined in firms where suppliers were physically involved in the manufacturer's plant and where manufacturers were actively involved in the supplier's plant.

b) Green Manufacturing

Green Manufacturing is defined by Atlas and Florida 1998 as production process which use inputs with relative low environmental impacts and also, in the same time, highly efficient. The production process should utilize clean technology (Monthatipkul 2010). Green manufacturing can lead to lower raw material costs, lower environmental and occupational safety expenses, higher production efficiency and improved corporate image.

Green manufacturing also includes green design in the process. It is about designing a product or a service that encourage environmental awareness. Life cycle analysis was introduced to measure environmental and resource related products to the production process. It involves in stages from extraction of raw materials, production, distribution, and remanufacturing, recycling and final disposal. The life cycle analysis examines and qualifies the energy and materials used and wasted and assess the impact of the product on the environment (Srivastava 2007) and (Gungor and Gupta 1999).

c) Green Distribution

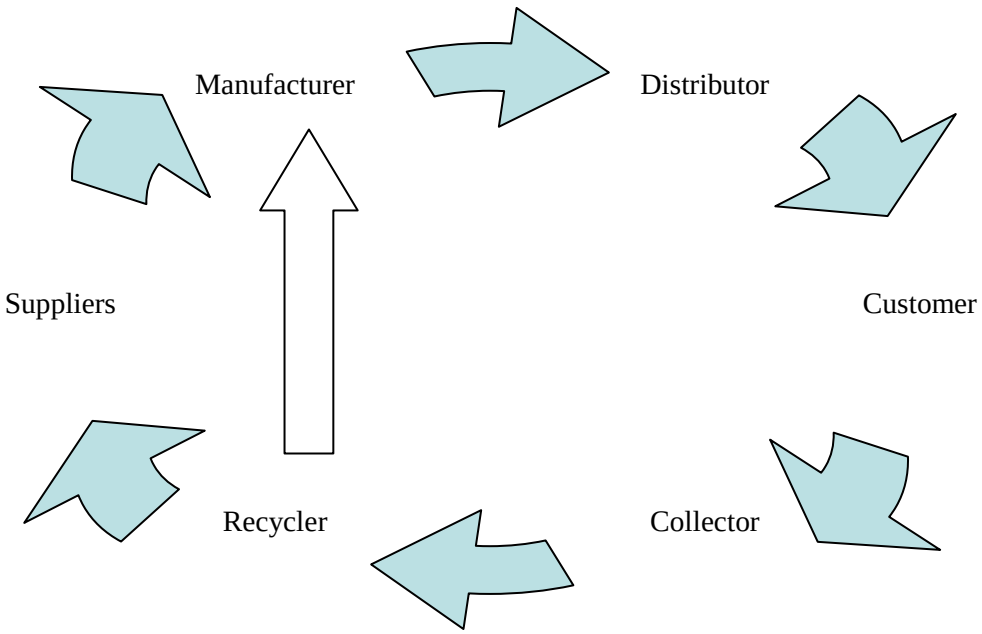
Green distribution are consists of green packaging and green logistics. Packaging can exist in endless formats, design and chemical components. Better packaging, with rearranged loading pattern during shipping can reduce materials usage, increase space utilization in the warehouse and the trailer, and reduce the amount of handling required. The company can do green packaging by 1) downsize packaging 2) use green packaging materials for example bio-plastic which come from renewable source and is degradable. 3) Cooperate with vendor to standardize packaging 4) minimize material uses and time to unpack 5) encourage and adopt returnable packaging methods and 6) promote recycling and reuse programme.

Green logistics involves the effort in storing, moving, transporting raw materials, products, parts and disposals with low expense and low effects on the environment. Green design on products and packaging can help, therefore, transport and store more effectively. Select proper mode of transport, avoid unfully loaded vehicle with intelligent system, use proper size of vehicle and type of energy, train eco-drive for driver or even consider right location for distribution center also promote green logistics.

d) Green Recycling

Green recycling is the last link throughout the green supply chain. It may say that this link make Green Supply Chain different from the traditional one. Recycling includes reverse flow of waste materials, information, capital, value and business. The flow can be both forward and backward and the whole logistics system becomes an integral part.

Figure 11 Players in Green Supply Chain



2.2.4 Benefits and Success Stories in Applying Green Supply Chain Management

Actually, Greening the supply chain is more than using less chemical substances or reducing less waste or carbon dioxide. GSCM can create results in all areas both tangible and intangible. Benefits of GSCM include environmental and society aspects. Zhu et al 2007 indicated that environmental management such as GSCM has positive relationship with an organizations' economic performance. It is suggested that it can provide new opportunities for competition and new ways to add value to core business programs. GSCM helps reduce environment load, reduce cost prices for supplier, reduce cost for producer, reduce ownership cost for customer and reduce resource consumption for society. In sense of immaterial, GSCM helps overcome preconceived opinions and cynicism for environment, less rejects for supplier, easier to manufacture for producer, convenience for consumer and make industry on the right track for society (Stevels 2002).

Some exploratory studies in various industries found out some companies succeed in applying GSCM. An outstanding case is AMD. The company wanted to be a sustainable organization as it was drove by its stakeholders. The company then worked together with its suppliers to find alternative materials to reduce environment impacts.

2.2.5 Barriers and Controversial of Applying Green Supply Chain Management

In the study of Zhu and Cote 2004 showed some barriers in applying GSCM in some industries. They are barriers in maintaining close relationships with suppliers, obtaining large market share through competition with domestic competitor in the same industry by improving product quality and reducing cost as well as ensuring the sustainability for the operation and reducing the environmental impacts. Different industry has different driver and factor in adopting GSCM in their organizations.

2.2.6 Reasons for GSCM in Automobile Industry

Simchi-Levi et al 2000 pointed out that one of the goals of companies is supply chain optimization and integration. Supply chain management help improve customer satisfaction and reduce costs. It also involves quality management. In addition, environmental management within supply chains has been gaining increasing interest.

Pollution and energy conservation issues such as cutting fuel consumption, regarding recycling, cutting emission and so on, lead to the extensive environmental customer requirements. Together with environmental regulations such as the Clean Air Act, the European End of Live Vehicles Directive (CEC 2000), car manufacturers got pressure to improve their environmental management functions. These concerns in 2 levels, the products and the processes related to the products. More eco-friendly vehicles and processes involve making vehicles are desirable. In order to meet the above requirements and pressure, car manufacturers have to cooperate with their suppliers. The degree of eco-friendly car depends on active suppliers involved in designing products. Most car manufacturers have adopted Environmental Management Systems according to ISO 14001 or the Eco-Management and Audit Scheme (EMAS: EC Regulation) in order to improve their environmental protection. These system or scheme should consist of the following elements:

- Defined Environmental Policy
- The Analysis of environmental impact on products and processes involved
- The Analysis of legal requirement on environmental protection
- Defined Environmental objectives and numeral target to achieve at all levels , functions and processes
- Monitoring procedures for each objective as well as other procedures in the event of non compliance with established environmental policies
- Procedures to ensure suppliers understand and comply the requirements. Suppliers should apply the same environmental standards as the customers do.

- Auditing of the EMS

Since the cooperation with the suppliers is very important, car manufacturers involve direct suppliers in extensive environmental control and follow up systems. In many cases, major car manufacturers have intensified its close cooperation with suppliers involving in designing products especially on their research and development activities. The environmental criteria in the evaluation and selection of suppliers become an important part. Suppliers should have enough capacities and readiness to fulfill environmental requirements. Suppliers are encouraged to apply the EMS. In addition the exchange of environmental information between the car manufacturers and suppliers is more crucial. It wills facilitate the state of mutual cooperation between them.

2.2.7 Key Performance Measures for GSCM in the Automotive Industry

2.2.7.1 Framework for GSCM performance measurement

Greening the automotive supply chain has become a major source of concern in many parts of the globe, thus measuring its performance is an important issue. The automotive supply chain is also complicate, compared to other industries' supply chain. To manufacture an automobile, it involves a lot of components and parts outsourced from various suppliers in different locations, at varying costs and complexities, therefore, using the regular supply chain does not fit in well for these products (Vonderembse etal., 2006; Olugu and Wong, 2009). The varying parts have made the automotive supply chain a bit more cumbersome than the ordinary one, thus measuring the performance of such a chain is quite demanding. Secondly, as green supply chain involves a from-birth-to-death approach, most products can easily be consumed once they get to the end user. The consideration on product entire life and recycling is an easy process. However, the case of the automotive industry is quite different since vehicles have a useful life of at least 5 years under normal circumstances. It is important that the automotive supply chain has to make sure that the end users get the products under good conditions at the right quantity at the right time (Wong and Wong, 2007). On the other hand, it is important to make sure that the end-of-life vehicles (ELVs) are recycled efficiently and effectively, and reabsorbed back into the manufacturing process. Greening the supply chain involves consideration of the total immediate and final environmental effects of all products and processes. It is, therefore, necessary to have a framework to measure its performance as a two- in-one chain and it extends the supply chain to include recovery operations such as remanufacturing, recycling, and reuse which adds an additional level of complexity to its design, and a new set of potential operational and strategic considerations. Thus, the effect on how the performance of a green supply chain should beaddressed (Beamon 1999b).

The first chain is concerned with the forward flow of vehicles which ends at the customer while the second one (back ward chain) starts after the useful life of the vehicle and ends when the product has been efficiently absorbed back into the chain. Beamon (1999b) also highlighted that the complexity in green supply chain management comes from two major sources which are uncertainties associated with the replacement/recovery process (on-time requirements, and quality and quantity of returned products), and the reverse distribution process itself which involves collection and transportation of used vehicles and parts. By adopting the proposed framework, the complexities will be considerably reduced. Olugu et al (2009a) also agreed that it is important to design a framework for supply chain performance

measurement in a way that would minimize its complexity. In this way, the forward chain will be aimed to make sure that products will get to the customers at the right time while satisfying the stakeholders' and regulatory bodies' needs. The backward chain will be aimed to make sure that the end-of-life vehicles will be reprocessed to minimize waste to the possible lowest level. Handfield and Nichols (1999) also agreed that green supply chain management should be concerned with three interrelated task areas, i.e. upstream, internal-stream and downstream of the organization. The upstream of the organization's supply chain involves the inclusion of environmental criteria in the evaluation and selection of suppliers and in the specifications of components. The internal stream involves with operations within the manufacturing company itself. The downstream of the chain is responsible for the disposal and sale of excess stock and the recovery and recycling of materials.

- *The Forward Chain*

This chain will involve all the processes aimed to make sure that the product is green enough and satisfies the customers' needs. The performance measurement of this chain, therefore, involves greening the processes of car manufacturing and delivering them to the end users while satisfying the customers' needs for on- time delivery of the right product at the right quantity. Thus, the performance measurement involves the assessment of all the echelons and their contribution in order to make sure that the product is green and, in the mean time, fit to satisfy key customers' value.

- *The Backward Chain*

This chain begins with the customers, and flows to the collection centers, then to the recycling centers where shredders, dryers, sorters and the actual recycling plants. From there, the recycled materials will go back to the supplier who makes them available to the manufacturer. It is also possible that manufacturer may collect materials directly from the recycling center and integrate it into its operation. It is important to assess the effectiveness of returning end-of-life vehicles and the efficiency of ensuing recycling processes and the smoothness of the recycled materials which are integrated back into the main operation stream.

2.2.7.2 Key performance measures and metrics for GSCPM in the automotive industry

Key performance measures and metrics to measure green supply chain performance in the automotive industry are recently developed by Olugu, Wong and Shaharoun. The measures and metrics are grouped under the framework of the forward and backward chain.

I. Forward Chain Measures

These measures are used to evaluate the forward chain operations. This consists of the evaluation of upstream supply chain operations involving the suppliers, the midstream operations which are processes within the manufacturing company itself, and the downstream operations involving the customers.

i. Upstream Measures

These measures are used to assess the suppliers' performance. Since the automotive industry involves mostly outsourced components or parts, the effectiveness of this part of the chain can be seen from the following measures and metrics.

a) Supplier Commitment

It is how supplier devotes to the greening exercise. It is very important since most automobile parts are outsources from various suppliers. Zhu et al. (2007), van Hoek (1999), Rao (2002) and Rao and Holt (2005) agreed that this measure is a very important. Some developed metrics are as follow.

