Prioritizing Drivers of Sustainable Competitive Advantages in Green Supply Chain Management Based on Fuzzy AHP

Nisakorn Somsuk
School of Aviation, Eastern Asia University, Pathumthani, Thailand
Email: nisakorn@eau.ac.th

***Abstract*—Successful implementation of green supply chain management (GSCM) can create a sustainable competitive advantage. A firm's specific internal and relational resources can be considered as drivers of sustainable competitive advantages in GSCM. To extend the scope of the limited research on the identification and prioritization of resource-related drivers having a strong influence on a firm's sustainable performance, this study was to explore the priority of these drivers based on the Triple Bottom Line. Fuzzy analytic hierarchy process (AHP) approach was applied to prioritize these drivers from experts' point of view — the view from the electronics industry in Thailand. Resource-based and relational views were then used to determine the drivers and develop an AHP model for prioritizing such drivers. The model based on our previous research. Finally, managerial and policy recommendations for more effective strategic management tailored to the context of the electronics industry in Thailand were provided.**

***Index Terms*—green supply chain management, drivers, fuzzy analytic hierarchy process, triple bottom line, resource-based view, relational view**

I. Introduction

Green supply chain management (GSCM) also known as environmental supply chain management, is the intra- and inter-firm management of the upstream and downstream supply chain concentrated on minimizing the overall environmental impact of the forward and reverse flows of the supply chain [1]-[3], while creating economic value, and lowering costs of production of the firms [4]-[6].

Nowadays, it is known that successful green supply chain management (GSCM) can create a sustainable competitive advantage for each company in a supply chain [7]. GSCM is getting more attention as a sustainable development mode for modern enterprises and some studies [8]-[10] have shown that a majority of the world's manufacturing will be carried out in Asia in the upcoming decades.

The strategic management literature (e.g. [11]-[13]) indicates that the specific internal and relational resources of a firm can be considered as a driver of GSCM. Therefore, in order to successfully implement the GSCM, the identification and prioritization of drivers of sustainable competitive advantages in GSCM are required.

Since the 1990s, many studies have dealt with the determination of drivers of sustainable competitive advantages in GSCM. As a result, there are several different drivers identified, but there are limited studies to draw conclusions about which drivers should receive the most attention.

To determine the relative weights of drivers, analytic hierarchy process (AHP) based on subjective judgment can be applied. Although traditional AHP using crisp values may elicit the expert's knowledge, it cannot fully reflect their knowledge or thinking [14]. Therefore, a fuzzy AHP approach using linguistic values is more appropriate to include the vagueness associated with experts in a decision making process [15]-[18].

Since the sustainability analysis is complicated by the fact that it requires researchers to think about the links between indicators and drivers of sustainable competitiveness, therefore several researchers have applied the multiple theories to develop a comprehensive analysis of sustainable competitiveness [19].

In this study, the resource-based view (RBV) and relational view (RV) are needed, not just to identify drivers, but also to develop a theoretical framework and an AHP model to explore some of the most significant drivers.

II. Theoretical Background

A. GSCM in Electronics Industry

In electronics industry in Thailand, an environmental awareness has become an important issue due to the present global agenda of sustainable development. Since 1st July 2006, new electrical and electronic equipment (EEE) sold in the European Union (EU) market must comply with the Restrictions of the use of Hazardous Substances (RoHS) directive.

In recent years, like other countries, EEE manufacturers in Thailand exporting products into the EU have introduced GSCM into their operations, as an effort to ensure compliance with the requirements of the RoHS directive and to subsequently gain a competitive position

Manscript received August 23, 2013; revised October 22, 2013.

©2014 Engineering and Technology Publishing
doi: 10.12720/jomb.3.4.259-266

in the EU market [20]. Many leading international EEE manufacturers, including Dell, HP, IBM, Motorola, Sony Panasonic, NEC, Fujitsu, and Toshiba have already established their green supply chains [11], [21].

B. Sustainable Competitiveness Indicators

The most widely used interpretation of sustainability is described in three different areas: environmental, social and economic dimensions [22]. These three areas are also known as the "triple bottom line (TBL)." "Sustainability of businesses and sustainable performance can be defined as an integration of environmental, social and economic performance" [23]. Various key performance indicators belonging to these three dimensions relevant to GSCM have been identified through this research as follows:

Environmental performance indicators for evaluating an environmental performance taking into account the effect upon an environment of business activities, processes, goods and services, consist of the following categories: material consumption, fuel usage, emissions, waste created.

Economic performance indicators which are used for assessing sustainability consist of the following categories: cost reduction, market share growth, and profit increase.

Social performance indicators for examining social impacts of a firm on its local and wider community for sustainable development are generally 'internally' focused towards such aspects as employee safety, health and security and job satisfaction levels.

C. Sustainable Competitiveness Drivers

Recently, both the RBV and the RV have been perceived as influential theoretical frameworks to explain firms' competitive advantages [24]. In this study, the RBV and RV were considered as a grounded theory to develop the drivers and the model.

