USING ANP FOR THE SELECTION OF GREEN SUPPLY CHAIN MANAGEMENT STRATEGIES

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ABSTRACT

This study aims to designate the appropriate green supply chain management (GSCM) strategies for electronic industries to control their business functions and activities effectively. Because many previous works mixed up green strategies, regulations, and activities, we propose an integrated network model from the aspect of product development so that four business functions, i.e., design, purchasing, manufacturing, and marketing, and their activities can be identified. These functions and activities under strategies are considered to be clusters and elements of the network. Some dependent relations are processed by analytic network process (ANP) with pair-wise comparison, and suitable alternatives will be selected. In the final section, the model is employed by one leading electronic company in Taiwan.

Keywords: Green strategy, Analytic network process, Green management, Business function, Dependence, Electronic industry.

1. Introduction

Recently, continuous environmental deterioration has drastically force people notice the environmental problems, and then there are more and more people discussed about sustainable and green issues. In respond to increased worldwide concern related the overall condition of the natural resources and

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environment, many regulations of Packaging and Packaging Waste, Restriction of Hazardous Substance in Electrical and Electronic Equipment, Waste Electrical Electronic Equipment, Eco-design Requirement for Energy Using Product are adopted in many countries. It is not difficult to observe that most of the legislations asked manufacturers to decrease the pollutions (solid and hazardous waste, air and water pollution) during the whole production processes. Indeed, these pollutions resulted in environmental degradation mostly ascribed to manufacturing and production operations (Beason, 1999). Especially for electronic industry, with the rapid technology development and the consumers' desires for pursuing the newest products, the product life cycle of electronic products is shorten and then fasten the numbers of e-wastes indirectly. Due to stricter prescriptions and subsequent public pressures, many manufactures adjusted their manufacturing philosophy, and introducing environmental programs into the organizations. Even some companies that recognized the importance and urgency of environmental protection proactively integrated environmental goal into corporate strategy. Such as Xerox, Interface and IBM, brand enterprises all set environmental criteria to manage the EOL products or evaluate the value of them. Sony also required all related suppliers to review the Green Partner Activities instituted in 2001, and improve their own green management efforts (Lu, Wu, and Kuo, 2007).

With rapid business development in globalization, some companies with relatively limited resources have to outsource some business functions or operations, purchase raw materials or components/sub-components from other suppliers to establish a interrelated supply network. Consequently, if they would like to execute green programs to advance their environmental performance, they not only monitor their own operations, also coordinate other partners in their supply networks, including material suppliers, manufacturers, distributers, users and so on. For supply chain mangers, they both insured traditional performance criteria as well as environmental criteria, known as green supply chain management (GSCM) (Lu et al. 2007). Taiwan electronic manufacturing companies as an essential player of global supply chain should consider proactively how to effectively implement inner and outer GSCM.
Based on the literature review of green supply chain management, several researches involved green, environmental or sustainable concepts to traditional supply chain management, and extended GSCM issues included GSCM practices, definitions and decision framework (Sarkis, 2003 ; Zhu and Sarkis, 2004 ; Hervani, Helm and Sarkis, 2005). However, most above studies emphasized reduction, remanufacturing, recycling in product design, process design, manufacturing practices, and procurement. Few studies emphasized how to develop GSCM strategies from overall organizational perspective.

The study aims to provide a guideline for the electronic industry on how to choose an appropriate GSCM strategy, which incorporates environmental perception with corporate functional strategies in order to achieve an effective green management. The integration of environmental corporate strategy with every corporate functional strategy will facilitate the connections between each functional strategy and thereby eliminate obstacles to environmental integration (Handfield et al. 2005). Due to the fact that many companies have just started exploring environmental concerns in the recent years, a lot of environmental-related factors have not yet been identified systematically.

In addition, the interdependency among those factors contributes to the complexity in the analysis. For these reasons, the study adopts the Analytic Network Process (ANP) in order to provide a precise description of the complex relationships among the factors. An empirical study is presented to demonstrate the robustness and effectiveness of the proposed ANP model.