- Level of supplier environmental certification
- Number of supplier initiatives on environmental management.
- Level of disclosure of environmental initiative to the public

ii. Midstream Measures

These measures are used to assess the internal operations of the car manufacturer company towards achieving and maintaining an environmentally sound supply chain

a) Greening Cost

This is the overall cost incurred by the company which shows the level of how its operations are environmentally sustainable. Beamon (1999b), Hervani et al. (2005), Tsoulfas and Pappis (2008) and Zhu et al. (2007). Klassen and Whybark (1999) considered this very important since it will demonstrate how much the company invests to get green performance. Greening cost is one of the major measures for an efficient green supply chain management. The metrics under this measure are as discussed as follow.

- Cost associated with environmental compliance
- Cost associated with energy consumption
- Cost associated with environmentally friendly materials.

b) Level of Process Management

This demonstrates how the organization has gone in optimizing and modifying its processes to enhance the reduction of environmental impact. This is very crucial as it reduces the immediate and final products effects significantly. This was also supported by Mclntyre et al., 1998; Beamon, 1999b; van Hoek, 1999; Rao, 2002; Rao and Holt, 2005; Hervani et al., 2005; Tsoulfas and Pappis, 2008. The following metrics are used.

- Availability of process optimization for waste reduction
- Level of spillage, leakage and pollution control
- Level of waste generated during production

c) Product Characteristics

This involves how the features and components of the automobile contribute to green environment. The studies done by Mclntyre et al. (1998), Beamon (1999b), van Hoek (1999) Rao (2002) Hervani et al. (2005), Rao and Holt (2005), Zhu et al. (2007), and Tsoulfas and Pappis (2008) also supported this. The metrics considered are as follows.

- Level of recycled material in products
- Availability of eco-labeling
- Level of biodegradable content in products
- Level of market share controlled by green products

d) Management Commitment

This shows the level of overall effort and initiatives implemented by the management of an organization in order to deal with anti-environmental practices within its supply chain. Without top management support it will not succeed. Managers are key persons involving decision making in selecting suppliers and operation processes (Rao and Holt, 2005; Zhu et al., 2007) (Beamon, 1999b; Hervani et al., 2005; Tsoulfas and Pappis, 2008; Rao, 2002; van Hoek, 1999). The metrics under this measure are as follows.

- Level of management effort to motivate employees
- Availability of environmental auditing systems
- Availability of mission statement on sustainability
- Number of environmental management initiatives
- Availability of environmental reward systems
- Level of management effort to motivate suppliers

e) Traditional Supply Chain Cost

This is the regular supply chain cost incurred as a result of the normal operations in the chain. This cost has been identified as an important measure of the supply chain performance for a long period of time It is believed that to make it green, the traditional supply chain cost will be influenced in one way or another (Gunasekaran etal., 2001; Beamon, 1999a; Schonsleben, 2004; Stephens, 2001; Morgan, 2004; Bhagwat and Sharma, 2007). Different kinds of cost are identified as follows.

- Percentage decrease in total supply chain cost (tangible and intangible cost)
- Percentage decrease in delivery cost
- Percentage decrease in inventory cost
- Percentage decrease in ordering cost

f) Responsiveness

This is to measure how the supply chain responds to certain elements such as order lead time, product development cycle time, manufacturing lead time, total supply chain cycle time and on-time delivery. This is one of the key measures (Gunasekaran et al.(2001) and Beamon (1999a). The responsiveness will be affected by the greening initiative and, therefore, it is necessary to measure its effect. The metrics under this measure are as follows.

- Percentage decrease in order lead time
- Percentage decrease in manufacturing lead time
- Percentage decrease in total supply chain cycle time.
- Percentage increase in on-time delivery

g) Quality

This is to measure the standard of the product which is considered to have big impact on supply chain performance as Artz (1999), Gunasekaran et al.(2001), Beamon (1999a), Stephens (2001), Hieber (2002), Chan and Qi (2003), Chan (2003), Graham et al.(1994), Bhagwat and Sharma (2007), Morgan (2004), and Windischer and Grote (2003). The metrics under this measure are listed as follows.

- Percentage decrease in customer dissatisfaction
- Percentage decrease in delivery unreliability
- Percentage decrease in scrap and rework

h) Flexibility

This is to see the adjustment ability to fit various scenarios that may occur due to changes in the normal supply chain processes Chan (2003), Beamon (1999a), Gunasekaran et al. (2004), Gunasekaran et al.(2001), Stephens (2001) and Schonsleben (2004). Due to the greening process, the change can be found by using several metrics as listed below.

- Percentage increase in demand flexibility
- Percentage increase in delivery flexibility
- Percentage increase in production flexibility

iii. Downstream Measures

This is aimed to measure the downstream of a supply chain which concern the customer point of view.

a) Customer Perspective

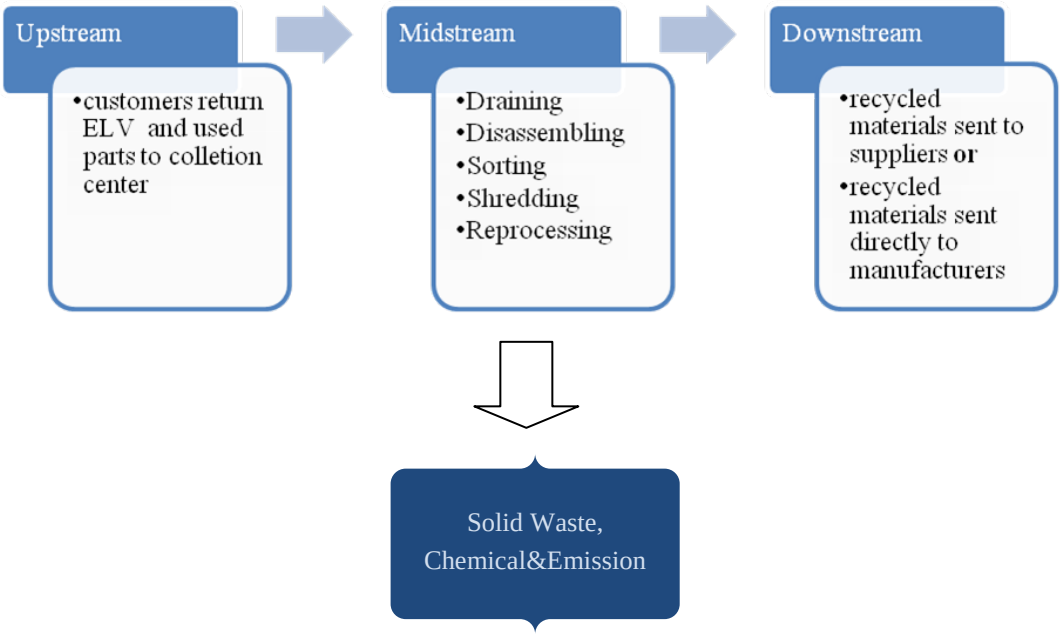
This involves customers' views on the green supply chain and the product there of. This is very important since every manufacturer wants to sell their products to the consumers and customers' satisfaction should be maintained (Gunasekaran et al., 2004) (Beamon, 1999a; van Hoek et al., 2001; Zhu et al., 2007). Some metrics under customer perspective have been listed as follows.

- Level of customer interest in green products
- Level of customer satisfaction from green product

II. Backward (Reverse) Chain Measures

This is to assess the performance of the reverse chain. It is important to evaluate the efficiency and effectiveness of returning the end-of-life vehicles (ELVs) and their subsequent recycling and reintegration into the main manufacturing process. The operations upon which the measures are established for the reverse chain are presented in figure 12.

Figure 12 Reverse Chain Activities



It shows that the ELV moves from the customer to the collection center. Then it is sent to recycling unit which involves draining (for fluid, petrol, and oil), disassembling car into pieces, then, sorting and classifying and finally reprocessing. Oligu, Wong and Shaharoun (2010) suggested the list of measures used for evaluating this backward chain as follows.

i. <u>Upstream Measures</u>

a) Customer Involvement

This is to evaluate overall customers‘s cooperation in returning the ELVs. Without support from customer, the process will not succeed (Dyckhoff et al. 2004 and Theyel 2006) stated that in order to bridge the gap in the collection of ELVs, the customers must be considered and supported this fact. Some metrics under this measure are listed below.

- Level of understanding of green process by customers
- Level of customer to customer dissemination of information
- Level of understanding of green process by the customers

ii. Midstream Measures

a) Recycling Cost

The cost associated with recycling the ELVs is considered as remanufacturing cost Inderfurth (2004). Therefore, these costs should be identified considered it as remanufacturing cost. Since cost has already been identified as very vital to supply chain performance measurement, the cost associated with the reverse chain will no doubt be a very important measure. Some metrics under recycling cost are listed.

- Cost associated with processing of recyclables
- Cost of disposal for hazardous and unprocessed waste

b) Material Features

This is to assess the composition and effect of the materials in the ELVs on the reverse supply chain. Different automobiles create different compositions; therefore, affect the entire reverse logistics process. It may consider this as the recyclability of the materials (Hesselbach et al. 2007). This is the important measure since it shows the effectiveness of the reverse chain. Some metrics are listed below.

- Level of waste generated in recycling process (quantity of waste (solid and liquid) that is generated per ELV at the end of the recycling process) (Dyckhoff et al (2004 and Cruz-Rivera and Ertel 2009)
- Material recovery time
- Ratio of materials recycled to recyclable materials.

c) Management Commitment

This is to measure the top management's involvement to make sure that the recycling is efficiently and effectively carried out. Under this measure, there are several metrics which could be employed. Mezher and Ajam (2006) and Olugu et al.(2009b) agreed that this factor is also important for environmental stewardship of a product. Some metrics are listed below.

- Availability of collection centers
- Availability of waste management schemes

d) Recycling Efficiency

This is to measure the overall effectiveness of the recycling processes. The higher recycling efficiency, the greener the supply chain management. Below are some metrics used to assess the efficiency of recycling process.

- Availability of recycling standards
- Percentage decrease in utility usage during recycling
- Percentage reduction in emission and waste generated.

iii. Downstream Measures

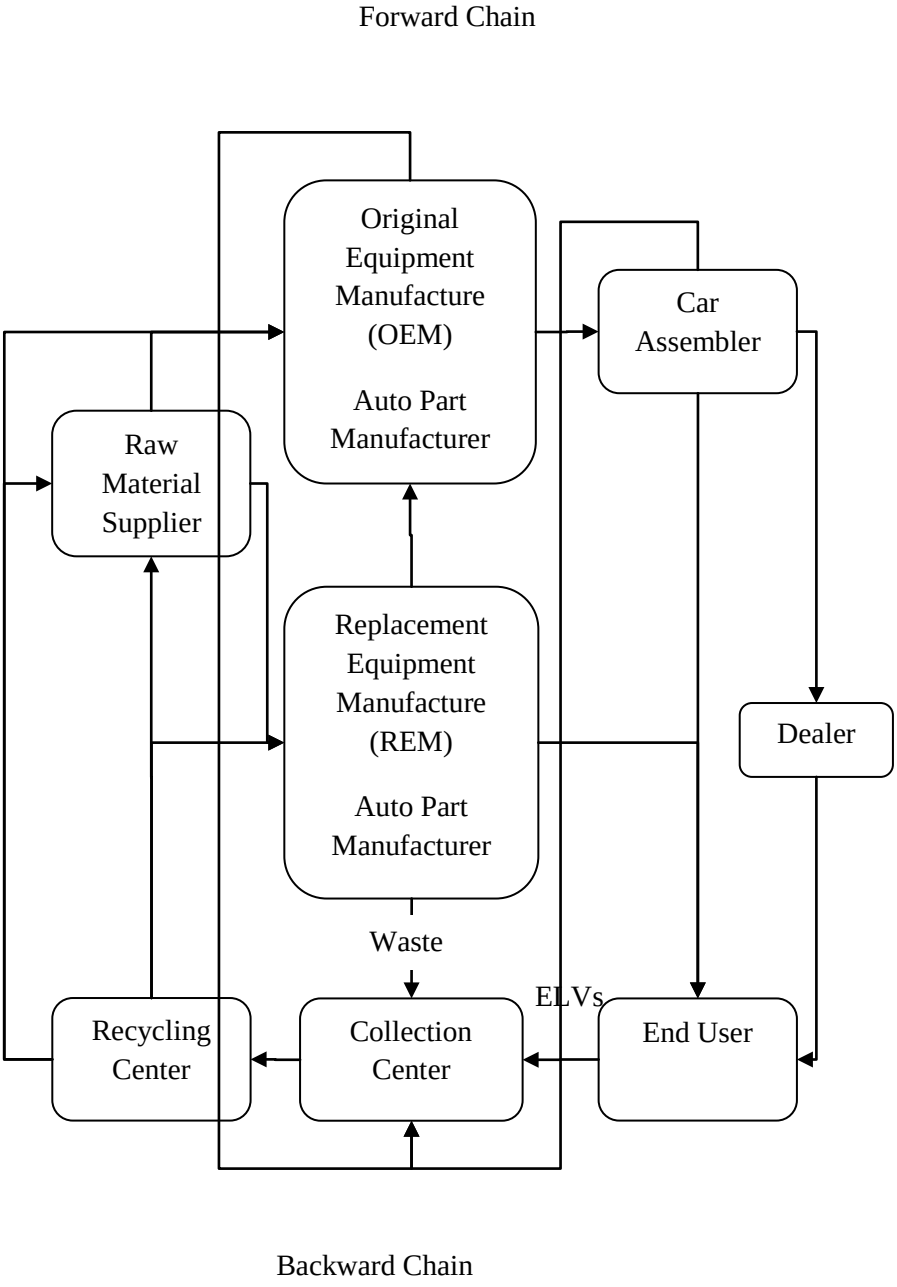
a) Supplier Commitment.