The RBV: explains that a sustainable competitive advantages stems from the valuable, firm-specific resources (and capabilities) that are imperfectly mobile and imperfectly imitable [25]. The term "resources" refers to tangible and intangible assets, employee- and firm-level capabilities, organizational processes and attributes, information, knowledge etc., which are controlled by a firm and its employees, and positively affect its efficiency [25], [26]. According to Barney [27], in order to provide a sustainable competitive advantages and, thereby, superior performances, a resource must be valuable, rare, imperfectly imitable, and non-substitutable (VRIN) attributes.

The RV: emphasizes that competitive advantages derives not solely from a firm's unique resources but also from the strategic relational resources (or capabilities) generated from collaboration between firms [28]-[30]. According to the relational view [28], there are four potential sources of inter-organizational competitive advantages: relation-specific assets, knowledge-sharing routines, complementary resources, and effective governance. In the literature (e.g., [29], [31]), the relational view can be regarded as an extension of the RBV with a focus on inter-firm relationships and routines – for example, knowledge or capabilities generated by inter-firm relations which are seen as valuable resources.

TABLE I. THE DRIVERS OF GSCM BASED ON THE RBV AND RV

Driver Categories	Drivers and their Brief Descriptions
Organizational Resources	*Cross-functional collaboration for environmental improvements (OR1):* The degree of cooperation among functional units in the product innovation process [39], [40].
	Environmental education and training (OR2): A learning process that increases employees' environmental knowledge and awareness, and develops the necessary skills and expertise to address its associated challenges and a method for employees to gain environmental knowledge [41].
	Environmental policy for GSCM (OR3): A commitment of protecting the environment and improving environmental performance ceaselessly [42].
	Establishing an environmental risk management system for GSCM (OR4): A set of activities designed to identify, characterise, prevent or minimize environmental risks and potential impacts on the environment.
	Manpower involvement (OR5): A participative process which the employees involved in GSCM practices and implementation that uses the entire capacity of employees and is designed to encourage increased commitment to the organizational success [43].
	Top management support (OR6): The degree of top manager's understanding of the specific value and support for their attempts made a significant difference to the success of their GSCM practices [44], [45].
	Tracking the development of directives (OR7): Tracking the development of environmental regulations with respect to the emerging hazardous substances because the restricted substances and exemption index is continuously updated.
Physical Resources	*Green and cleaner production (PR1):* Workplace activities that require the use of equipment, technologies and processes to improve the environmental performance of manufacturing firms.
	Green design (PR2): An environmentally -conscious design of a product and its packaging that aims to reduce environmental impacts of the product and its packaging throughout its entire life and promote environmental practices [46].
	Green purchasing (PR3): An environmentally-conscious purchasing practice that aims to ensure that purchased items meets environmental objectives of the firm [47], [48].
	Information system (PR4): A combination of people, processes, and technologies that enables the processing and sharing of digitized information [49] to support decision making.
Relational Resources	*Collaborative R&D with suppliers (RR1):* Efforts between firms and their suppliers focused on "solving specific current problems of practice and at the same time.
	Effective communication within companies and with suppliers (RR2): Clear, consistent, and frequent communication about environmental issues with their suppliers and other partners in the green supply chain.
	Environmental auditing for suppliers (RR3): A systematic, documented, periodic and objective evaluation and assessment of how well environmental performance of suppliers is performed, which is coordinated with the strategic procurement.
	Supplier evaluation and selection (RR4): A routine process of finding and keeping suitable suppliers and a list of preferred suppliers for the next procurement process.

Source: Adapted from Somsuk *et al.* [32]

©2014 Engineering and Technology Publishing

According to our prior study [32] on classifying the drivers of sustainable competitive advantages in GSCM, we classified resources of the firm to three categories: physical, organizational, and relational resources. A brief discussion on each category is given below.

Physical resources (PR): refers to natural (raw) resources, technologies, machines, buildings, computer networks, information systems, distribution facilities, and the production capacity.

Organizational resources (OR): refers to systems, competence, culture, routines, policies, and business processes.

Relational resources (RR): refers to those that are generated by inter-firm relationships, as proposed by the relational view, e.g., relationships with suppliers and customers.

Based on our prior study [32], [33], from the literature review, 15 drivers extracted from the RBV and RV perspectives were identified as summarized in Table I.

D. Fuzzy AHP

AHP is widely used across industries for dealing with multiple criteria decision-making problems involving subjective judgment. However, AHP is often criticized for its inability to adequately accommodate the inherent uncertainty and imprecision associated with mapping decision–maker perceptions to an exact number.

Since a multiple criteria decision-making problem is subjective and qualitative in nature, it is very difficult for a decision–maker to express the strength of the preferences using exact numerical values. Therefore, fuzzy AHP method, which combines traditional AHP with fuzzy set theory, was developed for coping with uncertain judgments and to express preferences as fuzzy sets or fuzzy numbers which reflect the vagueness of human thinking. The basic idea of fuzzy set theory is that an element has a degree of membership in a fuzzy set.

The membership function $\mu_A(x)$ of a fuzzy set operates over the range of real numbers [0, 1]. In this study, triangular fuzzy numbers (TFNs) are used to represent subjective pairwise comparisons of experts' judgments.