Ultimately, we could conclude the ANP model assist decision makers adjust the GSCM strategy to respond the variation in dynamic competitive environment. Our initial step of building the ANP model was to follow the process of new product development in order to obtain detailed information concerning the key factors of the design, purchase, manufacturing, and marketing of green product. Subsequently, each type of GSCM strategy was identified as the foundation of the ANP model. As a final step, relative

priorities of the considered alternatives of GSCM strategy were derived from pair-wised comparison, serving as a guideline for decision makers in selecting the most appropriate GSCM strategy for the companies in responding to the dynamic competitive environment.

The rest of the paper is organized as follows. Section 2 describes the key dimensions, factors of each dimension and alternatives. Then section 3 introduces the ANP process and proposes the decision framework, and section 4 applies a real case study to validate the model. Finally, we conclude main conclusions obtained from the analysis and future research directions.

2. Literature Review

A good decision is not equal completely a good decision consequence, the latter means the decision-makers satisfy the result; the former is created by a process with following characteristics: (1) includes the qualified people, (2) provides reasonable and enough information and adaptable alternatives, (3) uses resources economically, and (4) makes a decision corresponding to the preferences of the decision makers (Seppälä, Basson and Norris, 2002). Therefore, in this section, we will provide (1) green management perspectives for mangers to clearly identify their attitude toward environmental-related activities, and (2) appropriate information and alternatives for decision-makers to consider their future strategic direction via the aspect of product development so that design, purchasing, manufacturing, and marketing functions, and their essential factors can be identified. These functions and factors under strategies are considered to be clusters and elements of the decision network.

2.1 Green management perspective

Hoek (1999) believed any business should face up to environmental issues and create competitive advantages by some green initiatives. Hoek used the three approaches in green management proposed by Kopicki, Berg, Legg and Maggioni (1993) that are: (1) reactive approach, (2) proactive approach, and (3) value-seeking approach. Noci (1997) initially involved green perspective to supplier selection process, and he divided corporative green strategies into (1) reactive strategy, and (2) proactive strategy two types. The former requested suppliers defer to regulators only; the latter expected suppliers to assist in green product developments and align any environmental requirements from the firm. Winsemius and Guntram (1985) showed four continues stages of a firm's environmental awareness: (1) reactive, (2) receptive, (3) constructive, and (4) proactive.

In accordance with the above-mentioned different classifications, we suggested each firm should deliberate and estimate the situations for determining how many resources invested in green management and then create green strategic attitude become the core values of developing GSCM strategies. In sum, we proposed four distinct green management perspectives and explained the characteristics of them (see Table 1).

Table 1. Types of green management perspectives and their characteristics

Green management perspective	Characteristics
Proactive innovation	(1) Raise the green management capabilities and then become the part of the corporate strategy. (2) Strength green management performance through innovation.
Active integration	(1) Outer: develop cooperative relations with partners in the supply chains. (2) Inner: incorporate environmental programs with other business functions.
Receptive learning	(1) Introduce environmental initiatives non-spontaneously.

	(2) Take other better organizations as models.
Reactive response	(1) Compliance environmental regulations. (2) Obey customers' environmental instructions

2.2 Green design

During the design stage, the new product development (NPD) teamwork usually determined most essential material selection, production procures, package design and energy-usage. All of them not only influence primary costs and profit of the new product, also affect the environmental impact of the new product in each phase of the life cycle (Chen, 2001; Kurk and Eagan, 2008; Goldberg and Middleton, 2000). With the importance of environmental protection is increasing, a growing number of manufacturers involved environmental-friendly considerations in multifaceted aspects of product designs for protecting the human environment and promoting sustainable development. Combination of environmental awareness to design stage is named as design-for-environment (DfE), eco-design, life-cycle design (LCD) or green design (Kurk and Eagan, 2008; Goldberg and Middleton, 2000; Karlsso and Luttropp, 2006). The designers or design departments of companies with DfE concepts as hard as they possibly can avoided from adopting the hazardous chemicals to reduce costs resulted from waste water and solid wastes disposal .

On the other hand, some environmental-friendly firms also design for disassembly, reuse and recycling (DfDRR), this "design for" concept not only enables the product and its components to be easily reused, re-manufactured or recycled at the end of life, but also facilitates the electronic parts with longer life expectancies easily separated and replaced (Goldberg and Middleton, 2000). Bhat (1993) pointed an intelligent company should view green design as an approach to improve competitiveness of their products. He also provided source reduction strategies and waste management strategies, two green design strategies for product designers to be guidelines. Although many companies had introduced DfE, DfDRR programs, and modified new products design to achieve the goal of environmental protections; there also existed conflicts between green requirements and traditional product performances, i.e., speed, convenience. Therefore, how to strike a balance between the green and the practical functions is a highly obstacle, it needs more innovations for obtaining better solutions in developing green products with multi-objectives. To summarize the discussion above, any organizations with green design should possess DfE constructs and control following key factors: abstaining from utilizing toxic substances, saving energy, complying with DfDRR principles and increasing innovation capabilities.

