

# An Analysis of Drivers Affecting Green Supply Chain Management Implementation in Electronics Industry in Thailand

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**Abstract**—Manufacturers attention now focuses on green supply chain (GSCM) due to pressure from the government and environmental consciousness among customers. However, implementation of GSCM is not easy, so it is necessary to study about the key to success from the successful companies. In this research, electronics industry is depicted. The electronics industry plays a significant role in Thailand due to high exporting to international market. This industry also generates harmful wastes to the environment and makes social environmental problems. Therefore, this study aimed to identify factors that are critical for the implementation of the GSCM strategy of the electronic industry in Thailand in order to help the newcomer in electronic industry who wants to implement GSCM successfully. This study can be used as a guide for other industrial sectors. Data are collected through a questionnaire-based survey, and analyzed using analytic hierarchy process (AHP). Then, the main drivers those affect GSCM on the electronics industry in Thailand are ranked. We have found that regulatory is one of the most critical factors. Moreover, supporting for top management, market/consumer and organization strategy are also important drivers for implementing GSCM.

**Index Terms**—Electronics industry, green supply chain management, green industry.

## I. INTRODUCTION

Green supply chain management (GSCM) is one of the corporate environmental management that has been adopted by among manufacturing firms. It intends to reduce or minimize negative environmental impacts. The concept of GSCM is the integration of environmental thinking and supply chain management, such as development and product design, supplier selection and procurement, manufacturing process of clean technology, distribution of finished products to the customers as well as end-of-life recycling [1].

The electronics industry plays an important role in Thailand. There are more than 2,055 electronics companies. Revenues from exporting electronics parts to the international market are 8,143.97 million USD [2]. The major export markets are the United States, European Union (EU), Japan and China, etc. While the international trades are increasing, the environmental problems are also expanding.

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So, many organizations have been forced to implement GSCM [3].

The impact of environmental problems has affected government to enact the law for protecting the environment. Especially, The EU has regulations such as WEEE (Waste Electrical and Electronics Equipment) and RoHS (Restriction of Hazardous Substances in Electrical and Electronics Equipment) [4]. For this reason, it is necessary for business to adopt GSCM, in order to respond to the current environmental concern and create an enduring competitive advantage.

The Ministry of Industry is the primary agency in Thailand who has set strategies for industrial development. In promoting the growth and development of industries, the Ministry of Industry has launched a Green Industry Project. Companies who enroll in this project will be certified and evaluated about green considerations in their organizations. As a result, these industries will have a good image of credibility and public trust. Moreover, the creation of a green economy will result in higher gross domestic product (Green GDP) [5]. The green industry levels are divided into five levels. Firstly, “Green Commitment” is for the company who commits to reduce their environmental impact, and communicates about green concern within their organizations. Secondly, “Green Activity” is for the company who implements some methods to reduce the impact on the environment and fulfills the commitment set. Thirdly, “Green System” is for the company who has a system of environmental management. Fourthly, this level is for the company who has assessed and reviewed for continuous improvement. Moreover, it should have the environmental award-winning and environmental standards. Fourthly, “Green Culture” is the company that everyone in the organization cooperates in environmental concern. The company has an environmental friendly in all aspects of the operation. Green becomes part of the corporate culture. Finally, “Green Network” is the expansion of green to the network of supply chain, by encouraging partners to process and certify by Green Industry Project [5].

However, the major factors that affecting to the implementation of GSCM in the electronics industries in Thailand has not been investigated. So, it is difficult for the newcomers who want to initiate implementation of GSCM to their factories. Knowing the main drivers for successful implementation of GSCM will help the organization to start the operation. Therefore, this study aimed to identify factors that are critical to the implementation of the GSCM strategy of the electronics industry in Thailand.

The scope of this paper is to study the main drivers of implementation GSCM from 6 experts of the certified electronics factories who obtain a green culture and green network levels in the green industry project.