A TFN can be denoted by triplet (a, b, c). The parameter "b" is the most promising value of $\mu_M(x)$, the parameters "a" and "c" are the lower and upper bounds which limit the field of possible evaluation. The triangular fuzzy conversion scale used to convert such linguistic scales into fuzzy scales in the evaluation model is given in Table II.

TABLE II. TRIANGULAR FUZZY CONVERSION SCALE.

Linguistic scale	Triangular fuzzy scale
Equally important	(1, 1, 3)
Moderately important	(1, 3, 5)
Fairly important	(3, 5, 7)
Very strongly important	(5, 7, 9)
Absolutely important	(7, 9, 9)

There are many fuzzy AHP methods proposed by different authors (cf., e.g. [34]-[37]). The common theme of all of these methods is using the concepts of fuzzy set theory and hierarchical structure analysis. In this research, Chang's [36] fuzzy extent analysis method is applied to the evaluation model since the steps of this approach are relatively easier than other fuzzy AHP approaches and similar to traditional AHP [37], [38].

E. Chang's Fuzzy Extent Analysis Method

First, the outlines of the extent analysis method on fuzzy AHP are given as follows:

Let $X = \{x_1, x_2, \ldots, x_n\}$ be an object set, and $U = \{u_1, u_2, \ldots, u_m\}$ be a goal set. According to Chang's extent analysis [36], each object is taken and an extent analysis for each goal, g_i, is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, \quad \text{for } i = 1, 2, \ldots, n$$

where, all the $M_{g_i}^j (j = 1, 2, \ldots, m)$ are TFNs.

Therefore, based on these outlines, the fuzzy judgment matrix can be constructed as follows:

$$\left(M_{g_i}^j\right)_{n\times m} = \begin{bmatrix} M_{g_1}^1 & M_{g_1}^2 & \cdots & M_{g_1}^m \\ M_{g_2}^1 & M_{g_2}^2 & \cdots & M_{g_2}^m \\ \vdots & \vdots & \vdots & \vdots \\ M_{g_n}^1 & M_{g_n}^2 & \cdots & M_{g_n}^m \end{bmatrix}.$$

Second, the steps of Chang's fuzzy extent analysis can be summarized as follows:

Step 1: Compute the value of fuzzy synthetic extent with respect to the i^{th} object using the following equation:

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \tag{1}$$

Step 2: Compute the degree of possibility of $S_i \geq S_j$, when $S_i = (a_i, b_i, c_i)$ and $S_j = (a_j, b_j, c_j)$ for $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, m$ and $i \neq j$, using the following equation:

$$V(S_i \geq S_j) = \begin{cases} 1, & \text{if } b_i \geq b_j \\ 0, & \text{if } a_j \geq c_i \\ \frac{a_j - c_i}{(b_i - c_i) - (b_j - a_j)}, & \text{otherwise,} \end{cases} \tag{2}$$

Step 3: Compute the degree of possibility of S_i over all the other $(n-1)$ fuzzy numbers, $i = 1, 2, \ldots, n$, using the following equation:

$$V(S_i \geq S_j \mid j = 1, 2, \ldots, m; i \neq j) = \min V(S_i \geq S_j \mid j = 1, 2, \ldots, m; i \neq j) \tag{3}$$

Step 4: Compute the priority vector $W = (w_1, w_2, \ldots, w_n)^T$ of the fuzzy judgment matrix as follows:

Assume that $w_i' = \min V(S_i \geq S_j \mid j = 1, 2, \ldots, m; i \neq j)$,

©2014 Engineering and Technology Publishing

$$w_i = \frac{w_i'}{\sum_{i=1}^{n} w_i'} \quad (4)$$

where, w_i is a non-fuzzy (crisp) value.

The priority vector, $W = (w_1, w_2, \ldots, w_n)^T$ (5)

III. Research Methodology

According to our prior research [32], we have identified a common set of drivers of success of GSCM, with respect to the specific strategic internal and relational resources of the firm through the lens of the RBV and RV. Then we classified them into three resource-related categories by applying the Q-Sort method [50]-[52] to assess reliability of consistency for each category. These categories are physical, organizational and relational resources.

Our subsequent research [33] determined applicable drivers of success of GSCM for the electronics industry in Thailand that may contribute to an enhancement of the performance of firms in supply chain along the three dimensions of the TBL. Based on the applicable drivers, their categories and performance indicator dimensions, with the grounded theory of the RBV and RV, the AHP model for prioritizing drivers was developed with regard to sustainability concepts in GSCM implementation.

Our current study was divided into two phases. The first, a planning phase, included the selection of a group of subject matter experts, defining scope and boundaries of the AHP and decomposing the problem into a hierarchy. The second phase involved the application of fuzzy AHP. In this phase, an integrated Chang's extent analysis [36] on fuzzy AHP to GSCM to prioritize the applicable drivers and their categories was applied to the supply chain management practices in the electronics industry in Thailand. The research methodology was as follows:

Step 1: Developing a hierarchy model

We adopted an AHP model that was proposed in our previous study [33]. First, we used the RBV and RV perspectives as a grounded theory to develop the theoretical framework for a sustainable competitiveness analysis of a firm in the green supply chain. Based on the applicable drivers, their categories, and performance indicator dimensions, with the theoretical framework (as shown in Fig. 1), the AHP model was then developed to help promote sustainability in GSCM implementation.