2.3 Green purchasing

Traditionally, companies viewed purchasing function generally as a supportive role in achieving business objectives, and then it was little of significance or contributions then other main functions of the companies. Instead, in order to response to public pressures or concern about environmental protections, many organizations forced to introduce green programs in new product developments, packages designs, and source reduction. Whatever green programs should undertake waste elimination via green purchasing, therefore, they reevaluated the purchasing function for improving the performance of green management. In other words, companies had perceived the increased critical and strategic influences of purchasing (Green, Morton and new, 1998; Zsidisin and Siferd, 2001; Handfield and Melnyk, 1998).

Green purchasing means that focus more on environmental conscious practices including sources reduction, waste elimination, recycling reuse, purification and substitution of materials without producing an effect in materials property (Min and Galle, 2001; Narasimhan and Carter 1998). Firm implementing green purchasing activities could establish environmental standards in purchasing policies involved the suppliers selections, evaluations, relationship development to green their suppliers (Zsidisin and Siferd, 2001; Green et al. 1998; Hsu and Hu, 2009; Walton, Handfield and Melnyk, 1998). Hsu and Hu (2009) assessed suppliers from 5 dimension: (1) procurement management, (2) R& D management, (3) process

management, (4) incoming quality control, and (5) management system. Noci (1997) suggested a firm with green viewpoint should evaluate suppliers through following 4 factors: (1) green competencies, (2) current environmental efficiency, (3) green images, and (4) net life cycle cost.

As a result, the companies could assure the materials and components they bought satisfied the environmental stipulations, and prevented from hazardous substance created from the whole production processes. Due to large numbers of materials or parts needed to compose of a product, suppliers selection is a vital job caused successful green purchasing. We claimed that any organizations acted green purchasing should rate alternative suppliers according to three crucial factors: (1) green competencies, (2) green image, and (3) green management abilities.

2.4 Green manufacturing

As mentioned previously, the green design outcomes almost impact sequential stages in entire supply chains. However, the realization of them relied on green manufacturing techniques and processes. Because the manufacturing processes had to consume lots of energy acquired from burning varied natural resources, such as coal, coke, natural gas, and the combustion processes caused air pollution again (Pal, 2002). In electronic industries, the technologies many companies used to produce easily generated a large amount of waste, previous related green manufacturing studies mainly discussed how to enhance current production processes or techniques to decrease the generation of toxic or harmful matter (Azzone and Noci, 1998; Tan, Liu, Cao and Zhang, 2002).

Consequently, almost of all current green manufacturing issues explored two directions: (1) supplying the greener source of energy and reducing the utilization via new technologies; (2) extending the life cycle of pollutants and wastes and increasing the production efficiency via new processes (Pal, 2002). To sum up, successful green manufacturing should master following key factors in production processes: (1) the amount of energy or/and resources utilization, (2) the green degree of energy, (3) the amount of hazardous wastes, and (4) the reuse times of the hazardous wastes.

2.5 Green marketing

Companies delivered finished goods to the markets and took marketing strategies to attract people to consume and use. Currently, there are numerous customers had experienced the effect of global warming and the climate changes resulted form it, and then begun reevaluating what they bought. The methods of helping environments used by “green” consumers not only adjusted original living habits, but also assessed the green attributes of a product/service in their buying processes. For example, “green consumers” aimed at saving electronic energy, recycling papers, returning bottles or cans, and buying more environmental-friendly products (Ginsberg and Bloom, 2004).

Normally, most people considered green marketing as emphasizing green characteristics in selling or promoting products/services and stressed less environmental destruction (Polonsky, 1994). Besides, green marketing should evolved into a strategic activity, included manipulating STP and 4Ps activities, greening logistics, developing green alliances (Prakash, 2002; Polonsky and Rosenberger III, 2001; Ginsberg and Bloom, 2004). After choosing the appropriate green strategy, Ginsberg and Bloom (2004) reminded managers should endeavor four elements: greening the corporate culture, educating consumers, accumulating credibility, and retaining original functions of products. Therefore, having a successful path to green marketing requires organizations to (1) make good use of ICT tools, (2) disclose environmental information of products/services, and (3) apply extended producers responsibility.