This is to assess the initiatives by the suppliers to make sure that the whole reverse supply chain process is successful (Hamner 2006). Some metrics used are listed below.

- Certification system for suppliers in the recycling process
- Number of supplier initiatives in the recycling process
- Extent of delivery from suppliers back to manufacturers.

3 RESEARCH METHODOLOGY

Figure 13 Auto Part Manufacturer as part of Supply Chain Management



3.1 Data Collection

Since the automotive supply chain is the most complex supply chain in all manufacturing system (Wang et al 2006). This is because cars are complicated and a lot of components and parts are used to assemble them. These parts and components come from various sources which are located in different locations. To measure the whole supply chain is too complex and time consuming. In addition, the car manufacturers' cooperation was not available at the time of research survey. Therefore, this research was focused only on the auto part manufacturers who also play important role in the automotive industry. Thai auto part manufacturers act as suppliers of original equipment manufactured (OEM) auto parts (1^{st} tier) for car assembly manufacturers in the chain. There are also some auto part manufacturers (2^{nd} and 3^{rd} tier) who produces parts and components for OEM auto part suppliers (1^{st} tier) and replacement equipment manufactured (REM) auto parts for end users as shown in the figure above. Thus their customers can range from car assembly factories, OEM auto part suppliers, who reprocess parts for car assemblers, and customers as end users. As they purchase raw materials from their suppliers and produce products for their customers, this part of the chain therefore move further backward. As they are part of the chain, the research was aimed to explore how these auto part suppliers perform their green activities in their supply chain.

It was planned to collect primary data through survey by using questionnaire and interviews. Since the researcher was not in Thailand where all respondents resided, the electronic survey with questionnaire was conducted. Based on key performance measures developed by Olugu et al 2010, a five page questionnaire in English was developed. It comprised two parts. The first part of the questionnaire was to obtain the background information about the respondents such as gender, age, educational background, number of years of experience in the business and their position. The second part comprised 73 metrics to measure the whole supply chain of auto part manufacturing. In the questionnaire five choices represent level of the importance of their perception on each metric. A scoring scale from 0 to 5 was applied; 0 = no/ no idea, 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high

It is so simple that the respondents are asked to rate each metrics to assess the important level choosing a scale from 0 to 5.

To avoid respondents' confusion on each measures and metrics, a brief explanation was also provided.

After the development of questionnaire was done, it was sent to experts of automotive and related industries to test the questionnaire. It was agreed that the questionnaire was too long. It is too much time consumed for businessmen to complete the whole questionnaire. It should also be developed in only one version with two languages: Thai and English. The comments and feedbacks from the experts were, then, used to revise the questionnaire. The revised version of the questionnaire comprised only 47 metrics representing all measures developed by Olugu et al 2010 in 4 page length in new concise format in order to facilitate the respondents to be more convenient in completing the form. The questionnaire was developed in form of electronic web based questionnaire. The web based platform would handle the data in a smooth manner. After the revision, the questionnaire was not sent back to the same experts since they were quite busy for further comments.

Since this research was focused on Thai auto part manufacturers therefore experts from the industry were selected with the cooperation of the Thai Auto Part Manufacturers Association (TAPMA). A total of 280 emails were randomly sent using the database of the association. The researcher sought for the cooperation in completing questionnaire voluntarily via website (www.questionpro.com). These respondents were based on the factories located in Thailand. A majority of the respondents belonged to private owned enterprises. The No greater consideration to the companies' size is to be taken. However, a majority of respondent enterprises fall into the small and medium sized company categories. This study targeted respondents who would be in the positions of engineer, manager at middle or higher management levels, industrial owners and others who related to the overview of supply chain of the company. Following the study done by Carter et al, this research included mid - level managers such as those in the purchasing department could facilitate the adoption of GSCM. Bowen et al is finding also support this. It showed the positive relationships between middle managers' perception of GSCM. Furthermore, it was assumed these respondents easily accessed to the internet since nowadays the internet was widely used and they probably feel comfortable to answer the question via computer. The objective of the survey, together with the GSCM concepts were briefly introduced to the targeted respondents to make sure that they had a full understanding of the items in the survey questionnaire. The respondents were asked to fill and submit the questionnaire during 24 August – 30 September 2010.

While preparing the questionnaire, the interview with key industrial people was planned to conduct in Thailand. The interview will create opportunity to get more information and business point of view. One big problem realized during the research was the problem of time and scheduling for the interviews. Since these

interviewees were very busy due to harder Thai currency effect on the country' s export, the appointment for interview therefore were not possible. Fortunately, the researcher had been informed that there was a trade fair, ***Automechanika***, held in Frankfurt, Germany during 15 – 19 September 2010, There would be some Thai auto part manufacturers participating in this fair. Therefore it would be a very good opportunity to meet and interview them there. The interviews were not formally constructed. It took around 30 minute per one interviewee. The idea was to get additional industrial information and comments valuable for this study. This type of interview as supportive research method served our purpose very well. In addition to information received, it also gave the opportunity to more freely discuss related subjects with the interviewees as it was mentioned as an advantage by Nordin (2006). The discussion was steered into roughly their view for present situation and future development of the industry.

3.2 Data Analysis

The researcher gathered the score from the questionnaire to find out mean and then analyze in the descriptive way. The detail of how to calculate the results by using mean are described below. For the result got from the interview would be concluded in the discussion.

- *Arithmetic Mean*

In mathematics and statistics, the arithmetic mean, often referred to as simply the mean or average when the context is clear, is a method to derive the central tendency of a sample space. The term "arithmetic mean" is preferred in mathematics and statistics because it helps distinguish it from other averages such as the geometric and harmonic mean.

In addition to mathematics and statistics, the arithmetic mean is used frequently in fields such as economics, sociology, and history, though it is used in almost every academic field to some extent. For example, per capita GDP gives an approximation of the arithmetic average income of a nation's population.

While the arithmetic mean is often used to report central tendencies, it is not a robust statistic, meaning that it is greatly influenced by outliers. Notably, for skewed distributions, the arithmetic mean may not accord with one's notion of "middle", and robust statistics such as the median may be a better description of central tendency.

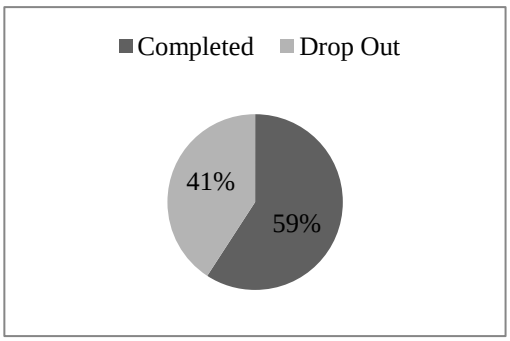
Suppose we have sample space $\{x_1, \ldots, x_n\}$. Then the arithmetic mean *A* is defined via the equation

$$A := \frac{1}{n} \sum_{i=1}^{n} x_i .$$

If the list is a statistical population, then the mean of that population is called a population mean. If the list is a statistical sample, we call the resulting statistic a sample mean.