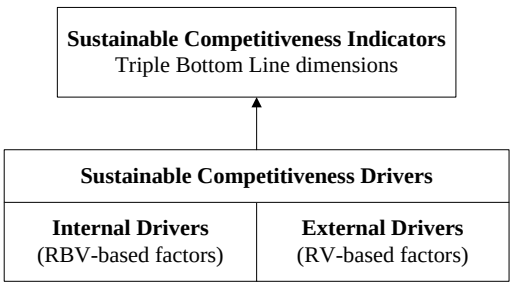

Figure 1. A theoretical framework for sustainable competitiveness analysis, Source: Somsuk *et al.* [33]

The theoretical framework contains a comprehensive set of links between the indicators and drivers of sustainable competitiveness. Fig. 1 shows that a firm's specific internal and relational resources can be considered as a driver of sustainable competitive advantages in GSCM. Sustainability was described in three different areas: environmental, social and economic dimensions of TBL.

The resulting theoretical framework can be a basis for developing a hierarchical system of elements. The hierarchy model is given in Fig. 2.

Step 2: Developing a pairwise comparison questionnaire based on fuzzy AHP

A questionnaire was designed in an AHP questionnaire format (pairwise comparison) based on the hierarchy. The questionnaire was then developed for collecting input data by pairwise comparison of elements in each level with respect to the upper level element, using linguistic terms which were expressed by the fuzzy numbers.

Step 3: Collecting input data by pairwise comparisons of decision elements and establishing a fuzzy judgment matrix

A panel of experts was selected based on their experiences in the GSCM field or on their participation in several GSCM implementations. Each expert was asked to assign linguistic terms based on his/her subjective judgment, for the pairwise comparisons by asking which one of the two elements was more important and how much more important it was with respect to an upper level of the elements. After getting the responses for linguistic terms from the experts, these linguistic judgments were then converted to triangular fuzzy sets as defined in Table II. By the used of triangular fuzzy numbers, via pairwise comparison, the fuzzy judgment matrix was constructed as shown in Table II.

Step 4: Checking the consistency of each pairwise comparison matrix

The consistency of fuzzy judgment matrices was tested. If the subjective judgments of the decision makers are inconsistent (or a consistency ratio value is larger than 0.1), they will not be considered in the next step of fuzzy AHP analysis.

Step 5: Combining the opinions from several experts by using geometric mean

The perception of each expert possibly varies according to individual experience and knowledge. In order to get a consistent and fair outcome from several experts' subjective judgments, the informed judgments were aggregated through the geometric mean of individual experts' judgments [53]. By using a geometric mean method to derive the fuzzy weight, different judgmental values can be converted to one element by using the fuzzy judgment matrix.

Step 6: Calculating the local priority weights of each element

According to Chang's extent analysis method [36] on fuzzy AHP, the local priority weights of each element were calculated, and then calculation of the local priority weights was repeated for all the levels in the hierarchy.

©2014 Engineering and Technology Publishing

Step 7: Calculating the global priority weight of each element

The global priority weight could be calculated by multiplying its local priority weight with its corresponding weight along the hierarchy. The global priority weights were sorted decreasingly and the priority of drivers which denotes the relative importance of the resource-based drivers was ranked finally.

IV. An Application of an Integrated Fuzzy AHP Model to Electronics Industry

A. Confirming the Applicability of the Fifteen Drivers in the Context of Thailand

In this paper we extend our previous studies [32], [33] on the degree of applicability of the identified drivers (as in Table I). So, the interviews with the two managers of different firms in electronics industry were carried out to validate and confirm the survey results of our previous study [33] to ensure that these drivers are applicable to electronics industry in the context of Thailand. These managers were selected based on their practical experience in GSCM field and their willingness to participate in the interview. Based on the interview results, all managers agreed with the survey results that all fifteen drivers are critical and applicable to electronics industry in Thailand. Therefore all fifteen drivers should be prioritized using fuzzy AHP afterwards.

B. Selecting the Experts

The experts were selected based on their experiences in the field or participating in several GSCM implementations. Chen *et al.* [54] argue that the number of experts should be large enough to assure multiple perspectives, and small enough to make the research manageable.

The selected expert panel included 13 persons: seven middle managers and six junior managers in the areas of sustainability, environmental issues, green production, green purchasing, or strategic management, who are policy makers and implementers in electronics industry. They were selected based on their experiences in participating in GSCM projects. An average experience of respondents (or experts) was greater than five years in the GSCM field.

All 13 experts received the fuzzy AHP questionnaire and were asked to complete it during June–July 2013 in Thailand. After two rounds of attempts, in total some 11 usable questionnaires were collected.

C. Determining Weights of the Drivers Using Fuzzy AHP

The procedure of fuzzy AHP approach to calculate weights of the drivers is as follows.