2.6 Green supply chain management strategy

No matter green manufacturing strategies or environmental strategies, past studied discussed and classified them mostly according to attitudes that companies held toward to green management, the

simplest is divided into proactive and reactive (Noci, 1997; Azzone and Noci, 1998). Besides, GSCM-related researches also examined the enhancement and implications of GSCM practices, and GSCM performance evaluations.

In order to foster the future development of GSCM activities, some GSCM strategies based on classical SCM theories were proposed. These four GSCM strategies as listed below (Simpson and Samson, 2008).
(1) risk-based strategy: companies choosing this kind of GSCM strategy most invested minimal resources of organization for green management, and also asked their suppliers to comply the environmental requirements for reducing risks. Although some international environmental rules are difficult to refer to, it is the simplest GSCM strategy compared to other types. Therefore, companies couldn't create unique competitive advantage, and then didn't' obtain many economic benefits from this strategy. Also, these companies didn't spontaneously introduce environmental programs; it is not possible to expect any innovation happened. The final goal of this type of strategy is risk minimization with accomplishing environmental programs passively.
(2) efficiency-based strategy: compared the above one, this type of strategy is more complicated owing to efficiency improving through specific approaches. It not only facilitated companies to allow increase economic benefits, but also won the environmental benefits resulted from waste reduction and resources used efficiently. However the efficiency-based strategy still aimed more on increasing productivity, it is impossible to avoid from any toxic or harmful substances during production processes completely. Hence, the environmental programs in this type of strategy primary directed firms to reduce cost and meet the operational optimization, and decrease environmental depredations at the same time. But the efficiency-based strategy still didn't create any proactive plans or activities, such as innovative technologies or approaches in environmental protection.
(3) innovation-based strategy: this type of strategy guided companies to develop products from product life-cycle viewpoints, and give stricter environmental requirements to their suppliers, and even train them to adjust operational processes just followed the newest environmental regulations. The companies utilizing the kind of strategy should possess professional environmental expertise, and integrate specific relevant green activities, such as green design, green procurement to improve current processes, product developments. As a result, the innovation-based strategy forced companies to invest more resources and cultivate innovative capabilities to green managements
(4) closed-loop strategy: it is the most complicated type of GSCM strategy, and it linked the environmental performance to the entire supply chain activities. In other words, it required the more players in the supply chains involved more. For the simplest form in the closed-loop strategy, reverse logistics, it should take back materials produced from any production processes and end-of-life products, and disposed of them in various methods relied on complex degree of this type of strategy. However, it is difficult for manufacturers to track all of the products distributed from factories due to too many channels. Besides, the amount of return goods also accumulated enough to create economic scale. For these reasons, companies implementing the type of strategy successfully could incorporate efficiently economic, operational and environmental performance as well. As the authors mentioned, it needs lots of efforts to integrate highly, cooperate with many parties, and develop quite specialized knowledge and technology. Therefore, it is the final goal for those executing green managements completely.

3. The proposed model in GSCM strategy selection

Due to the interdependency among the dimensions and factors earlier mentioned resulted to complicated interactions, decision makers require a systematic method to understand the impacts of each dimension and factors and how they were influenced. ANP is a multi-criteria decision-making approach facilitated decision makers to clarity the complex relationships between many factors, and also evaluated tangible and intangibles factors at the same time. Hence, we used the ANP to be an analysis tool in the study. This section will briefly introduce the procedures of ANP, and then propose the decision-making model.

3.1 The procedures of ANP

With the scope of the study, the process of a single network of ANP contains following five phases (Gencer and Gürpinar, 2007; Yilmaz, 2008).

Phase1: Confirm the goal and define the factors influencing the goal

In the study, we proposed a model for electronic companies to select the appropriate GSCM strategy, so the goal of the model is choosing the suitable strategy. From product development perspective, we identified key factors derived from green design, green purchasing, green manufacturing and green marketing business functions.

Phase2: Construct the model and formulate the links

First, we identified the control hierarchy, each clusters and element within them. Moreover, decision model includes a cluster of alternatives. Finally, determining the interactions between and within clusters and elements based experts' opinions.