## II. GREEN SUPPLY CHAIN MANAGEMENT

### A. Green Supply Chain Management

Green supply chain management (GSCM) definition can vary depending on the research objectives and related issues [4]. GSCM comprises of the manufacturing process that minimize waste and pollution [6]. It also integrates environmental thinking in supply chain management, from conceptual product to design to the delivery of the final product to the consumers, and also involves end-of-life management. GSCM emphasizes the concerns for the environment along the whole supply chain and requires long-term and strategic collaborations between the supply chain members [7]. It encompasses environmental initiatives in inbound logistics, production, outbound logistics, and reverses logistics [8]. Moreover, it consists of green procurement, green manufacturing or material handling, green distribution or marketing, and reverse logistics activities [9]. These concepts are applied to the methodology of this research.

### B. The Drivers Affecting the Implementation of Green Supply Chain Management

TABLE I: EXTERNAL DRIVERS AFFECTING THE GSCM ADAPTATION

References	Sup	Reg	Mkt	Com	Soc
Diabat and Govindan (2011), [10]	✓	✓			
Zhu <i>et al.</i> (2004), [11]	✓	✓	✓	✓	
Khiewnavawongsa, (2011) [12]	✓	✓	✓		
Walker <i>et al.</i> (2008), [13]	✓	✓	✓	✓	✓
Liu <i>et al.</i> (2012), [14]		✓	✓		
Abdul Rehman and Shrivastava (2011), [3]	✓	✓	✓	✓	✓
Sari and Hasnelly (2012), [15]		✓	✓		
Lin (2013), [16]		✓			✓
Routroy (2009), [17]		✓	✓		
Lee (2008), [18]		✓	✓		
Vachon (2008), [19]	✓				

Note: ✓ Shows the drivers that the corresponding study found to be significant.

TABLE II: INTERNAL DRIVERS AFFECTING THE GSCM ADAPTATION

References	Top	Org	Cos	Eco	Rev
Diabat and Govindan (2011), [10]		✓			✓
Zhu <i>et al.</i> (2004), [11]		✓	✓		
Khiewnavawongsa (2011), [12]		✓	✓		
Walker <i>et al.</i> (2008), [13]		✓			
Liu <i>et al.</i> (2012), [14]	✓	✓			
Abdul Rehman and Shrivastava (2011), [3]		✓	✓	✓	
Sari and Hasnelly (2012), [15]	✓	✓			
Lin (2013), [16]					
Routroy (2009), [17]	✓	✓		✓	✓
Lee (2008), [18]	✓				
Vachon (2008), [19]		✓			✓

Note: ✓ Shows the drivers that the corresponding study found to be significant.

The various important drivers for the implementation of GSM practices can be divided into two categories, which are

external and internal drivers. External drivers include supplier (Sup), regulation (Reg), market/consumer (Mkt), competitors (Com) and social/stakeholder (Soc) and the internal drivers are described as organizational factors, which are supporting from top management (Top), organization strategy (Org), Cost reduction (Cos), economic benefit (Eco) and reverse logistics (Rev). These key drivers affecting GSCM strategy are gathered from many literatures and summarized in Table I and Table II.

#### 1) External drivers

##### a) Suppliers

There are a few researches, which identified suppliers as a key driver of environmental supply chain management practices [13]. However, the role of suppliers is considered an important part in fostering environmental practices. Due to the members within the supply chain requires the cooperation to achieve an environmental objective [13]. Manufacturers collaborate with suppliers to set environmental standards for exploring green supply chain management, such as designing product, which can eliminate the environmental impact of producing and developing environmentally friendly packages [10]-[12], [20].