4 RESULTS AND DISCUSSION

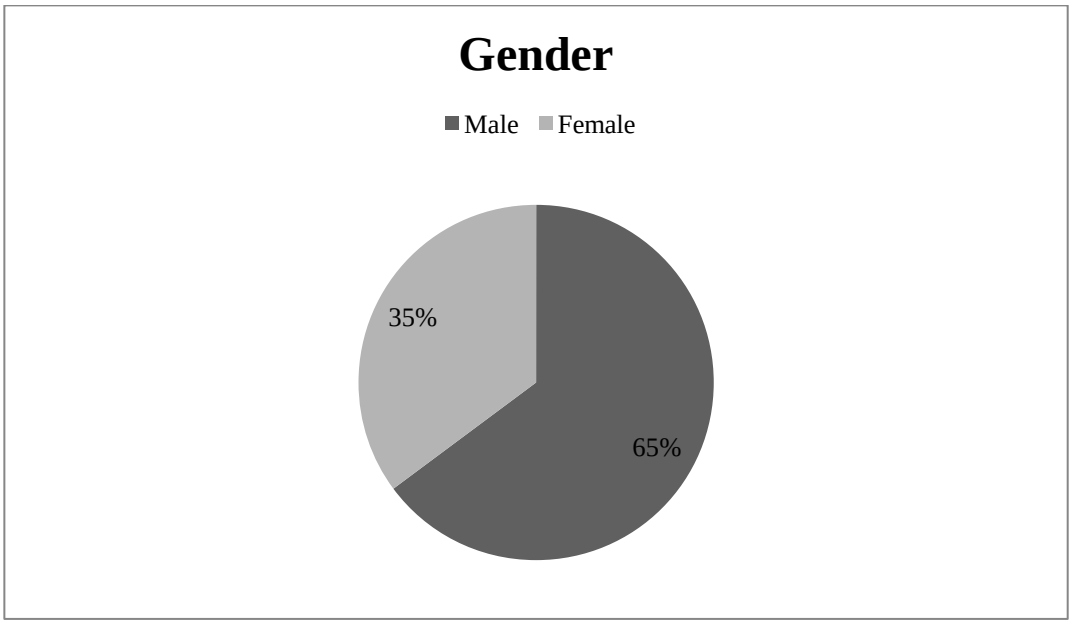
Figure 14 Survey Report

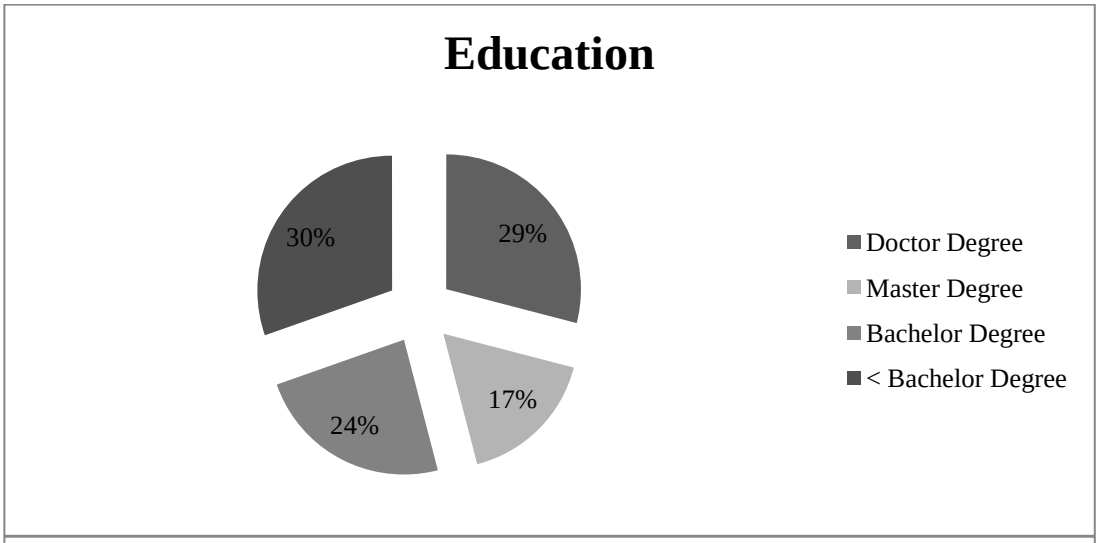


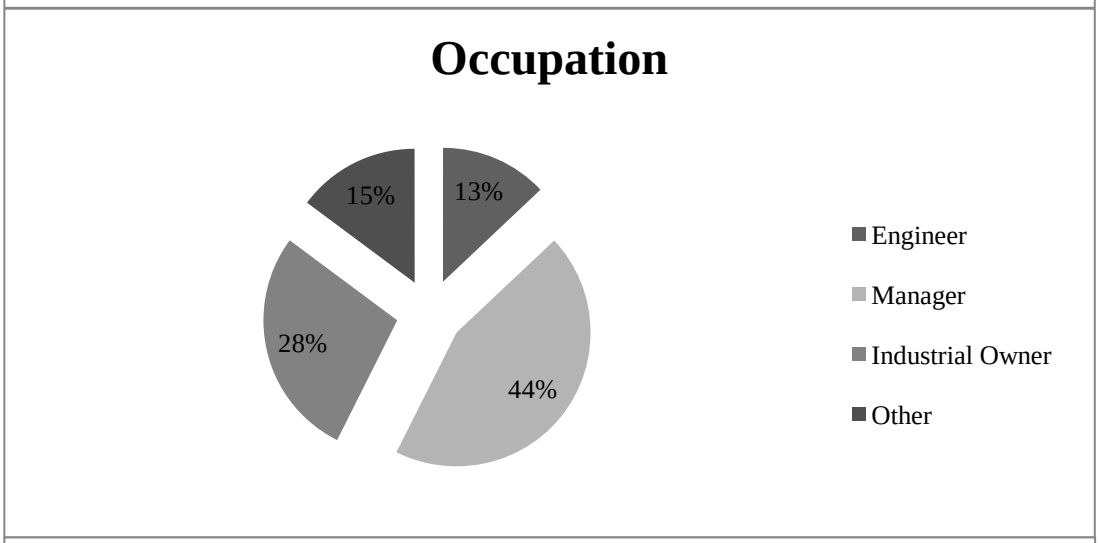
Viewed	Started	Completed
98	71	42

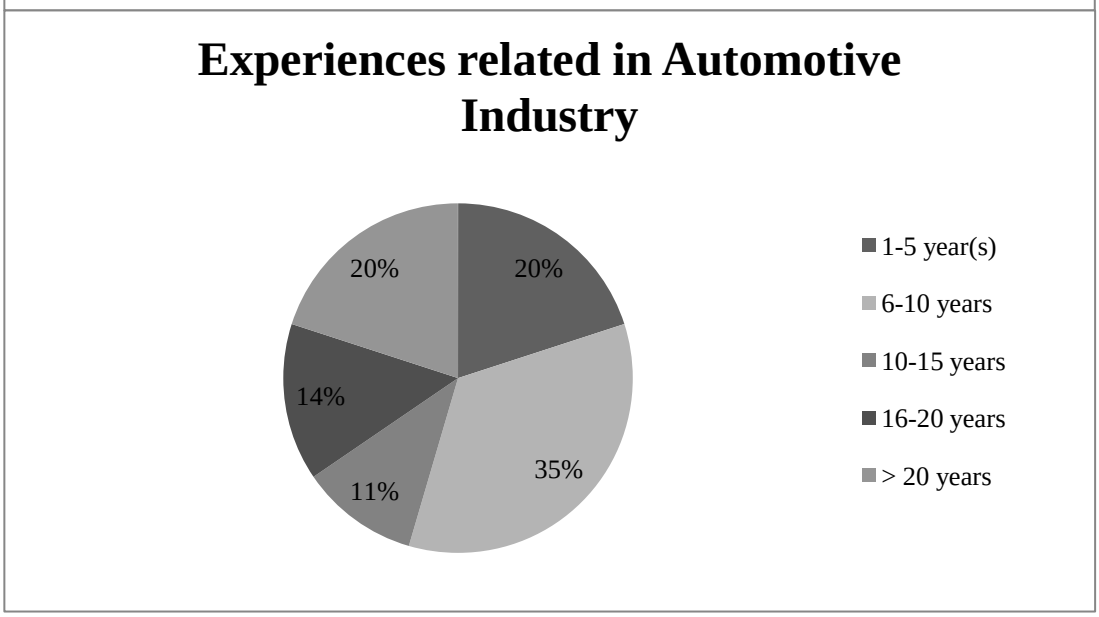
After the link was sent to 280 respondents by email, seeking the cooperation to answer the questionnaire, the responses were received within the fixed period which was around 30days. It was found out that 98 persons had viewed the questionnaire, 71 persons had started doing questionnaire but not finished. Only 42 were completed which was accounted 15% of the targeted email respondents and also 41% of persons who had already viewed the questionnaire. This is acceptable level according to Gunasekaran et al (2004) which considered 14 % adequate. 29 respondents who were unable to complete the questionnaire stated that the questions were not related to their field.

Figure 15 Respondents' Information




Education
30%
29%
24%
17%
Doctor Degree
Master Degree
Bachelor Degree
< Bachelor Degree


Occupation
15%
13%
28%
44%
Engineer
Manager
Industrial Owner
Other

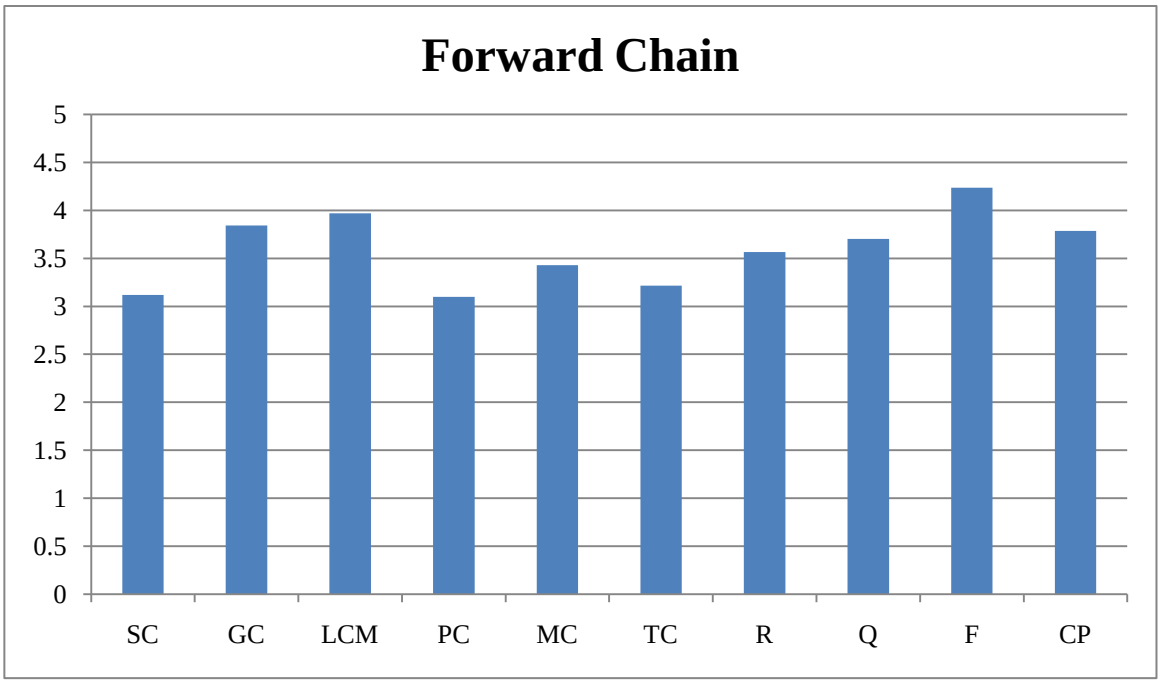

Experiences related in Automotive Industry
20%
20%
14%
35%
11%
1-5 year(s)
6-10 years
10-15 years
16-20 years
> 20 years

The qualification of the questionnaire respondents are depicted in the charts above. The summary of their qualifications are as follows.

1. 65% and 35% of respondents were male and female respectively.
2. Around 70% of the respondents finished higher education ranging from Bachelor to Doctorate degrees.
3. It was interesting that the respondents are in the positions of manager, owner and engineer accounted for 44%, 28% and 13% respectively.
4. Almost 50% of the respondents had more than 10 years of experience.

As mentioned earlier, each measure was accessed based on their corresponding metrics. Therefore, each measure was calculated to find an average mean score to establish their level of importance and application. The results are summarized in the figures below.

Figure 16 Forward Chain



SC – Supplier Commitment

	Mean
Level of Supplier Environment Certification This is the extent to which the selected suppliers of raw materials have been formally recognized as a committed practitioner of green sourcing and supplying. This can be judged by the number of environmental certifications acquired over the years	3.182
Number of Supplier Initiative on Environment Management This involves all the initiatives raw material suppliers have put in place to enhance their green status. They can be in the form of motivation programs for their workers, agents, etc.	3.267
Level of Disclosure of Environmental Initiative to the Public This involves the extent to which the suppliers declare their green intentions openly. When they declare their commitment openly, it is easy for people to be assured of their responsibility.	2.911
Total of Supplier Commitment	**3.120**

GC – Greening Cost

	Mean
Cost associated with environment compliance This is very important in assessing the greening cost. This involves all capital invested by a company in order to try to meet up with all the environmental requirements. It is believed that environmental compliance involves a series of expenditures. Therefore, the more a company spends in trying to achieve the compliance, the more likely it will yield an effective green supply chain.	3.844
Cost associated with energy consumption Under this cost, the energy which is consumed by the company in its operation is considered especially the cost of energy of the plant and machineries and costs that were spent on other function in the organization. For a green company, the level of consumption should be comparatively low.	4.089
Cost associated with environmentally friendly materials This involves the totality of capital invested by an organization towards the acquisition of environmentally compliant raw materials. It is a known fact that in order to acquire environmentally friendly raw materials, a company will have to spend additional capital on the suppliers. Higher capital invested in this regard will yield greater motivation to the suppliers and thus will boost the greening effort.	3.600
Total of Greening Cost	**3.844**

LPM - Level of Process Management

	Mean
Availability of process optimization for waste reduction This is to consider whether the company has any structure in place to enhance the reduction of waste including both solid and liquid, generated during manufacturing.	4.227
Level of spillage, leakage, and pollution control It is to consider the environmental effects associated with manufacturing such as the level of emission, spillage and leakage control is considered.	4.205
Level of waste generated during production This is the quantity of waste generated through manufacturing operations within an organization. It is believed that if the process is green enough, the level of waste generated should be considerably minimal.	3.477
Total of Level of Process Management	**3.970**

PC – Product Characteristics

	Mean
Level of recycled materials in products This is the extent to which the company integrates recycled materials back into its main stream manufacturing process. This is a major step in encouraging reverse logistics by becoming a major customer of its own recycled materials.	3.911
Availability of eco-labeling Eco-label is a labeling system for consumer products that are made to avoid harm effects on the environment. This has been identified a case of the environmental compliance of a given product making it look good for a green conscious customer.	2.556
Level of biodegradable content products This measures the quantity of materials in the product which is capable of being decomposed by biological agents such as bacteria and other biodegradable detergents. Biodegradable materials will finally return to the earth after they have been disposed. They do not pose much threat to the environment. Inclusion of such materials in the part components contributes to the greening drive.	3.022
Level of market share controlled by green products This is a measure of the proportion of industry sales of a green auto parts. It is believed that this will have a great impact on assessing the success of a green product.	2.911
Total of Product Characteristics	**3.100**

MC – Management Commitment

	Mean
Level of management effort to motivate employees This metric measures the top management's effort in motivating its employees towards green supply chain management. Since the employees are directly in-charge of implementing the strategy, it is necessary to motivate them towards its success.	3.911
Availability of environmental auditing systems This metric evaluates the availability of such internal environmental regulating systems. This is to ensure the right attitudes and actions are being implemented towards greening the internal processes within the company.	3.523
Availability of mission statement on sustainability A mission statement demonstrates business goals and values of an organization. If companies include greening in their mission statement, it implies they should seriously carry it out. Availability of such a document is one way to measure of greening commitment.	3.568
Number of environmental management initiatives This is a measurement of the level to which the organizations have devised several programs aimed to encourage green supply chain management within and outside their immediate organizations.	3.674
Availability of environmental reward systems This measures the availability of an incentive package or any form of compensation created to encourage individuals, departments or suppliers to practice green supply chain management.	3.093
Level of management effort to motivate suppliers Under this metric, the level of encouragement given to the suppliers by the management of an organization aimed to boost their greening strives is assessed. It can be in the form of training, financial assistance, etc.	2.930
Total of Management Commitment	**3.428**