Phase3: Make pair-wise comparisons for the elements and clusters

In the phase, we asked experts to fill in pair-wise comparison matrices who compared 2 linking elements at a time according to upper level control hierarchy, and then if there were interactions between the elements of any 2 clusters, the experts continued to determine pair-wise comparisons for those elements. Also, all comparison matrices should be examined via the consistency ratio to verify the consistency of them.

Phase4: Form and calculate the supermatrix

We located the local priority vectors of pari-wsied comparison matrix obtained from the elements in the supermatrix (unweighted supermatrix), and then weighted the blocks of the supermatirx by the corresponding priorities derived from the clusters to translate it into a column stochastic matrix (weighted supermatrix).

Phase5: Select the best alternative

The final phase is to multiply the weighed supermatrix by itself until the row values coverage to the same values for each column of the matrix, and then yielded the limiting supermatrix provided the priorities ranking for the cluster of alternatives. Therefore, alternatives with the highest value should be chosen.

3.2 The structure of ANP proposed model

The decision model is shown in **Error! Reference source not found.**. At the upper control level, we can see the objective of the ANP model is to choose the GSCM strategy, and the control hierarchy is green management perspective in electronic companies. At the lower network level, it consists of 5 clusters: green design, green purchasing, green manufacturing, green marketing and GSCM strategies, besides, there are some elements in each cluster (see Figure 1).

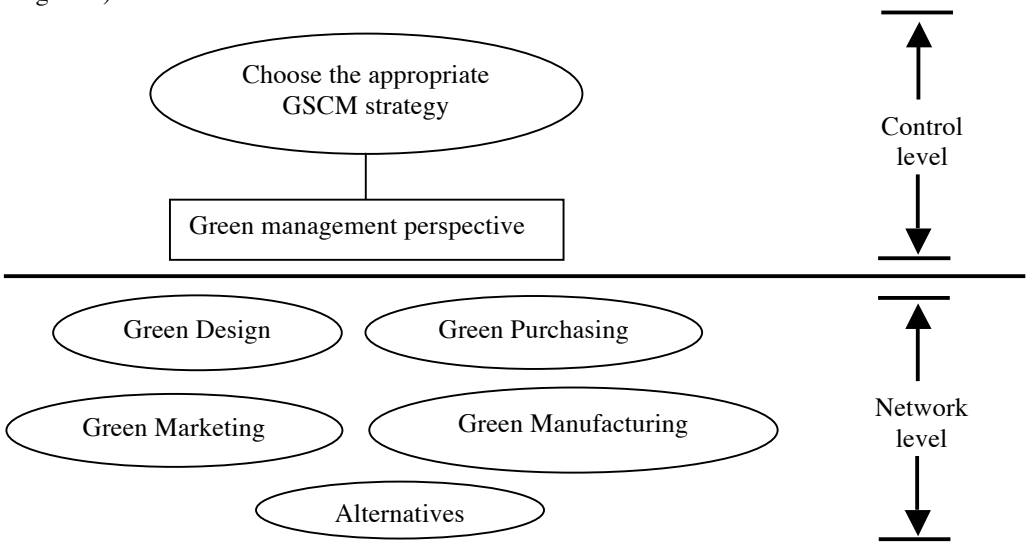

Figure 1. The structure of the proposed ANP model

4. Case study

The S company is one of the famous largest electronic manufacturing corporations in Taiwan. It organized a steering committee, built Green IT e-systems, and had DfE concepts in the design process for producing environmental-friendly electronic products. Besides, it also was responsible of disposing of end-of-life products and made efforts to increase energy efficiency for reducing environmental depredation. Until now, the company still endeavored to enhance its green management capabilities to be one of the most green electronic technology corporations in the world.

With the numbers of green programs was increasing; it was more difficult for the company to ensure the performances of them. Therefore, the top management should consider carefully which type of green management perspective they had, and assessed the importance of every factor in each green business activity objectively. In sum, they should choose an adequate GSCM strategy to guide all of the employees to strive to upgrade the overall environmental performances. For above the reasons, we targeted the key managers related the green programs of the S companies and other experts in other companies with green programs to establish the ANP network and assist the S company to confirm the best GSCM strategy.
In the following section, we will propose the ANP model and take the S company to be an example to explain a company how to apply the model to choose the appropriate GSCM strategy.