##### b) Regulatory

The government regulation and legislation is a major driver for companies' environmental efforts to implement GSCM practices [3], [13]. The government of each country has different regulations in the electronics industry [4]. Therefore, manufacturing firms have to study regulations and environmental standards for each country to maintain their market shares. In Thailand, the manufacture firms need to compliance with environmental legislation in the domestic and foreign market to satisfy customer's requirements [4]. Reference [3] argued that environment regulation and policies are driving the organizations to become environmentally conscious. To improve a firm's competitiveness the organization has to strive in order to meet current and upcoming stricter environmental regulations. In addition, the environmental policies can foster competition within the industry and improving the profitability and environmental performance.

##### c) Market/consumer

Market factors affect the decision on green supply chain management in the electronic industry because most companies are international businesses. Manufacturers need to comply with environmental standards and requirements of each country such as RoHS, WEEE and EPA [4]. As a result, the electronics industry have to implement GSCM to meet customer requirements of exports to the international market [21].

Consumers' behaviors are more likely to pay attention to the environmental products. They are likely to purchase a product that is environmentally friendly. Reference [22] found that consumers increasingly concern about the environment, which can be known from purchasing pattern. The growing number of organizations adopted the green product also indicates the need for suitable segmentation and positioning strategies.

##### d) Competitors

Social responsibility has become an important variable in

creating a global competitive advantage. Manufacturers are developing the green product to meet the market requirement in order to maintain competitiveness in the market [13].

e) *Social/stakeholder*

Deterioration of the environment in the last decade has increased public awareness of environmental issues. Social has demanded for products from the company, which has environmentally friendly operation. The public pressure causes most companies to review their environmental practices within their supply chain. The threat or disruption caused by the environmental awareness of the public could create opportunities for companies to reach new customers who want environmentally friendly products [13].

2) *Internal drivers*

a) *Supporting from top management*

Supporting from top management is the initially significant issue to implement GSCM. The commitment of top management plays a significant role in bringing GSCM strategies to achieve successful results. For example, top management defines the vision, mission and organization policies, and communicates these policies to employees at different levels can achieve collaboration across the company [23].

b) *Organization strategy*

Consumers are more aware of environmental standards and preferable to buy the product from the companies that offering the environmentally friendly products. For this reason, many firms had to adapt the green strategy to enhance the brand image and maintain the market share [3].

c) *Cost reduction*

The ultimate goal of business is to generate profits for the firms. By adopting GSCM leads to save the manufacturing cost and increase the profit. Cost reduction refers to the conservation of energy, water, and raw materials. The valuable of cost reduction is environment improvement and reduction of cost [25]. Furthermore, the previous researches have supported that adopting GSCM can reduce the cost [3]. Reference [17] stated that the objective of GSCM is to manufacture environmentally friendly product with minimum resources (material, energy, water, etc.) and minimum wastage. The benefit of GSCM is to create a competitive advantage to the organization.

d) *Economic benefit*

The benefits derived from the implementation of GSCM strategy are cost saving, increasing customer satisfaction, new market opportunities, improving corporate image, and higher profits [25]. Reference [17] also found that some of the significant benefits of GSCM are the system cost reduction, easier penetration of global markets, reduction of resource usage, reduction of wastes and risks, good publicity, achieving competitive advantage, and enhancement of customer satisfaction. Moreover, the higher profits can motivate firms to implement GSCM increasingly.

e) *Reverse logistics*

Reverse logistics refers to creating value added products for reducing costs and environmental impact of the product life cycle. Reference [17] mentioned that the benefits of reverse logistics not only economic benefits, bus also

environment benefit. Reverse logistics is a significant driver which regulated in Europe, North America, and state in other parts of the world.

III. ANALYTIC HIERARCHY PROCESS (AHP)

The Analytic Hierarchy Process (AHP) is one of the most popular multicriteria decision making techniques. It was proposed by Thomas L. Saaty in the mid of 1970s. AHP combines tangible and intangible aspects to obtain the priorities associated with the alternatives of the problem. This is the advantages of AHP. It has a structural framework, which allows decision makers to improve the understanding of complex decisions by decomposing the problem into a hierarchical structure. The incorporation of all relevant decision criteria, and their pairwise comparison to trade-offs among criteria. It provides mechanisms to monitor the consistency with which a decision maker makes a judgment.