1) Develop a hierarchical structure for prioritizing the drivers

A fuzzy AHP model based on the identified drivers, their categories, and performance dimensions, is developed as shown in Fig. 2. With a hierarchical structure, a complicated and complex problem is converted to a hierarchical system of elements.

An AHP model was developed based on the applicable drivers, their categories, and performance dimensions with the grounded theories of the RBV and RV perspectives.

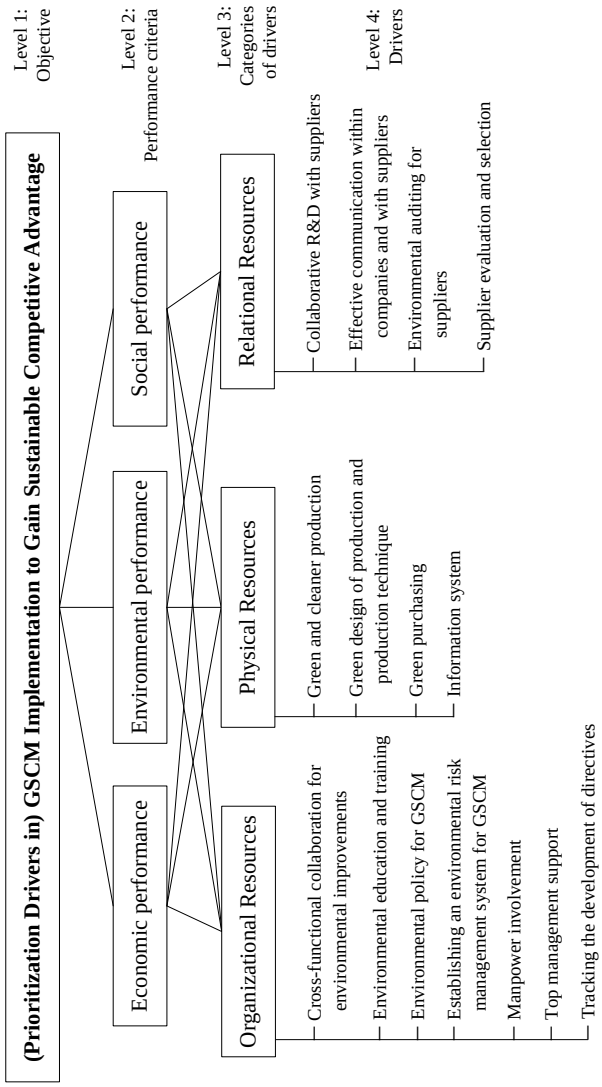

Figure 2. The hierarchical structure for prioritizing the drivers of GSCM, Source: Adapted from Somsuk *et al.* [33]

Fig. 2 depicts a 4–level AHP model of prioritization of drivers. The first level shows the overall goal of this study, which is the prioritization of drivers of sustainable competitive advantages. The second level presents the three main performance dimensions of TBL. The third level presents the three categories of drivers. The lowest level shows the attribute of factors that acts as the performance drivers.

2) Establish a fuzzy judgment matrix

A panel of experts was asked to make pairwise comparisons for elements. The questionnaires were provided to collect information from the experts. Each expert was asked to assign linguistic terms based on his/her subjective judgment by asking "which one of two elements is more important" and "how much more

©2014 Engineering and Technology Publishing

important it is with respect to their upper level." In decision–making, each expert gave his/her preference on the elements using fuzzy judgment matrix. After getting the answers from experts in linguistic terms, these linguistic judgments were then converted to triangular fuzzy sets as defined in Table II.

3) Combine the opinions from several experts by using geometric mean

In this step, the pairwise comparison matrices were aggregated into one matrix by applying geometric mean technique. Then the local priority weights for all levels in hierarchy were calculated by applying Chang's [36] fuzzy extent analysis method.

4) Calculate the global priority weight of each element

The global priority weight of each element was calculated by multiplying its local weight with its corresponding weight along the hierarchy.

V. Results

TABLE III. LOCAL AND GLOBAL WEIGHT SCORES OF THE DRIVERS AND THEIR CATEGORIES AND THEIR PRIORITY RANKINGS

Driver Categories	Local Weights of Driver Categories			Global Weights of Driver Categories	Drivers	Local Weights	Global Weights	Priority Ranking
	Economic Performance (0.448)	Environmental Performance (0.389)	Social Performance (0.163)					
Organizational Resources	0.487	0.457	0.414	0.463	OR1	0.166	0.077	5
					OR2	0.050	0.023	14
					OR3	0.235	0.109	2
					OR4	0.165	0.076	6
					OR5	0.137	0.063	7
					OR6	0.240	0.111	1
					OR7	0.006	0.003	15
Physical Resources	0.218	0.297	0.374	0.274	PR1	0.203	0.056	11
					PR2	0.391	0.107	3
					PR3	0.218	0.060	9
					PR4	0.188	0.052	12
Relational Resources	0.296	0.247	0.212	0.263	RR1	0.220	0.058	10
					RR2	0.237	0.062	8
					RR3	0.148	0.039	13
					RR4	0.395	0.104	4

Note: Parentheses ( ) denote the local weight of performance dimension

From Table III, the most important (highest–global weight) performance dimension was "economic performance", followed by "environmental performance", and "social performance", respectively. The category of "organizational resources" was the most importance, followed by the categories of physical and relational resources, respectively. The four most important drivers were "top management support", "environmental policy for GSCM", "green design" and "supplier evaluation and selection", respectively. In contrast, "tracking the development of directives" was the least influential/significant driver.