Stpe1: Define the problem and link the relationships in the ANP model
The decision-making problem is choose the suitable GSCM strategy for the S company, and before resolving the problem, we collected the experts' opinions and form the following the network (see Figure 2) .

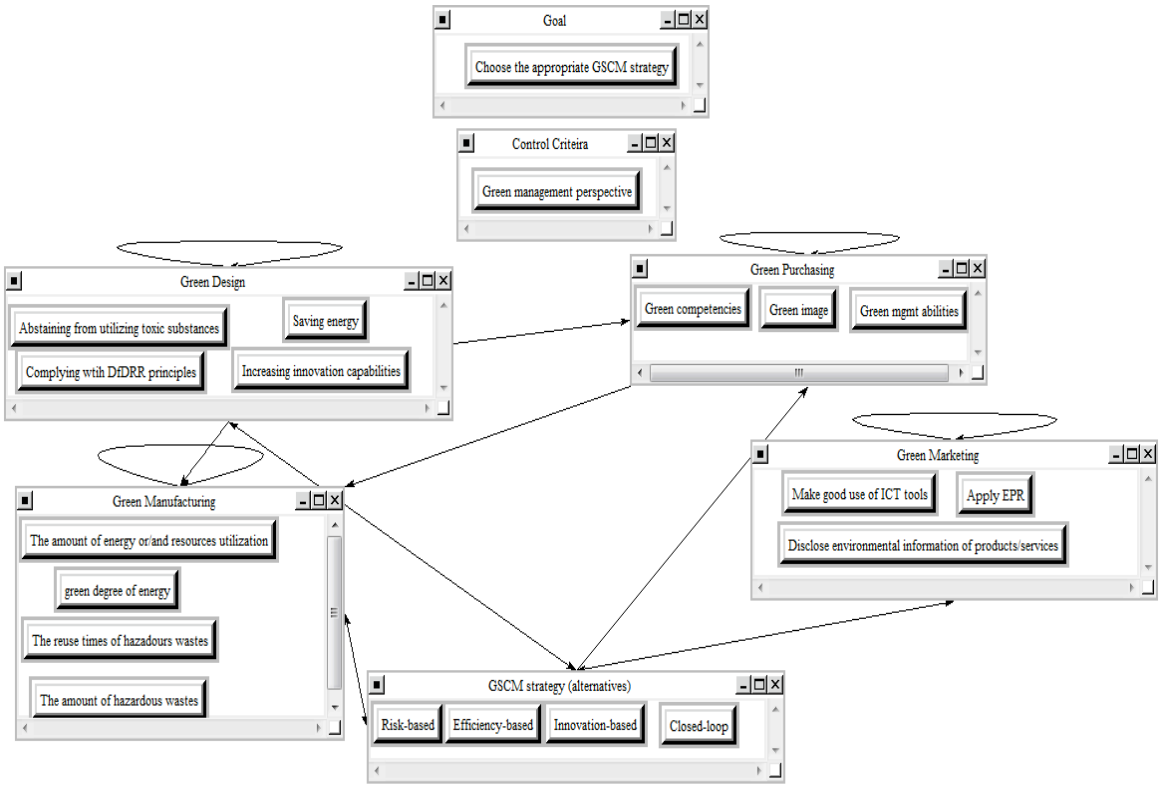

Figure 2. The proposed ANP model

Step2: Clarify the green management perspective

As earlier mentioned, the decision-makers should confirm the green management perspective in their own organizations first, and then it could be a guideline for them to determine the following each pair-wised comparisons. In the case, although the S company had begun to develop relations with partners in the supply chains, integrated environmental programs into other business functions fully. It continued to struggle for the advancement and learn from successful experiences of other better companies. As a result their green management viewpoint is receptive learning.

Step2: Perform the pair-wise comparisons and calculate the supermatrix

After the first step, the key managers and other experts we aimed took into account the Saaty's 1-9 fundamental scales and made the pair-comparisons between the clusters and the elements. We examined the consistency of each matrix through inconsistency index. The unweighted supermatrix (see table 2) consisted of the local priorities in each comparison matrix. Then, we could derive the weighted supermatirx (see table 3) by multiplying the each block in the unweighted supermatrix by the corresponding the cluster weight. Finally, we multiplied the weighted supermatrix by itself until the column of values coverage to the same for every column, and we obtained the limit supermatrix (see table 4). The explanation of abbreviations showed table 5.