TC - Traditional Supply Chain Cost

	Mean
Percentage decrease in total supply chain cost (tangible and intangible cost) This is to measure the total cost incurred in running the entire supply chain by an organization. It takes into account all costs accruable in making sure that goods get to the end users. Gunasekaran et al. (2001) commented to include cost of operation per hour. Chan (2003) suggested considering total over head cost, both tangible cost and incentive cost. Beamon (1999a) included total cost of resources and manufacturing. It was described to cover returns processing cost and total supply chain cost (Stephens, 2001). Bhagwat and Sharma (2007) called it supply chain finance, logistic cost and cost associated with assets.	3.209
Percentage decrease in delivery cost Based on the assumption that the cost of delivery will be reduced under a sound green supply chain management. Chan (2003) highlighted this to be a very important metric. Schonsleben (2004) expressed it as cost of finished goods in transit. The change in delivery costs could be a metric to assess the overall traditional supply chain cost.	3.209
Percentage decrease in inventory cost This is to assess the cost of inventory storage within the company over a period of time. It may be called differently such as "inventory carrying cost" by Morgan 2004 or "cost of inventory for supplies" by Stephens (2001) or "inventory utilization and warehousing cost" by Chan and Qi (2003) or "inventory obsolesce and inventory investment cost" by Beamon (1999a). It was also called inventory turnover cost and "total inventory cost" as suggested by Schonsleben (2004) and Bhagwat and Sharma (2007), respectively. It is believed that inventory cost will reduce as a result of green supply chain management.	3.290
Percentage decrease in ordering cost This is the cost associated with orders placed on raw materials. It should include economic order quantity and effectiveness of production schedule as elements in ordering cost as suggested by Gunasekaran et al. (2001). Beamon (1999a) also included the number of back orders and stock out probabilities. Morgan (2004) suggested to look at the order processing cost. It is believed that a good supply chain practice such as green supply chain management should reduce the ordering cost.	3.163
Total of Traditional Supply Chain Cost	**3.217**

R - Responsiveness

	Mean
Percentage decrease in order lead time This is the time elapsed between the ordering of raw materials, and receiving them. Gunasekaran et al (2001) suggested that it include supplier lead time and purchase order cycle time. Beamon (1999a) expressed it is as the average of the lateness and earliness of the orders. Stephens (2001) and Chan (2003) agreed that this was the order fulfillment lead time.	3.390
Percentage decrease in manufacturing lead time This is to measure the delay from the moment the order is ready for manufacturing until its completion. It was considered to be an important measurement as suggested by Beamon (1999a) and Stephens (2001).	3.561
Percentage decrease in total supply chain cycle time This is the total time elapsed between the ordering of raw materials from the suppliers until when the finished products reach the customers. It is also crucial as supported by Schonsleben (2004), Gunasekaran et al.(2001) and Beamon (1999). Schonsleben (2004) and Morgan (2004) identified it as total supply chain response time. These show the level of importance attached to this metric.	3.452
Percentage increase in on-time delivery This measures the tardiness in the delivery of finished products. Traditionally, some researchers looked at it as Gunasekaran et al. (2001), Chan (2003), Beamon (1999a), Stephens (2001) identified it as delivery lead time. The emphasis on this has been established based on the level of attention it has received.	3.857
Total of Responsiveness	**3.565**

Q – Quality

	Mean
Percentage decrease in customer dissatisfaction This involves dissatisfaction of the customer when use the product. It can be seen from customer complaint (Beamon 1999a) and (Morgan 2004. Bhagwat and Sharma (2007) also discussed this as service level against competitors' and customer perception of service. This is considered as a very important since the satisfaction of the customer is the most valuable asset an organization can have.	3.674
Percentage decrease in delivery unreliability This refers to the level of dissatisfaction arising from unsatisfactory delivery of products. It is believed that a high quality should be reflected in the reduced number of complaints with regard to unreliable delivery.	3.628
Percentage decrease in scrap and rework This is the number of products that is reworked due to certain reasons as well as those which cannot be reworked which are classified as scraps. Chan (2003) termed this as the proportion of wrong products manufactured. Morgan (2004) called it damaged product. It is believed that a reduced level of scrap and rework depicts a high level of quality in manufacturing processes.	3.810
Total of Quality	**3.704**

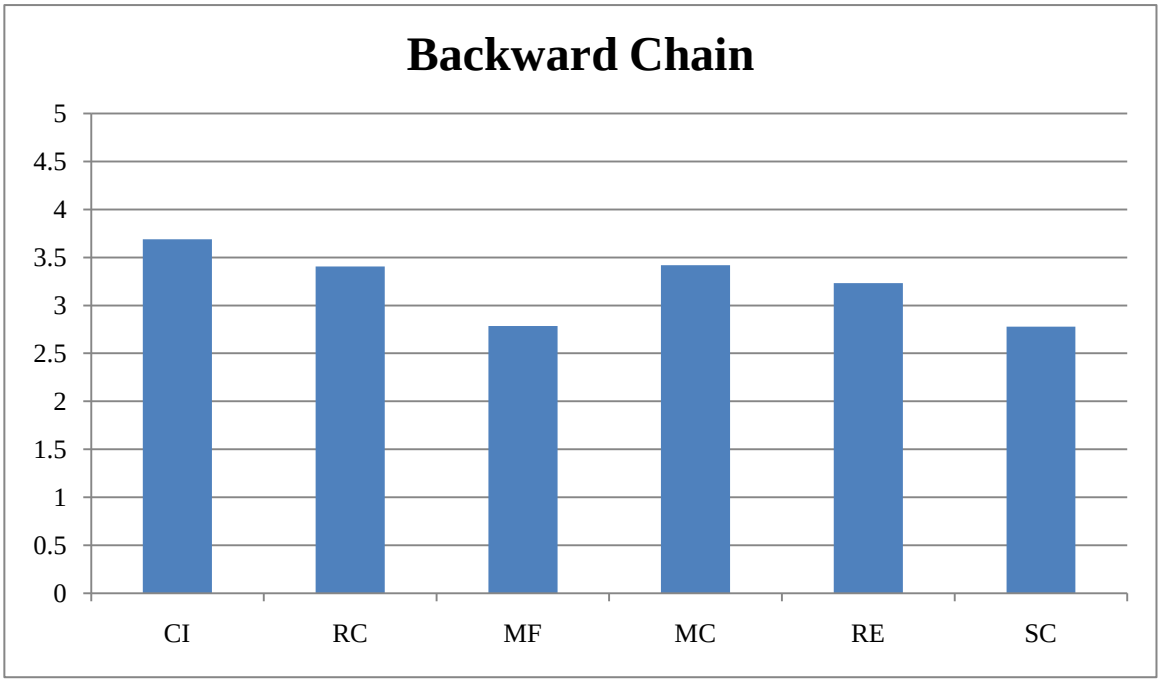
F – Flexibility

	Mean
Percentage increase in demand flexibility This is the level to which the orders can be changed due to customers' demands (Morgan, 2004). The supply chain should be able to accommodate changes in customers' orders without much effect on the system. Bhagwat and Sharma (2007) also identified it as effectiveness of scheduling.	4.405
Percentage increase in delivery flexibility This is the ability of the system to accommodate changes in delivery time and method. It may be called ability to respond to urgent deliveries or delivery flexibility (Gunasekaran et al. 2001), (Bhagwat and Sharma 2007), and (Chan and Qi 2003) and (Beamon1999a)	4.238
Percentage increase in product flexibility This is the flexibility of production systems to meet particular customer needs (Bhagwat and Sharma, 2007; Stephens, 2001). Schonsleben (2004) and Beamon (1999a) called it as volume capacity, while Bhagwat and Sharma (2007) used the term range of products.	4.071
Total of Flexibility	**4.238**

CP - Customer Perspective

	Mean
Level of customer interest in green product This involves considering the extent to which the customers really care about the environmental effects of the products they consume. It is believed that some customers who have been victims of environmental degradation would really care about the extent to which it is considered in the design of a product. Hence, customers' interest is very vital in the design and production of green products.	3.762
Level of customer satisfaction from green product Under this metric, the satisfaction derived by the customer from the green product is measured. Since green products must entail certain modifications, it is believed that it is worthy to measure the extent to which the customers are satisfied with these products despite the modifications.	3.810
Total of Customer Perspective	**3.786**

Figure 17 Backward Chain



CI – Customer Involvement

	Mean
Level of understanding of green process by customers This measures the understanding of customers in the greening process. It is very important that the customers should understand the greening process and then fully cooperate (Dyckhoff et al. 2004)	3.690
Total of Customer Involvement	**3.690**

RC- Recycling Cost

	Mean
Cost associated with processing of recyclables This includes the cost of draining, disassembling, shredding and final reprocessing of the end of live products, wasted and residues. It may be called cost of reprocessing activities.	3.395
Cost of disposal for hazardous and unprocessed waste At the end of the recycling process, there is always a residue. This waste should constitute less of end of life products as possible. It should be properly disposed. The cost involved in this disposal (Dyckhoff et al., 2004**)** is considered here.	3.419
Total of Recycling Cost	**3.407**

MF - Material Features

	Mean
Level of waste generated in recycling process This is the quantity of waste (solid and liquid) that is generated per end of live product at the end of the recycling process. This waste should have a direct relationship with the material composition of the end of live products (Dyckhoff et al. 2004). Cruz-Rivera and Ertel (2009) also highlighted that this waste is a very important metric. Therefore, the higher the non-recyclable portion of the automobile, the higher the expected quantity of waste to be generated.	2.786
Total of Material Features	**2.786**

MC - Management Commitment

	Mean
Availability of collection centers It is expected that the management will be responsible for providing a collection center. Dyckhoff et al.(2004) and Helms and Hervani(2006) believed that this will be very necessary for an effective returning of end of live products. The availability and ease of accessibility of collection centers for ELVs will boost the returning process.	3.163
Availability of waste management schemes This is aimed at measuring the availability and effectiveness of the waste management scheme for waste generated at the end of the recycling process. It should have a proper management and disposal program in place (Dyckhoff et al. 2004), (Schultmann et al. 2004) and (Hesselbach et al. 2007).	3.674
Total of Management Commitment	**3.419**

RE - Recycling Efficiency

	Mean
Availability of recycling standards This is to measure the existence of a standard established for all the recycling processes. Without a standard, it will be difficult to know whether the recycling is effective or not (Hesselbach et al. 2007) and (Spengler et al. 2004)	3.209
Percentage decrease in utility usage during recycling This is to measure of the amount of power consumed, water used, gas used, etc., during the recycling of a given quantity of end of live products. A higher efficiency of the process, the lower usage of utilities (Tsoulfas and Pappis 2008) and Hervani et al. (2005)	3.140
Percentage reduction in emission and waste generated It is to measure the amount of pollutant per commodity by looking at the reduced level of the emission and waste generated during each recycling operation. Since recycling is aimed at waste reduction, the lower the waste and emission generated, the more efficient the recycling process.	3.349
Total of Recycling Efficiency	**3.233**

SC - Supplier Commitment

	Mean
Certification system for suppliers in the recycling process The availability of a system that will certify the effectiveness of the suppliers in reverse logistics is assessed here. It can serve as an audit system to know whether the integration is really taking place. Hamner (2006) and Sroufe (2006) believed this to be a very crucial metric.	2.767
Number of supplier initiatives in the recycling process This is a measure of the number of initiatives put in place by the suppliers to encourage and promote the effective recycling of the ELVs. This should be evaluated based on the key programs employed by the raw material suppliers aimed at boosting the recycling process. Sroufe (2006) highlighted this to be an important metric.	2.791
Total of Supplier Commitment	**2.779**

The results are summarized in figure 16 and 17. For the forward chain of auto part manufacturers, it can be seen from figure 16 that flexibility (F) in adjusting in various scenario that might happen due to changes in the normal supply chain had the high score of 4.238 implied an 84.76 % importance. This was followed by level of process management (LCM), which concerned the extent a company has done to optimize and modify its processes to enhance the reduction of environment impact, accounted for 3.970 and its importance was 79.4%. Then, greening cost (GS)'s score was 3.844 or 76.88% of its importance The list continued with customer perspective (CP), quality (Q), responsiveness (R), management commitment (MC), traditional supply chain cost (TC) supplier commitment (SC) which scores were 3.786, 3.704, 3.565, 3.428, 3.217, respectively. The percentages of importance were 75.72 %, 74.08%, 71.3%, 68.56%, and 64.34%. The lowest score was product characteristic (PC) which equal to 3.1 or its important of 62%.