VI. Discussion

Table III shows the local and global weight scores of the drivers and their categories. It also shows the results of prioritization of the drivers. The priority ranking of all drivers is based on their global weights.

Applying fuzzy AHP to determine weights of the drivers allows considering the vagueness associated with evaluating relative importance of decision making experts. It can be concluded that Thai experts from electronics industry considered the category of organizational resources as the most important resource category for GSCM implementation success. In this category, drivers of "top management support" and "environmental policy for GSCM", followed by the relational and physical resources, respectively. The obtained priority rankings of drivers and indicators enable the management team to strategically manage the priority effectively and lead to improve a firm's performance. By using these priorities, managers can decide which drivers they will focus on first, next, and then last.

VII. Conclusions, Implications, Limitations and Future Research

A. Conclusions

This study prioritized the weights of the applicable drivers using fuzzy AHP. The hierarchical structure model proposed consists of three main performance dimensions of TBL; environmental, social and economic performance, three categories of resource-based drivers; physical, organizational, and relational resources, and 15 drivers. The fuzzy AHP results reflect the relative importance of drivers for firms' GSCM implementation in Thailand. In promoting the success of implementing GSCM, the management team needs to devote their

©2014 Engineering and Technology Publishing

efforts, and carefully monitor and manage drivers that have the highest priority. Therefore, organizational resources, especially in top management support should be emphasized first and most.

Knowledge of the prioritization of drivers will lead to better strategic management in the in–house resources of a firm, and its inter-firm relationships and routines. The research findings also will help firms to use the right resources required to implement their GSCM practices.

B. Implications

This research presents a theoretical implication. This research contains an approach to identify the ranking of drivers by considering RBV and RV theories. A theoretical framework is proposed, and it enables the prioritization problem to be modeled as a hierarchical structure. The finding reinforces the RBV and RV perspectives, according to which a unique bundle of resources can provide firms with superior performance [22].

Moreover, the research also contributes three main managerial implications. First, it enables practitioners to realize the role of internal and relational resources as a firm's GSCM drivers. Second, it helps managers' and policy makers' resource allocation decisions. An effective management can ensure that they have resources and capabilities required to implement its GSCM. Lastly, the obtained priorities help practitioners understand the relative importance of the drivers. This is helpful to establish their strategic plans as they may not have sufficient resources to deal with all drivers simultaneously.

C. Limitations of the Research

This research has two limitations. First, the sample size indicates limited generalization of the study results, and the results should therefore be treated with caution. Second, this study based on only the managers' point of view. However, multiple perspectives from senior managers and consultants specializing in the GSCM should be incorporated in the prioritization process.

D. Future Research Direction

There are several directions in which this type of research can investigate. First, replicating this research with more experts including a variety of expert types will be recommended. Second, best practices for accomplishing the 15 drivers can be identified to help a firm's management team benchmark the ways of achieving superior performance. Third, the proposed model can be adapted for other industries and/or countries, especially emerging economies. Lastly, though our study addresses prioritized drivers from the electronics industry in Thailand, it omits international comparisons. Therefore, comparative questions of prioritizing drivers between developed and developing countries are worthy of study.

ACKNOWLEDGMENT

The researcher wishes to thank Mr. Pongtiwa Pongpanich and Assoc. Prof. Dr. Sombat Teekasap for data collection, and all questionnaire respondents for their valuable and insightful contributions.

REFERENCES

[1] R. I. van Hoek, "From reverse logistics to green supply chains," *Supply Chain Management: An International Journal*, vol. 4, no. 3, pp. 129–134, 1999.

[2] R. D. Klassen and P. F. Johnson, *The Green Supply Chain, in Understanding Supply Chains: Concepts, Critiques, and Futures*, S. New and R. Westbrook, New York: Oxford University Press, 2004.

[3] Q. Zhu, J. Sarkis, and K. Lai, "Confirmation of a measurement model for green supply chain management practices implementation," *International Journal of Production Economics*, vol. 111, no. 2, pp. 261–273, 2008.

[4] Q. Zhu and J. Sarkis, "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises," *Journal of Operations Management*, vol. 22, no. 3, pp. 265–289, 2004.

[5] S. Vachon and R. D. Klassen, "Environmental management and manufacturing performance: The role of collaboration in the supply chain," *International Journal of Production Economics*, vol. 111, no. 2, pp. 299–315, 2008.

[6] J. F. Kirchoff, "A resource-based perspective on green supply chain management and firm performance," PhD diss., University of Tennessee, 2011.

[7] J. Drake, *Introduction to Supply Chain Modeling: Transportation and Logistics, Drake's Supply Chain Management Primer*, Georgia Institute of Technology, Spring 2006.