Table 2. Unweighted supermatrix

	D1	D2	D3	D4	M1	M2	M3	M4	K1	K2	K3	P1	P2	P3	A1	A2	A3	A4
D1	0.4092	0.3352	0.4996	0.6148	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.1472	0.0828	0.6613
D2	0.1451	0.4980	0.2626	0.2276	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.1418	0.2342	0.1532
D3	0.1112	0.1044	0.0589	0.0542	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0598	0.5968	0.0803
D4	0.3345	0.0624	0.1789	0.1034	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.6512	0.0863	0.1051
M1	0.1337	0.1427	0.2788	0.0689	0.3000	0.1250	0.1096	0.1501	0.0000	0.0000	0.0000	0.0956	0.1036	0.1420	0.1056	0.0939	0.1056	0.1004
M2	0.0382	0.0468	0.0565	0.2202	0.1000	0.1250	0.0915	0.1056	0.0000	0.0000	0.0000	0.1686	0.1464	0.1276	0.1501	0.1645	0.1501	0.1094
M3	0.5623	0.5352	0.5254	0.4940	0.3000	0.3750	0.5785	0.3722	0.0000	0.0000	0.0000	0.3679	0.3107	0.3475	0.3722	0.3085	0.3722	0.3162
M4	0.2659	0.2754	0.1393	0.2169	0.3000	0.3750	0.2203	0.3722	0.0000	0.0000	0.0000	0.3679	0.4393	0.3828	0.3722	0.4330	0.3722	0.4740
K1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6000	0.4934	0.4000	0.0000	0.0000	0.0000	0.5936	0.6000	0.5936	0.5396
K2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.1958	0.2000	0.0000	0.0000	0.0000	0.2493	0.2000	0.2493	0.1634
K3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.3108	0.4000	0.0000	0.0000	0.0000	0.1571	0.2000	0.1571	0.2970
P1	0.2897	0.6833	0.6491	0.6267	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2790	0.3090	0.2797	0.3196	0.2684	0.5591	0.4286
P2	0.0549	0.1169	0.0719	0.0936	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0719	0.1095	0.0936	0.1220	0.1172	0.0887	0.1429
p3	0.6554	0.1998	0.2790	0.2797	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6491	0.5816	0.6267	0.5584	0.6144	0.3522	0.4286
A1	0.2786	0.0741	0.2047	0.2640	0.1782	0.3121	0.1891	0.2656	0.5565	0.2500	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A2	0.0642	0.4066	0.0669	0.1115	0.1444	0.1098	0.1057	0.1372	0.1085	0.2500	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A3	0.1307	0.1742	0.6577	0.5492	0.2779	0.1933	0.2148	0.1744	0.2808	0.2500	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A4	0.5266	0.3452	0.0706	0.0753	0.3995	0.3847	0.4904	0.4228	0.0542	0.2500	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 3. Weighted supermatrix