For backward chain measures represented in figure 17. Customer involvement (CI) got highest score of 3.407 or it importance of 68.14%. This followed by management commitment (MC), recycled efficiency (RE) and material features which was accounted for 3.419, 3.407, 3.233, respectively. Their importances were 68.38%, 68.18% and 64.46% respectively. The low scores were material features (MF) and

supplier commitment. The scores were 2.786 and 2.779 or their importances were 55.72% and 55.58% respectively.

From the result obtained, it can be noticed that all measures of forward chain got a mean important score of more than 3. The most important measures identified by the respondents were flexibility. This may imply that applying green supply chain facilitated the companies in term of flexibility though the chain. It was assumed that there was high level of cooperation among all players in the chain (Stevels 2002). This helps adjust themselves more flexible to any changes such as customers' demand, urgent delivery etc. This was supported by information got from the interview. Most of auto part manufacturers in Thailand are small enterprises. The decision making channel was quite short and involved fewer people. This created close relationship among suppliers and other auto part manufacturers as well as car assembly plant via multi channels. In addition to this, it can save more cost, better close relationship, and also better deal with the changing situations.

The result also shows that level of process management got high score. This means the auto part manufacturers had an attempt to modify its processing to enhance the reduction of environmental impact. The information got from the interview also supported this. Auto part manufacturers, especially OEM, would like to demonstrate environmental friendly image to their customers who were mainly multinational corporations. They wanted to see their suppliers perform positive environmental activities. Greening cost measure got similar scores. It is assumed that it may result from optimized operation process. It also implied that auto part manufacturers had a certain level of investment to comply as much as possible of greening concept. Customer perspective measure had similar score compared with the greening cost measurement. This implies that auto part manufacturers take into account the customers' view with respect to the green supply chain at a certain level. Supply chain performance must be build around the customers' satisfaction. This supported by the study of van Hoek et al 2001 and Gunasekaran et al 2004.

The measures which got medium scores are management commitment and responsiveness. For management commitment measure, the auto part manufacturers accepted that their top management did not aggressively initiate programs in combating anti environmental practices since they already got close cooperation from employees to implement activities to favor the greening concept. For their responsiveness as abilities to respond to certain elements such as order lead time, manufacturing lead time etc. were in medium level.

For product characteristic and supplier commitment which got quite low scores, it implied that they had less influence on greening the chain. Product characteristic measure implied some interesting finding. It is about the features of auto parts which involved directly with the features of final products: cars. It may be expected that this measure should get high score due to the reason that auto part should carry as much as possible of favorable features to the environment. This should be found in the group of OEM auto part manufacturers since their customers expressed the requirement of auto parts to be greener. And this requirement would further affect the requirement of raw materials from their suppliers too. However, half of respondents were REM auto part manufacturers which produced replacement parts for end users. Majority of their customers were in developing countries which requirements for environmental friendly products were not so demanding. Therefore, it is important to encourage end users to be more awareness and use more of this kind of products. Together with tighten related legislations, this will create changes and green products become necessary for everyone in the markets.

For reverse chain measures, there were six measures used to access auto part manufacturers' performance in implementing green supply chain.

The recycling efficiency, management commitment recycle cost and customer involvement got similar level of scores of 3.419, 3.407, 3.233 and 3.00 or its importance of 68.38%, 68.14%, 64.66% and 60% respectively. The lower scores were material features (2.786 or 55.72% of its importance) and supplier commitment (2.779 or 55.58% of its importance). The measures are aimed to evaluate the efficiency and the effectiveness of returning end of life products. The results showed that the overall performance of reverse chain of auto part manufacturers in Thailand were not well integrated into their supply chain like the ones in developed countries. It is assumed that this attempt may be quite difficult to carry out since there are no direct laws concerning the management of end of life products in Thailand (Akaraj 2008). In addition, used auto part and used car markets in Thailand including other developing countries are huge. Used products have been changed from one hand to others for a long period of time until obsolete. The interview also supported that at present the respondents use less recycled than new raw materials in their production. However, the trend of using more recycled and reused raw materials is growing. The study by Kaewkuekool and Laemlaksakul was showed that recycling materials had compatible qualities and properties to the new ones. They would be used to replace for car knocked down (CKD) auto parts. This can be seen from the big players in the industry. Auto assembly factories especially multi- national corporations have considered to use more recycled raw materials in their new car production. They try to tackle environmental regulations and make themselves appear as "green" as

possible. In the case of Ford, the company is studying ways to reclaim and recycle nearly all the different parts in its range of models. This must be done with the help from its suppliers; it is gradually replacing its virgin materials with recycled counterparts. Toyota also has strong intention to use as much as possible recycled parts in its hybrid model as it was stated in the car specification. The pressure from car assemble companies will force Thai auto part manufacturers especially OEM to integrated more recycled raw materials into their manufacturing. It is reported that there are markets for international reused auto parts. According to Michikazu Kojima, JETRO, reused auto parts such as engine, bumper, mirror etc. have been imported from Japan to Thailand from time to time. However, there are some protections in Thailand since it was found out that recycled materials were imported with non recycled materials. Therefore it should be some development of regulations and control in these areas in the near future.

5 CONCLUSION, LIMITATION AND RECOMMENDATION

This research was aimed to measure Thai auto part manufacturers' performance in implementing their green supply chain. First, the study described that the automotive industry in Thailand played important role in its economy. The car production was initially for local consumption and import substitution but finally also for export. This export sector has been the big earner for the country as it has been the third largest in Thailand. There are more than 15 car assemblers in Thailand. They are leading car makers such as Honda, Toyota, Isuzu, Mitsubishi from Japan and BMW, Mercedes Benz, Volvo and Peugeot from Europe as well as General Motors, Ford from U.S.A. More investment of assemble plant is still growing and this will make Thailand become the largest automotive producer in Southeast Asia.

Thai Automobile Industry Structure consists of vehicle assemblers who are all large scale enterprises that are joint ventures or foreign owned and, around 648 large, medium and small scale tier- 1 suppliers and approximately 1,800 automotive parts suppliers. About 700 are Original Equipment Manufacturers (OEM). At the bottom end of the value chain, there are more than 1,100 small and medium local Thai enterprises producing replacement parts or REM.

Many new overseas joint ventures companies were set up to supply parts and accessories to the global manufacturers. The replacement market (REM) has greater volume consumption from independent Thai companies while the rest of the output is consumed by original equipment manufacturers (OEM).

The quality of automotive parts in Thailand is the highest of any ASEAN nation. Most of the suppliers in Thailand are certified with QS 9000 certification for quality. Systems used in auto-parts assembling, parts and servicing are certified with ISO 9000. Surveillance audits are conducted every 6 months to make sure for the quality compliance. In order to develop the outlook of the industry, auto-parts suppliers in Thailand are trying to comply with non-quality standards include ISO 1400 (Environmental – most of assemblers and component suppliers have been certified in Thailand), OHSAS 18001 (Operational safety aspects which is still at nascent stage), SA 8000 (Social aspects – child labor law, labor law compliance) safety and emission test compliance. With Thai automobile industry infrastructure, combined with current market size, market growth potential, trade and investment policy, has made Thailand to become one of the most attractive country for automobile investment.

Secondly, this research has reviewed some literature about the concept of supply chain and green supply chain management. The supply chain management was defined as a process of efforts involved in producing and delivering a final product from the supplier's supplier to the customer's customer. These efforts are planning, sourcing, making and delivering which include manage demand and supply, sourcing raw materials and parts, manufacturing, inventory tracking and warehousing, managing orders as well as distributing and delivering products , services and value to customers. The benefits of SCM will be recognized in immediate, medium term as well as long term impacts such as lower inventory, distribution, transportation costs, more flexibility especially when market changes and improvement of customer satisfaction etc.

The traditional supply chain comprises five important parts: raw materials, industry, distribution, consumer and waste. Each part can create pollution, waste and hazards to the environment in different degree. For raw materials, a company can choose to use environmentally harmful materials and put pressure to suppliers to choose more environmental friendly material and process.

It has been increasing awareness of the world's environmental problems. Several organizations responded to the problems by applying green principles. Then the principles expanded to one department to others, from one organization to others. Green supply chain management involves every stage in manufacturing from the first to the last stage of product life cycle. Actually not only manufacturing but GSCM can be applied in other organization types such as government, education and services.

Reasons why the company should adopt green supply chain are various. They are target marketing, brand reputation, lower cost/ increased efficiency, sustainability of resources, competitive and supply chain pressures, product differentiation, return on investment, employee morale and the ethical imperative. In many cases they are forced by government regulations and laws. Different industries are controlled by different regulations depending on industrial characteristics and resources needed. In addition, competition may force companies to apply GSCM in strong competitive business.

Green supply chain management involves traditional supply chain management practices by integrating green aspect throughout the entire process. , the green supply chain is divided into four main parts: green procuring (an environmental purchasing

consisting of involvement in activities that include the reduction, reuse and recycling of materials in the process of purchasing), green manufacturing (production process which use inputs with relative low environmental impacts and highly efficient. The production process should utilize clean technology), green distribution (green packaging and green logistics) and green recycling (Recycling includes reverse flow of waste materials, information, capital, value and business. The flow can be both forward and backward and the whole logistics system becomes an integral part).

Reasons for GSCM in Automobile Industry involved the product itself should be green as much as possible as well as the process to make it. To manufacture an automobile, it involves a lot of components and parts outsourced from various suppliers in different locations, at varying costs and complexities. Therefore, using the regular supply chain does not fit in well for these products. Greening the supply chain involves consideration of the total immediate and final environmental effects of all products and processes. It is, therefore, necessary to have a framework to measure its performance as a two- in-one chain and it extends the supply chain to include recovery operations such as remanufacturing, recycling, and reuse which adds an additional level of complexity to its design, and a new set of potential operational and strategic considerations.