[8] US-AEP, *Sector Based Public Policy in the Asia-Pacific Rregion*, US-AEP, 1999.

[9] P. Rao, "Greening the supply chain: A new initiative in South East Asia," *International Journal of Operations and Production Management*, vol. 21, no. 6, pp. 632-655, 2002.

[10] Q. Zhu and J. Sarkis, "An inter-sectoral comparison of green supply chain management in China: Drivers and practices," *Journal of Cleaner Production*, vol. 14, no. 5, pp. 472–486, 2006.

[11] C.-W. Lee, "Green suppliers with environmental performance in the supply chain perspective," *Asia Pacific Management Review*, vol. 13, no. 4, pp. 731–745, 2008.

[12] J. Sarkis, Q. Zhu, and K.-H. Lai, "An organizational theoretic review of green supply chain management literature," *International Journal of Production Economics*, vol. 130, no. 1, pp. 1–15, 2011.

[13] H. Walker, L. Di Sisto, and D. McBain, "Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors," *Journal of Purchasing & Supply Management*, vol. 14, no. 1, pp. 69–85, 2008.

[14] C. Kahraman, U. Cebeci, and Z. Ulukan, "Multi-criteria supplier selection using fuzzy AHP," *Logistics Information Management*, vol. 16, no. 6, pp. 382–394, 2003.

[15] C. C. Huang, P. Y. Chu, and Y. H. Chiang, "A fuzzy AHP application in government-sponsored R&D project selection," *Omega*, vol. 36, no. 6, pp. 1038–1052, 2008.

[16] C. H. Cheng, "Evaluation naval tactical missile system by fuzzy AHP based on the grade value of membership function," *European Journal of Operation Research*, vol. 96, pp. 343–350, 1996.

[17] C. H. Cheng, "Evaluation weapons systems using ranking fuzzy number," *Fuzzy Sets and Systems*, vol. 107, pp. 25–35, 1999.

[18] O. Duran and J. Aguilo, "Computer-aided machine-tool selection based on a fuzzy-AHP approach," *Expert Syst. Appl.*, vol. 34, pp. 1787–1794, 2008.

[19] T. T. Coates and C. M. McDermott, "An exploratory analysis of new competencies: a resource based view perspective," *Journal of Operations Management*, vol. 20, pp. 435–450, 2002,

[20] Q. Zhu, Y. Geng, T. Fujita, and S. Hashimoto, "Green supply chain management in leading manufacturers: Case studies in Japanese large companies," *Management Research Review*, vol. 33, no. 4, pp. 380–392, 2010.

[21] Q. Zhu and J. Sarkis, "An inter-sectoral comparison of green supply chain management in China: Drivers and practices," *Journal of Cleaner Production*, vol. 14, no. 5, pp. 472–486, 2006.