	D1	D2	D3	D4	M1	M2	M3	M4	K1	K2	K3	P1	P2	P3	A1	A2	A3	A4

D1	0.0163	0.0134	0.0199	0.0245	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.0153	0.0086	0.0688
D2	0.0058	0.0199	0.0105	0.0091	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.0148	0.0244	0.0159
D3	0.0044	0.0042	0.0023	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.0062	0.0621	0.0084
D4	0.0133	0.0025	0.0071	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.0678	0.0090	0.0109
M1	0.0357	0.0381	0.0746	0.0184	0.1500	0.0625	0.0548	0.0750	0.0000	0.0000	0.0000	0.0478	0.0518	0.0710	0.0178	0.0159	0.0178	0.0169
M2	0.0102	0.0125	0.0151	0.0589	0.0500	0.0625	0.0458	0.0528	0.0000	0.0000	0.0000	0.0843	0.0732	0.0638	0.0253	0.0278	0.0253	0.0185
M3	0.1504	0.1431	0.1405	0.1321	0.1500	0.1875	0.2893	0.1861	0.0000	0.0000	0.0000	0.1839	0.1553	0.1738	0.0628	0.0521	0.0628	0.0534
M4	0.0711	0.0736	0.0373	0.0580	0.1500	0.1875	0.1102	0.1861	0.0000	0.0000	0.0000	0.1840	0.2197	0.1914	0.0628	0.0731	0.0628	0.0800
K1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3000	0.2467	0.2000	0.0000	0.0000	0.0000	0.0431	0.0435	0.0431	0.0391
K2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1000	0.0979	0.1000	0.0000	0.0000	0.0000	0.0181	0.0145	0.0181	0.0119
K3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1000	0.1554	0.2000	0.0000	0.0000	0.0000	0.0114	0.0145	0.0114	0.0215
P1	0.0367	0.0866	0.0822	0.0794	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1395	0.1545	0.1398	0.2092	0.1757	0.3660	0.2805
P2	0.0070	0.0148	0.0091	0.0119	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0360	0.0547	0.0468	0.0798	0.0767	0.0581	0.0935
p3	0.0830	0.0253	0.0353	0.0354	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3246	0.2908	0.3134	0.3656	0.4022	0.2305	0.2805
A1	0.1577	0.0419	0.1159	0.1494	0.0891	0.1561	0.0946	0.1328	0.2782	0.1250	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A2	0.0363	0.2301	0.0379	0.0631	0.0722	0.0549	0.0529	0.0686	0.0543	0.1250	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A3	0.0740	0.0986	0.3723	0.3109	0.1390	0.0967	0.1074	0.0872	0.1404	0.1250	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A4	0.2980	0.1954	0.0400	0.0426	0.1998	0.1924	0.2452	0.2114	0.0271	0.1250	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 4. Limit supermatrix

	D1	D2	D3	D4	M1	M2	M3	M4	K1	K2	K3	P1	P2	P3	A1	A2	A3	A4
D1	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093
D2	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
D3	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057
D4	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051
M1	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541	0.0541
M2	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484
M3	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604	0.1604
M4	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378	0.1378
K1	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185
K2	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068
K3	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
P1	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075
P2	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324	0.0324
p3	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694	0.1694
A1	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560	0.0560

A2	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294
A3	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508
A4	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952	0.0952

Table 5. Explanation of abbreviations

D1	Abstaining from utilizing toxic substances	D2	Complying wtih DfDRR principles
D3	Increasing innovation capabilities	D4	Saving energy
M1	Green degree of energy	M2	The amount of energy or/and resources utilization
M3	The amount of hazardous wastes	M4	The reuse times of hazadours wastes
K1	Apply EPR	K2	Disclose environmental information of products/services
K3	Make good use of ICT tools		
P1	Green competencies	P2	Green image
P3	Green mgmt abilities		
A1	Closed-loop strategy	A2	Efficiency-based strategy
A3	Innovation-based strategy	A4	Risk-based strategy

Step3: Obtain the final priorities and determine the best alternative
After all calculations, we could acquire the overall results of the four GSCM strategies shown in table 5. We could conclude the risk-based GSCM strategy is more suitable for the S company.

Table 5. Overall Results

GSCM Strategy (Alternatives)	Ideal	Normal	Raw
Closed-loop	0.588263	0.241966	0.055980
Efficiency-based	0.308938	0.127073	0.029399
Innovation-based	0.533977	0.219637	0.050814
Risk-based*	1.000000	0.411323	0.095162

5. Conclusion

There are more and more enterprises introduced environmental programs and would like to build good corporate image and become a real green company. However, the path to successful green management is full of difficulties needed to overcome by companies. Besides advanced technology, innovation capabilities, establish nice relationships and interactions with the entire players in the supply chains as well. For any companies implementing green management; it indeed requires a systematic and more complete analysis approach to judge which direction is better for companies to develop in the future. Therefore a GSCM strategy selection is quite important decision in the companies.

For above reasons, this study aimed to: (1) provide a model for electronic industry to realize more about the decision-making problem and then determine an appropriate GSCM strategy to elevate the environmental performances and fulfill an effective green management; (2) validate the model proposed by a case study of an electronic company.

This ANP model we proposed directed electronic industry to understand more clearly how the business functions affect the GSCM strategy selection, and which one is more critical than others when determining the GSCM strategy. Then the decision makers could assess and adjust their directions of the GSCM strategy in their own firms to response to the competitive and dynamic business environment. This model in the paper is a single network, so we could further deliberate how to add other merits, such as cost merit, to strength the robustness and effectiveness of the proposed ANP model.

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