The steps to follow in the AHP are given below [24]:

- 1) Define the problem and determine the objective.
- 2) Structuring the problem into a hierarchy. Hierarchies distribute a property (the goal) among the elements being compared (factors), to judge which one influences or is influenced more.
- 3) Construct a set of pairwise comparison matrices (size  $n \times n$ ) for each of the lower levels with one matrix for each element in the level immediately above by using the numerical rate as shown in Table III. The pairwise comparisons are done in terms of which element dominates the other as the following matrices :

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix} \quad (1)$$

- 1) There are  $\frac{n(n-1)}{2}$  judgments required to develop the set of metrics in step 3. Reciprocals are automatically assigned in each pairwise comparison.
- 2) Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the summation is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.
- 3) Having made all the pairwise comparisons, the consistency is determined by using the eigenvalue,  $\lambda_{max}$ , to calculate the consistency index, *CI* as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (2)$$

where  $n$  is the matrix size. Judgment consistency can be checked by taking the consistency ratio (*CR*) of *CI* with the appropriate value (*RI*) in Table IV. The *CR* is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

- 4) Steps 3 – 6 are performed for all levels in the hierarchy.

TABLE III: SCALE FOR PAIRWISE COMPARISONS [25], [26]

Numerical rate	Definition
1	Equal important
2	Equally to moderately more important
3	Moderately more important
4	Moderately to strongly more important
5	Strongly more important
6	Strongly to very strongly more important
7	Very strongly more important
8	Very strongly to extremely more important
9	Extremely more important

TABLE IV: AVERAGE RANDOM CONSISTENCY (RI) [25], [26]

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

In this research, AHP methodology is used to rank the drivers affecting scores for implementation of GSCM in the electronics industry. The goal of the AHP hierarchy is the successful implementation of GSCM. Selected drivers for GSCM are suppliers, regulatory, market/consumer, competitors, social/stakeholder, supporting from top management, organization strategy, cost reduction, economic benefit and reverse logistics. The hierarchical structure can be drawn as shown in Fig. 1.

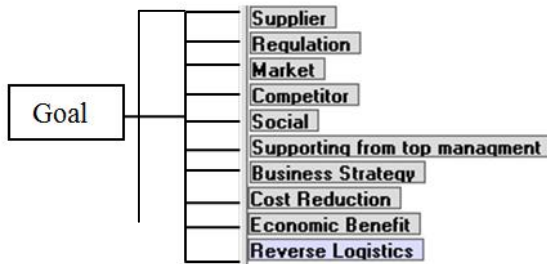


Fig. 1. The hierarchical structure of the successful implementing GSCM.

Relational data were obtained with the aid of questionnaire from a group of executive such as directors, production managers and engineers within the electronics firms, which obtained a green culture and green network levels in Thailand, totally 6 experts. In this research, Expert choice software based on AHP is used to calculate weight of criteria.

IV. RESULTS AND DISCUSSION

Results of questionnaires from 6 experts are combined by geometric means. The result of combined comparison based on the pairwise comparison provided in Fig. 2. Main drivers affecting the implementation of GSCM with respect to goal of successful implementation of GSCM in Thailand are regulation, supporting from top management, market/consumer and organization strategy. The weights of each driver are regulated (0.271), supporting from top management (0.138), market/consumer (0.123), organization strategy (0.114), economic benefit (0.084), competitors (0.083), cost reduction (0.081), social/stakeholder (0.044), reverse logistics (0.039), and suppliers (0.021), accordingly as shown in Fig. 3. The overall inconsistency ratio is 0.01, which is lower than 0.1. So, consistency of experts is acceptable.