©2014 Engineering and Technology Publishing

[22] J. Eklington, "Towards the sustainable corporation: Win-win-win business strategies for sustainable development," *California Management Review*, vol. 36, no. 2, pp. 90–100, 1994.
[23] A. Kocmanová and M. Dočekalová, "Corporate sustainability: Environmental, social and corporate performance," *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, vol. 59, no. 7, pp. 203–209, 2011.
[24] L. F. Mesquita, J. Anand, and T. H. Brush, "Comparing the resource-based and relational views: Knowledge transfer and spillover in vertical alliances," *Strategic Management Journal*, vol. 29, pp. 913 – 941, 2008.
[25] J. B. Barney, "Firm resources and sustained competitive advantage," *Journal of Management*, vol. 17, pp. 99–120, 1991.
[26] J. B. Barney, "Resource-based theories of competitive advantage: a ten-year retrospective on the resource-based view," *Journal of Management*, vol. 27, no. 6, pp. 643–650, 2001.
[27] J. B. Barney, *Gaining and Sustaining Competitive Advantage*, Prentice Hall: New Jersey, 1997.
[28] J. H. Dyer and H. Singh, "The relational view: cooperative strategy and sources of interorganizational competitive advantage," *Academy of Management Review*, vol. 23, no. 4, pp. 660–679, 1998.
[29] D. Lavie, "The competitive advantage of interconnected firms: an extension of the resource-based view," *Academy of Management Review*, vol. 31, no. 3, pp. 638–658, 2006.
[30] J. Dyer, P. Kale, and H. Singh, "How to make strategic alliances work" *Sloan Management Review*, vol. 42, no. 4, pp. 37–43, 2001.
[31] M. Farjoun, "Towards an organic perspective on strategy," *Strategic Management Journal*, vol. 23, pp. 561–594, 2002.
[32] N. Somsuk, P. Pongpanich, and S. Teekasap, "Determining and classifying drivers of sustainable competitive advantages in green supply chain management: Resource-based and relational views," in *Proc. IEEE Int. Conf. on Industrial Engineering and Engineering Management*, Bangkok, Thailand, 10-13 Dec 2013.
[33] N. Somsuk, P. Pongpanich, and S. Teekasap, "Developing an AHP-based model for prioritizing drivers of sustainable competitive advantages in green supply chain management: Resource-based and relational views," in *Proc. 3rd Int. Conf. on Engineering and Applied Science*, Osaka, Japan, 7-9 Nov 2013.
[34] P. J. M. Laarhoven and W. Pedrycz, "A fuzzy extension of Saaty's priority theory," *Fuzzy Sets and Systems*, vol. 11, pp. 229–241, 1983.
[35] J. J. Buckley, "Fuzzy hierarchical analysis," *Fuzzy Sets and Systems*, vol. 17, pp. 233–247, 1985.
[36] D. Y. Chang, "Applications of the extent analysis method on fuzzy AHP," *European Journal of Operational Research*, vol. 95, no. 3, pp. 649–655, 1996.
[37] C. E. Bozdag, C. Kahraman, and D. Ruan, "Fuzzy group decision making for selection among computer integrated manufacturing systems," *Computers in Industry*, vol. 51, no. 1, pp. 13–29, 2003.
[38] F. T. Bozbura and A. Beskese, "Prioritization of organizational capital measurement indicators using fuzzy AHP," *International Journal of Approximate Reasoning*, vol. 44, pp. 124–147, 2007.
[39] L. M. De Luca and K. Atuahene-Gima, "Market knowledge dimensions and cross-functional collaboration: Examining the different routes to product innovation performance," *Journal of Marketing*, vol. 71, no. 1, pp. 95–112, 2007.
[40] X. M. Song, M. M. Montoya-Weiss, and J. B. Schmidt, "Antecedents and consequences of cross-functional cooperation: A comparison of R&D, manufacturing, and marketing perspectives," *Journal of Product Innovation Management*, vol. 14, pp. 35–47, 1997.
[41] S. Kitazawa and J. Sarkis, "The relationship between ISO 14001 and continuous source reduction programs," *International Journal of Operations and Production Management*, vol. 20, no. 2, pp. 225–248, 2000.
[42] S. Liyin, Y. Hong, and A. Griffith, "Improving environmental performance by means of empowerment of contractors," *Management of Environmental Quality: An International Journal*, vol. 17, no. 3, pp. 242–257, 2006.
[43] P. Robbins, *Stolen Fruit: The Tropical Commodities Disaster*, Zed Books, London, 2003.
[44] A. H. Hu and C. W. Hsu, "Critical factors for implementing green supply chain management practice: an empirical study of electrical and electronics industries in Taiwan," *Management Research Review*, vol. 33, no. 6, pp. 586–608, 2010.
[45] S. Li and B. Lin, "Accessing information sharing and information quality in supply chain management," *Decision Support Systems*, vol. 42, pp. 1641–1656, 2006.
[46] Q. Zhu, J. Sarkis, and K. Lai, "Green supply chain management: pressures, practices and performance within the Chinese automobile industry," *Journal of Cleaner Production*, vol. 15, no. 11-12, pp. 1041–1052, 2007.
[47] H. Min and W. P. Galle, "Electronic commerce-based purchasing: a survey on the perceptual differences between barge and small organizations," *International Journal of Logistics: Research and Applications*, vol. 4, no. 1, pp. 79–95, 2001.
[48] G. A. Zsidisin and S. P. Siferd, "Environmental purchasing: a framework for theory development," *European Journal of Purchasing and Supply Management*, vol. 7, no. 1, pp. 61–73, 2001.
[49] N. P. Melville, "Information systems innovation for environmental sustainability," *MIS Quarterly*, vol. 34, no. 1, pp. 1–21, 2010.
[50] K. C. Chang, T. Lie, and M. L. Fan, "The impact of organizational intervention on system usage extent," *Industrial Management & Data Systems*, vol. 110, no. 4, pp. 532–549, 2010.
[51] A. Y. Nahm, L. E. Solis-Galvan, S. S. Rao, and T. S. Ragu-Nathan, "The Q-sort method: Assessing reliability and construct validity of questionnaire items at a pre-testing stage," *Journal of Modern Applied Statistical Methods*, vol. 1, no. 1, pp. 114–125. 2002.
[52] J. L. Fleiss, "Measuring nominal scale agreement among many raters," *Psychological Bulletin*, vol. 76, no. 5, pp. 378–382, 1971.
[53] H. Rafiei and M. Rabbani, "Project selection using fuzzy group analytic network process," *World Academy of Science, Engineering and Technology*, vol. 58, pp. 122–126, 2009.
[54] H. Chen, J. C. Ho, and D. F. Kocaoglu, "A strategic technology planning framework: A case of Taiwan's semiconductor foundry industry," *IEEE Transactions on Engineering Management*, vol. 56, no. 1, pp. 4–15, 2009.

Nisakorn Somsuk is an assistant professor in Industrial Engineering, School of Aviation, Eastern Asia University, Thailand. She obtained a PhD in Engineering, in 2012 from Thammasat University, Thailand. Her primary research interests include multi-criteria decision making, optimization, and operations management. She has published her research in Industrial Management & Data systems, and Technological Forecasting and Social Change.

©2014 Engineering and Technology Publishing