Figure 18 The Result of all Metrics in Forward Chain

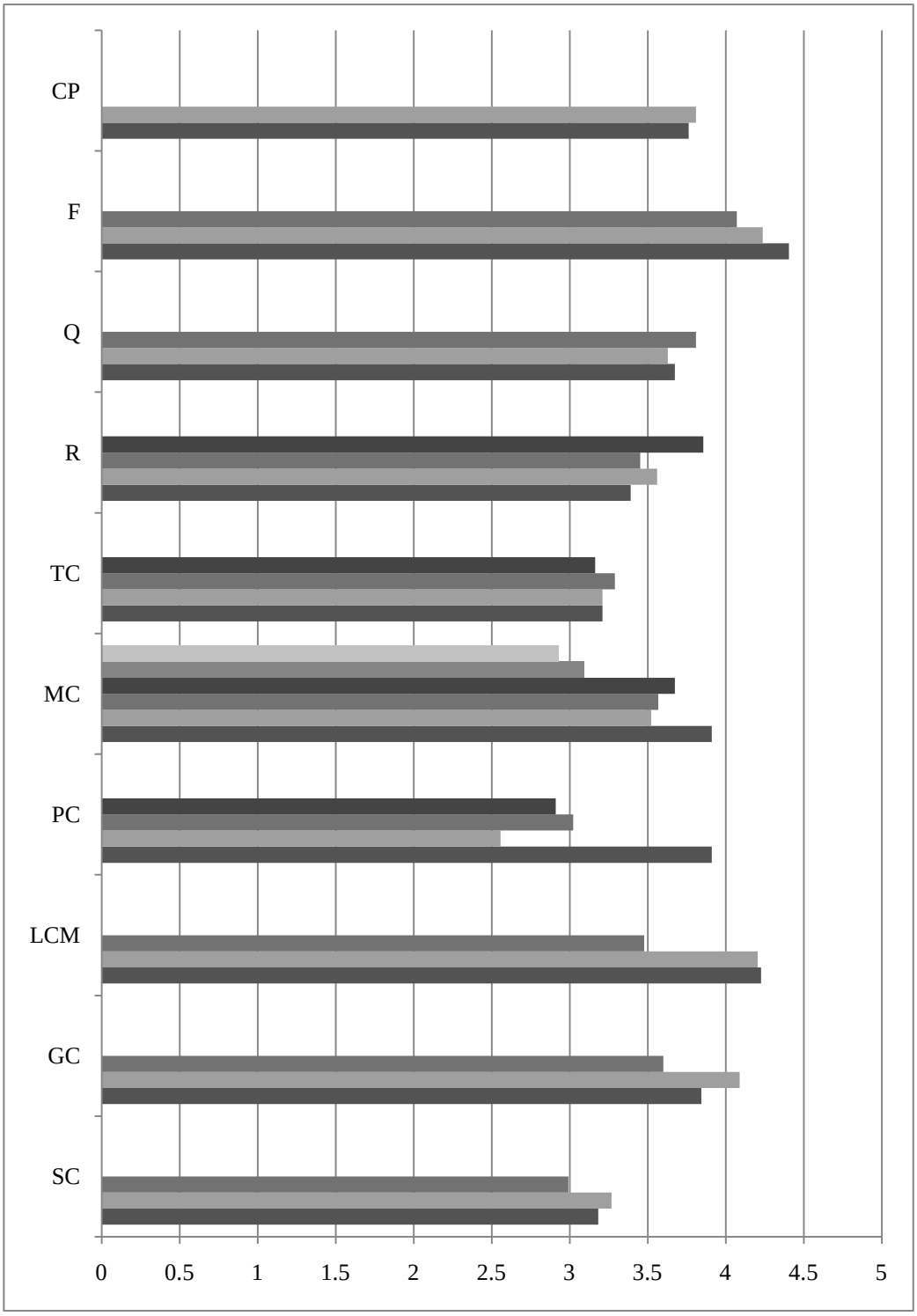
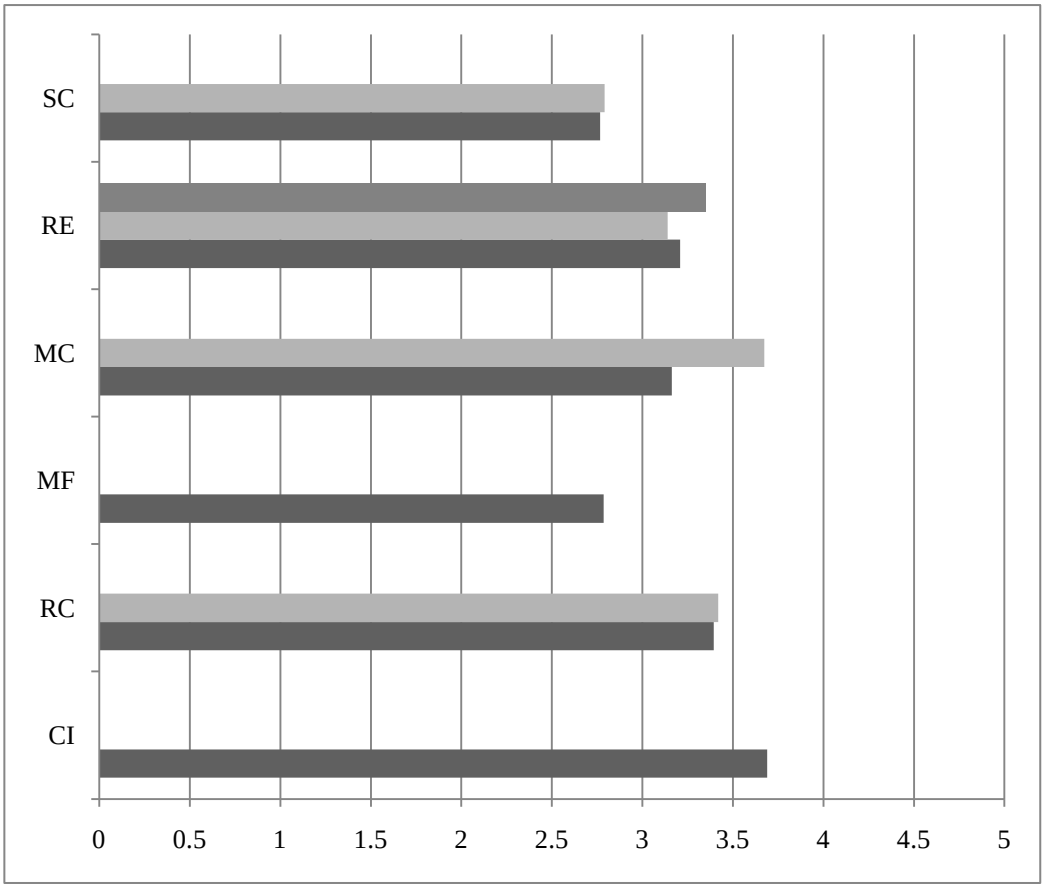


Figure 19 The Result of all Metrics in Backward Chain



The study was focused on Thai auto part manufacturers in order to see how they perform green supply chain management in their businesses. Their performance should be measured which was done by using key performance measures developed by Olugu et al 2010. 46 metrics applied to assess their performance in the forward and reverse (backward) supply chain. It was evaluated by conducting a survey using a questionnaire and interview. The respondents were staff of the auto part manufacturers who dealt directly or at least involved with the companies' supply chain. The results obtained showed that they have performed green activities in a certain level in their forward chain. However, their overall performance in the reverse chain was not well established especially REM auto part manufacturers who supply their products to end users located mainly in developing countries where the requirement for green products was not so demanding. However, the study also supported the trend of using more recycled materials in new car is developing especially the pressure from international car assemble companies. Together with forces from government such as tighten existing legislations and the development of related new laws as well as government allowances may accelerate the system.

Hence, it is expected that there will be greener in the whole supply chain the near future.

There were some limitations of this study. First is about the survey. Since the survey must be done in Thailand which was quite remote from where the researcher resides, it was time consumed in contacting, discussing, interviewing and following up with related coordinators and respondents. One reason is green supply chain management is still new and not widely recognized and used in the industry. Another reason is that they are quite busy and not so available to cooperate.

As mentioned earlier that automotive industry is quite complicated and related with a lot of players and in this thesis, of course, not all paths of green supply chain management of Thai automotive manufacturers had been fully investigated. Some areas of weak practices had been found. It is recommended that the future work of research should focus on all parts of the whole green supply chain management in the Thai automotive industry. The following topics of research are also recommended.

- The encouragement of the application of green supply chain management in Thai automotive industry.
- How to increase the environmental awareness in order to promote the usage of green auto parts in the developing countries.
- The possibilities of building a recycling system for obsolete auto parts in Thailand.

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LIST OF TABLES

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APPENDIX I VOC, CO, NO_x, and SO_x

VOC in the air react with oxides of nitrogen and sunlight to form ozone. For this reason, the EPA has determined that controlling VOCs is an effective method for minimizing ozone levels.

Carbon Monoxide is a colorless, odorless gas formed when carbon in fuel is not burned completely.

A group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. NOx forms when fuel is burned at high temperatures, as in a combustion process.

The general oxides of sulfur (SO_2, SO_3, etc.) are colorless gases formed by burning sulfur. SOx gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil or metals are extracted from ore. Sulfur dioxide (SO2) is the criteria pollutant that is the indicator of sulfur oxide concentrations in the ambient air.

APPENDIX II SIX LEVELS OF SUPPLY CHAIN EXCELLENCE

Level I, Business as Usual — working hard to instill best practices in individual departments within your link.

Level II, Link Excellence — looking within your link for opportunities to remove boundaries between departments and pursue continuous improvements.

Level III, Visibility — turning the lights on outside your organization to see the information that needs to be shared with other members of your supply chain, revealing what is and isn't working.

Level IV, Collaboration — working with other suppliers, vendors and customers to maximize customer satisfaction and drive out costs throughout the chain.

Level V, Synthesis — synchronizing new ways of thinking and strategies to provide even greater cost reduction and enhanced customer satisfaction.

Level VI, Velocity — reducing the lead-time to incorporate continuous improvements throughout the supply chain.

APPENDIX III QUESTIONNAIRE

สมาคมผู้ผลิตชิ้นส่วนยานยนต์ไทย
THAI AUTO-PARTS MANUFACTURERS ASSOCIATION
86/6 ชั้น 1 อาคารสำนักพัฒนาอุตสาหกรรมสนับสนุน ซ.ตรีมิตร ถ.พระราม 4 เขตคลองเตย กรุงเทพฯ 10110
86/6 1st Floor, Bureau of Supporting Industries Development, Soi Trimit, Rama 4 Road, Klongtoey, Bangkok 10110, Thailand.
Tel: +66 2712 2246-7 Fax: +66 2712 2970 E-mail: tapma@thaiautoparts.or.th Website: www.thaiautoparts.or.th

ที่สผย. 140/2553

9 กันยายน 2553

เรื่อง ขอความร่วมมือในการช่วยตอบแบบสอบถาม Green Supply Chain Management

เรียน ท่านสมาชิกสมาคมผู้ผลิตชิ้นส่วนยานยนต์ไทย ที่ได้รับการติดต่อ

จดหมายฉบับนี้เป็นจดหมายแนะนำคุณฤดี ศักดิ์พิทักษ์สกุล ซึ่งเป็นนักศึกษาปริญญาโทอยู่ที่ Vienna University of Technology ประเทศออสเตรีย โดยหัวข้อในการทำวิทยานิพนธ์ชื่อ Green Supply Chain Management in Thai Automobile Industry: Focusing on Auto Part Manufacturing ซึ่งหัวข้อเกี่ยวกับ Green Supply Chain Management เป็นเรื่องที่ถือได้ว่าค่อนข้างใหม่สำหรับสมาชิก และ/หรือ ผู้ผลิตชิ้นส่วนยานยนต์ไทย ในขณะที่หัวข้อดังกล่าวเป็นเรื่องที่กำลังอยู่ในกระแสของอุตสาหกรรมทางยุโรป

ดังนั้นทางสมาคมฯ จึงเห็นว่าการให้ความร่วมมือกับโครงการศึกษาวิจัยนี้ อาจจะทำให้เราได้มีโอกาสทำความรู้จักแนวคิด และอาจจะได้ข้อมูลที่เกี่ยวข้องบางอย่างสำหรับอุตสาหกรรมชิ้นส่วนยานยนต์ สำหรับการเตรียมการรับมือกับวิธีการบริหารการจัดการใหม่ที่เกี่ยวข้องกับอุตสาหกรรม ดังนั้นกระผมจึงขอความร่วมมือมายังท่านสมาชิกของสมาคมฯ ที่ได้รับการติดต่อจากคุณฤดี ศักดิ์พิทักษ์สกุลในการเสียสละเวลาเพื่อตอบแบบสอบถามในหัวข้องานวิทยานิพนธ์ครั้งนี้ และขอขอบคุณในความร่วมมือมาล่วงหน้าด้วย

ด้วยความเคารพอย่างสูง

ประสาทศิลป์ อ่อนอรรถ

(นายประสาทศิลป์ อ่อนอรรถ)

นายกสมาคมผู้ผลิตชิ้นส่วนยานยนต์ไทย

แบบสอบถามงานวิจัยเรื่อง - Green Supply Chain Management in the Thai Automobile Industry: Focusing on Auto Part Manufacturing

คำชี้แจง: แบบสอบถามนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาโท สาขา Engineering Management, Technische Universitaet Wien ประเทศออสเตรีย โดยผลที่ได้จะนำไปใช้เพื่อวัตถุประสงค์ทางการศึกษาเท่านั้น โดยมุ่งหวังที่จะได้ทราบว่ามีการดำเนินการด้านการจัดการห่วงโซ่อุปทานในการผลิตชิ้นส่วนยานยนต์ในประเทศไทยมากน้อยเพียงใด สำหรับแบบสอบถามจะมีทั้งหมด 2 ส่วน ดังนี้

ส่วนที่ 1: ข้อมูลเกี่ยวกับผู้ตอบแบบสอบถาม

ส่วนที่ 2: การจัดการห่วงโซ่อุปทานที่คำนึงสิ่งแวดล้อมของผู้ผลิตชิ้นส่วนยานยนต์

นิยามคำศัพท์:การจัดการห่วงโซ่อุปทานที่คำนึงถึงสิ่งแวดล้อม (Green Supply Chain Management) หมายถึง การรวบรวมการวางแผน และการจัดการของกิจกรรมทั้งหมดที่มีความเกี่ยวข้องกับการจัดหา การจัดซื้อ การแปรสภาพ และกิจกรรมการจัดการทั้งหมดโดยคำนึงถึงสิ่งแวดล้อม ที่สำคัญการจัดการโซ่อุปทานยังรวมถึงการประสานงาน (Coordination) และการทำงานร่วมกัน (Collaboration) กับผู้ที่เกี่ยวข้องต่างๆในห่วงโซ่อุปทานซึ่งจะเป็นผู้จัดส่งวัตุดิบ ตัวกลางผู้ให้บริการ ผู้ให้บริการลอจิสติกส์และลูกค้า แก่นสำคัญก็คือ การจัดการโซ่อุปทานจะบูรณาการ (Integrate) ทั้งการจัดการอุปสงค์และอุปทาน ซึ่งรวมถึงทั้งภายในและภายนอกบริษัท ผู้ตอบแบบสอบถาม ผู้ที่อยู่ในสายการผลิตชิ้นส่วนยานยนต์ ฝ่ายจัดการที่เกี่ยวข้อง วิศวกรโรงงาน เจ้าของกิจการ ผู้บริหารระดับสูงและบุคคลใดๆที่เกี่ยวข้องกับห่วงโซ่อุปทาน ข้อมูลที่ได้รับจากแบบสอบถามนี้ จะไม่เปิดเผยต่อสาธารณะ การอ้างอิงจะไม่มีการออกชื่อใดๆทั้งสิ้นในการตอบกรุณาเลือกช่องที่ตรงกับท่านมากที่สุด

ระดับ 0 หมายถึง ไม่มี/ไม่ทราบ
ระดับ 1 หมายถึง มีน้อยมาก
ระดับ 2 หมายถึง มีน้อย
ระดับ 3 หมายถึง มีอยู่ในระดับปานกลาง
ระดับ 4 หมายถึง มีมาก
ระดับ 5 หมายถึง มีมากที่สุด

ขอบพระคุณที่ให้ความร่วมมือในการตอบแบบสอบถาม

Questionnaire for Research

Research Title - Green Supply Chain Management in the Thai Automobile Industry: Focusing on Auto Part Manufacturing

For Your Information: The questionnaire is a part of Master Thesis in Engineering Management, Technische Universitaet Wien, Austria. The result will be used only for academic purpose. The objective of this research is to explore the development of the application of Green Supply Chain Management in auto part manufacturing in Thailand. The study will explore the drivers, the practices and performance of GSCM in the industry.