The importance levels of drivers affecting to the

implementation of green supply chain practice are significant in understanding of GSCM implementation. There are main 4 criteria, which have weight higher than 10% of the overall weight. They are regulatory, supporting from top management, market/consumer and organization strategy. These criteria are the main criteria for those companies who want to be successful in implementing GSCM in the electronics industry in Thailand. For the criteria at medium level, economic benefit, competitors and cost reduction have weights about 8%. The low weight criteria are social / stakeholder, reverse logistics and supplier, which are lower than 5%.

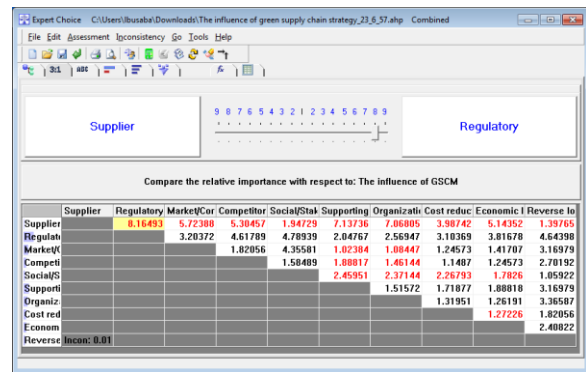


Fig. 2. Combined comparison of the relative importance with respect to the influence of implementing GSCM.

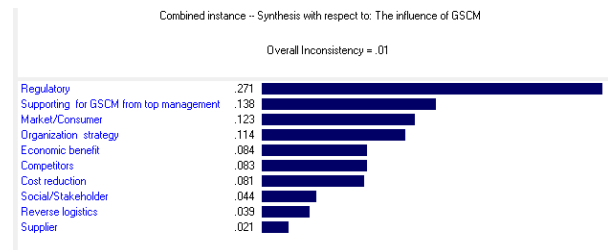


Fig. 3. The overall ranking of drivers affecting the implementation of green supply chain management.

Regulatory is the most important driver among the entire identified GSCM drivers, which is similar to the results obtained in the previous studies. In 2004, [11] investigated and described GSCM drivers, practices, and performance among various Chinese manufacturing organizations. They found that Chinese enterprises had increased their environmental awareness due to regulatory, competitive, and marketing pressures. Reference [3], studied the relationship among the identified GSCM drivers using interpretive structural modeling (ISM) and classified these drivers depending upon their driving and dependency on power. Their study found that drivers, which are important in understanding of successful GSCM implementation, are regulatory and market competitive pressures. Reference [28] also confirms that government regulations drive GSCM efforts.

Secondly, top management or entrepreneurial enterprises have multifunctional roles such as scanning for external opportunities, encouraging innovation, acquiring necessary resources from external sources, and monitoring progress. Reference [29] studied the barriers in implementing corporate environmental responsibility in Thai seafood industry. She has identified three barriers: the lack of system

perspective on sustainability, absence of top management commitment and cultural diversity. The result of interviews demonstrated that top managers were positioned to communicate their green visions and support the integration of environmental responsibility into corporate strategy. The study was shown that environment management depends upon the shape of organizational culture initiated by top management. Lack of top management commitments means that the goal of environmental strategy is unlikely to be achieved. References [23] and [28] demonstrated that top management should contribute the integration of information sharing into an overall organizational business strategy and provide vision, guidance, and support for the effective implementation of GSCM [13], [21].

Thirdly, market/consumer requests green products or the implementation of environmentally friendly practices to the manufacturers. Reference [30] argued that there are two main reasons that organizations' concern to develop green products. First, green consumerism is the end-customer requirement on green products. Second, there are the considerable pressures from the customers and retailers who want their supply chains to be green. The foreign motorcycle firms in Vietnam have been studied to answer two key questions: (a) how does market demand influence a firm's green product innovation? and (b) how can green product innovation affects firm performance? [31]. The empirical findings were shown that market demand positively correlated to both green product innovation and firm performance. Furthermore, green product innovation performance is positively correlated to firm performance. Moreover, [market pressure triggering environmental innovation practices, comes from two sources [30]. The first one is from overseas customer's green consumerism. The second one is from domestic customers' green consumerism pressure.