This questionnaire consists of 2 parts:
Part 1: General Information of respondents
Part 2: The Performance of Green Supply Chain Management in various parts in your company.

Definition: Green Supply Chain Management is the coordination and management of a complex network of activities involved in delivering a finished product to the end user or customer regarding environment. It involves green procurement, green manufacturing, green distribution, reverse logistics. Respondents are personals in the production line at managerial level including engineer, owner, CEO and anyone related to the supply chain. The information you provide is considered completely confidential. Anonymous quotations will be used. Please choose the appropriate answer

Level 0 - No/No Idea
Level 1 - Very Low
Level 2 – Low
Level 3 – Moderate
Level 4 – High
Level 5 - Very High

Thank you for your cooperation

Gender (เพศ)

1. Male (ชาย)
2. Female (หญิง)

Education (วุฒิการศึกษา)

1. < Bachelor Degree (ต่ำกว่าปริญญาตรี)
2. Bachelor Degree (ปริญญาตรี)
3. Master Degree (ปริญญาโท)
4. Doctor Degree (ปริญญาเอก)

Occupy (ตำแหน่งหน้าที่การงาน)

1. Engineer (วิศวกร)
2. Manager (ผู้จัดการ)
3. Academic (นักวิชาการ)
4. Industrial Owner (เจ้าของกิจการ)
5. Other (อื่นๆ)

Experiences related in Automotive Industry (ประสบการณ์การทำงานที่เกี่ยวของกับอุตสาหกรรมรถยนต์)

1. 1-5 year(s) (ปี)
2. 6-10 years (ปี)
3. 10-15 years (ปี)
4. 16-20 years (ปี)
5. > 20 years (ปี)

A1. Supplier Commitment - How do suppliers devote to green exercise.

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
A1.1. Level of Supplier Environment Certification Supplier ได้รับการรับรองมาตรฐานด้านสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
A1.2. Number of Supplier Initiative on Environment Management Supplier มีความคิดริเริ่มในการจัดการสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
A1.3. Level of Disclosure of Environmental Initiative to the Public มีการเปิดเผยเรื่องการจัดการสิ่งแวดล้อมต่อสาธารณะมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑

B1. Greening Cost - Overall cost to make operations are environmentally sustainable

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B1.1. Cost associated with environment compliance บริษัทมีค่าใช้จ่ายด้านสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B1.2. Cost associated with energy consumption บริษัทมีค่าใช้จ่ายด้านพลังงานมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B1.3. Cost associated with environmentally friendly material บริษัทมีค่าใช้จ่ายในการจัดหาวัตถุดิบที่เป็นมิตรกับสิ่งแวดล้อม	❑	❑	❑	❑	❑	❑

B2. Level of process management - The effort to modify processes to enhance the reduction of environmental impact

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B2.1. Availability of process optimization for waste reduction บริษัทมีการวางระบบกำจัดของเสียในโรงงานมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B2.2. Level of spillage, leakage, and pollution control บริษัทมีการจัดการมลพิษและการรั่วไหลมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B2.3. Level of waste generated during production บริษัทมีของเสียที่เกิดขึ้นระหว่างการผลิตมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑

B3. Product characteristics - Product features and components related to environmental aspects.

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B3.1. Level of recycled material in products มีการใช้วัตถุดิบที่สามารถรีไซเคิลได้ในสินค้ามากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B3.2. Availability of eco-labelling มีการปิดฉลากเกี่ยวกับสิ่งแวดล้อมในสินค้ามากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B3.3. Level of biodegradable content products ส่วนผสมของวัตถุดิบที่สามารถย่อยสลายในสินค้าได้มากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B3.4. Level of market share controlled by green products มีส่วนแบ่งการตลาดของสินค้าที่คำนึงถึงสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑

B4. Management Commitment - Overall effort and initiative employed by the management in combating anti-environmental practices within supply chain

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B4.1. Level of management effort to motivate employees ฝ่ายจัดการมีความพยายามในการสร้างแรงจูงใจต่อพนักงานมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B4.2. Availability of environmental auditing systems มีการใช้ระบบตรวจสอบด้านสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B4.3. Availability of mission statement on sustainability ริษัทมีการกำหนดพันธกิจที่เกี่ยวข้องกับสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B4.4. Number of environmental management initiatives มีจำนวนความคิดริเริ่มในบริษัทที่เกี่ยวข้องกับการจัดการสิ่งแวดล้อมมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B4.5. Availability of environmental reward systems มีระบบการให้รางวัลด้านสิ้งแวดล้อมมีมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑
B4.6. Level of management effort to motivate suppliers บริษัทมีความพยายามในการจูงใจ suppliers มากน้อยเพียงใด	❑	❑	❑	❑	❑	❑

B5. Traditional supply chain cost - Regular cost incurred by supply chain as a result of normal operation in the chain

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B5.1. Percentage decrease in total supply chain cost (tangible and intangible cost) บริษัทมีต้นทุนรวมในห่วงโซ่อุปทานลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B5.2. Percentage decrease in delivery cost บริษัทมีต้นทุนการส่งสินค้าลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B5.3. Percentage decrease in inventory cost บริษัทมีต้นทุนการเก็บสินค้าลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B5.4. Percentage decrease in ordering cost บริษัทมีต้นทุนในการสั่งวัตถุดิบลดลงเพียงใด	❑	❑	❑	❑	❑	❑

B6. Responsiveness - The rate at which the supply chain responds to certain elements

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B6.1. Percentage decrease in order lead time บริษัทมีระยะเวลาในการสั่งวัตถุดิบในช่วงระหว่างวางแผนและการผลิตลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B6.2. Percentage decrease in manufacturing lead time บริษัทมีการใช้เวลาในการปรับเปลี่ยนสายการผลิตลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B6.3. Percentage decrease in total supply chain cycle time บริษัทใช้เวลาในวงจรของห่วงโซ่อุปทานลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B6.4. Percentage increase in on-time delivery บริษัทมีความแม่นยำในการส่งสินค้าเพิ่มขึ้นเพียงใด	❑	❑	❑	❑	❑	❑

B7. Quality - A distinguishing attribute as it measures the standard of the products

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B7.1. Percentage decrease in customer dissatisfaction ความไม่พอใจของลูกค้าลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B7.2. Percentage decrease in delivery unreliability ความไม่แน่นอนในการส่งสินค้าลดลงเพียงใด	❑	❑	❑	❑	❑	❑
B7.3. Percentage decrease in scrap and rework ปริมาณสินค้าที่มีตำหนิลดลงเพียงใด	❑	❑	❑	❑	❑	❑

B8. Flexibility - The ability of supply chain for adjustment to suit the various scenarios that might arise due to change in the normal supply chain process

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
B8.1. Percentage increase in demand flexibility บริษัทมีความยืดหยุ่นในการตอบสนองความต้องการของลูกค้าเพิ่มขึ้นเพียงใด	❑	❑	❑	❑	❑	❑
B8.2. Percentage increase in delivery flexibility บริษัทมีความยืดหยุ่นในการจัดส่งสินค้าเพิ่มขึ้นเพียงใด	❑	❑	❑	❑	❑	❑
B8.3. Percentage increase in product flexibility ระบบการผลิตของบริษัทมีความยืดหยุ่นในการตอบสนองต่อความต้องการของลูกค้าเพิ่มขึ้นเพียงใด	❑	❑	❑	❑	❑	❑

C1. Customer perspective - Customers view with respect to the green supply chain

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
C1.1. Level of customer interest in green product ลูกค้ามีความสนใจในสินค้าที่เป็นมิตรต่อสิ่งแวดล้อมเพียงใด	❑	❑	❑	❑	❑	❑
C1.2. Level of customer satisfaction from green product ลูกค้ามีความพึงพอใจต่อสินค้าที่เป็นมิตรกับสิ่งแวดล้อมเพียงใด	❑	❑	❑	❑	❑	❑

D1.1. Customer involvement - Customer involvement in recycling process

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
D1.1.3. Level of understanding of green process by customers ลูกค้ามีความเข้าใจในกระบวนการต่างๆ ที่เป็นมิตรกับสิ่งแวดล้อมเพียงใด	❑	❑	❑	❑	❑	❑

D2.1. Recycling Cost - Cost associated with recycling process

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
D2.1.1. Cost associated with processing of recyclables บริษัทมีต้นทุนในกระบวนการรีไซเคิลเพียงใด	❑	❑	❑	❑	❑	❑
D2.1.2. Cost of disposal for hazardous and unprocessed waste บริษัทมีต้นทุนในการกำจัดวัตถุมีพิษและวัตถุที่ไม่สามารถรีไซเคิลได้เพียงใด	❑	❑	❑	❑	❑	❑

D2.2. Material features - Composition and effect of recycling material

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
D2.2.1. Level of waste generated in recycling process มีของเสียเกิดขึ้นในกระบวนการรีไซเคิลเพียงใด	❑	❑	❑	❑	❑	❑

D2.3. Management commitment - A measure of top management involvement aimed to make sure that recycling is efficiency and effectiveness

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
D2.3.1. Availability of collection centers มีศูนย์กลางในการรวบรวมสินค้าที่สามารถนำกลับมาใช้ใหม่เพียงใด	❑	❑	❑	❑	❑	❑
D2.3.2. Availability of waste management schemes มีแผนการจัดการของเสียเพียงใด	❑	❑	❑	❑	❑	❑

D2.4. Recycling efficiency - A measure of the overall effectiveness of the recycling process

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
D2.4.1. Availability of recycling standards มีมาตรฐานการรีไซเคิลเพียงใด	❑	❑	❑	❑	❑	❑
D2.4.2. Percentage decrease in utility usage during recycling มีการใช้สาธารณูปโภคระหว่างกระบวนการรีไซเคิลลดลงเพียงใด	❑	❑	❑	❑	❑	❑
D2.4.3. Percentage reduction in emission and waste generated มีการปล่อยของเสียลดลงเพียงใด	❑	❑	❑	❑	❑	❑

D3.1. Supplier Commitment - Suppliers attempt to make sure that reverse supply chain process is successful

	No Idea ไม่เคยเลย	Very Low น้อยมาก	Low น้อย	Moderate ปานกลาง	High มาก	Very High มากที่สุด
D3.1.1. Certification system for suppliers in the recycling process มีระบบในการรับรอง Supplier ในกระบวนการรีไซเคิลหรือไม่ เพียงใด	❑	❑	❑	❑	❑	❑
D3.1.2. Number of supplier initiatives in the recycling process Suppliers ที่มีความคิดริเริ่มเกี่ยวกับการรีไซเคิลสินค้าใช้แล้วมากน้อยเพียงใด	❑	❑	❑	❑	❑	❑