Organization strategy is also one of the critical criteria for implementing GSCM. According to the work of [32], they analyzed the factors influencing the adoption of green practices in the Chinese logistics industry. The determinant factors compose of technological, organizational, and environmental dimensions. Research results revealed that organizational support, the quality of human resources and company size will affect green adoption behavior of Chinese logistics companies by providing education and training program for managing environmental issues.

Regulations, supporting from top management, market/consumer and organization strategy are the main criteria for electronics industry in Thailand. Regulatory and market/consumer are external factors which strongly effect to the implementation of GSCM. For internal factors of an organization, top management and organizational strategy are the main drivers, which encourage members of an organization to start concerning and implementing GSCM.

Criteria at the medium level from this study are an economic benefit, competitors and cost reduction.

Economic benefit can lead to the better financial performance. Reference [30] found that the adopting of environmental innovation practices is lead to improve a firm's environmental performance, and indirectly improve financial performance. The finding indicated that firms should change the attitude and perception to intent on environment improvement as an economic and competitive

opportunity.

Global organizations face very high competitive pressure. To maintain the customers and market share, firms need to initiate and differentiate from the competitors [3], so competitors is also one of the factors. Greening the supply chain leads to significant values for competitiveness and economic performance [8], [33].

Cost reduction is to save the manufacturing cost and ultimately boosts the profit margin [3]. Research by [21] found that the Chinese enterprises have increased their environmental awareness to implement a variety of GSCM practices. However, GSCM practices have improved economic performance. The benefits range from straightforward cost reduction of facilitating the development of co-operative relationship with suppliers, and holistic view to management supply chain.

The remaining criteria are the low weight criteria for electronics industry in Thailand, they are social/stakeholder, reverse logistics and supplier.

Social/stakeholders are individuals or groups who affect a company's activities and influence the company involved in environmental practices [32]. Reference [34] indicated that a firm formulation of an environmental plan is positively influenced by customer pressure, shareholder pressure, government regulatory pressure, and neighborhood and community group pressure.

Reverse logistics includes the handling and disposition of returned products and the use of related materials and information [17]. There is the evidence that government regulation and legislation and reverse logistics are significant drivers to achieve the collaboration between product designers and suppliers to reduce and eliminate product environmental impact [10].

Suppliers who pay attention to environmental concern should be able to support the firms to be GSCM. However, the relationship between firms and suppliers are very important to support the green implementation [12].

## V. CONCLUSION

In this study, we have found the priority of factors that influence the implementation of GSCM in the electronics industry in Thailand. Firstly, regulatory is one of the most critical initiating factors for the development of environmental strategy. The electronics firms possess more experience of international business and faces higher regulatory pressure to initiative green supply chain management than other businesses. So, government should promote the green industry project to create the business opportunities by improving people, increasing knowledge-based, technology, innovation and creativity based on the concept of environmentally-friendly manufacturing industries. Supporting from top management is the second rank of factors in implementation GSCM. The attitude of top management toward environmental issues and visions is directly affected to organization policy. Thus, top management should commit to complete environmental policies, encourages employees to learn green knowledge, and provides resources for the environmental projects. Market/consumer concern is also a very important factor. This awareness level can only be increased by proper

education making environmentally friendliness an important concern of all individuals. Therefore, innovation, by green product innovation, should be adopted to meet market demand and gain a competitive advantage. Organization strategy is also one of the crucial factors that need for supporting the implementation of GSCM. Economic benefit, competitors, cost reduction, social/stakeholder, reverse logistics and supplier are the lower level of importance criteria those also influence to the implementation of GSCM in the electronics industry.

In the future work, we will study the influence of green supply chain strategy on business performance of electronics industry in Thailand.

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