



Improving sustainable supply chain management using a novel hierarchical grey-DEMATEL approach

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ABSTRACT

Sustainable supply chain management has been studied in the past. However, the previous studies lack proper justification for a multi-criteria decision-making structure of the hierarchical interrelationships in incomplete information. To fill this gap, this study proposes a hierarchical grey decision-making trial and evaluation laboratory method to identify and analyze criteria and alternatives in incomplete information. Traditionally, the decision-making trial and evaluation laboratory method does not address a hierarchical structure and involves incomplete information within its analytical method. However, the grey theory compensates for incomplete information. This study's purpose is to apply the proposed hierarchical structure to identify aspects of and criteria for supplier prioritization. This includes an original set of criteria for structuring the following: aspects as a sustainable plan, communities for sustainability, sustainable operational process control and sustainable certification and growth. The results present the recycle/reuse/reduce option as a tool to increase the material savings percentage, which is the top criterion for supplier selection. This study concluded that the hierarchical analytical method provides a strong basis for future academic and practitioner research.

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1. Introduction

Sustainable supply chain management (SSCM) implements corporate responsibility practices and achieves a higher efficiency in logistics performance and resource usage when pursuing the three dimensions of sustainability, i.e., economic goals, social goals and environment goals (Seuring and Muller, 2008; Seuring et al., 2008; Seuring and Gold, 2013; Tseng and Hung, 2014). A firm must consider environmental impacts across the entire supply chain, including the selection of suppliers, distributors, and partners and customer awareness. In addition, sustainability requires the integration of environmental problems and solutions across a firm's functional boundaries. This functional interaction across

functional areas includes a firm's strategy, product design, production and inventory management, marketing and distribution, and regulatory compliance (Lin and Tseng, 2016). Previous literature has addressed SSCM by proposing many sensible models or evaluation frameworks (Ahi and Searcy, 2015; Bai and Sarkis, 2010; Carter and Rogers, 2008; Chaabane et al., 2012; Gold et al., 2010; Govindan et al., 2013; Tseng et al., 2014). As previously noted, successfully managing the SSCM lies in measuring and monitoring information regarding critical aspects, criteria and supplier selection. Hence, what is the proposed SSCM hierarchical structure, its critical aspects and the criteria for achieving supplier selection to fulfill a business goal?

SSCM has multiple aspects and needs multi-operational functions to achieve competitive advantages in intensive competitions. It is a challenging to present various aspects and criteria to facilitate the attainment of competitive changes. For instance, Gupta and Palsule-Desai (2011) suggested that SSCM adopt a firm perspective instead of a societal or policy-maker perspective and focus on organizational decisions related to the entire product life cycle,

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which involves design, production, distribution, consumer use, post-use recovery and reuse. SSCM can include practices within a supply chain network that provides green products, excellent service and accurate information. Traditionally, prior studies have claimed sustainability to be an aspect closely tied to SSCM effectiveness. Many studies have presented the multi-level structure to achieve economic performance and reduce environmental impacts simultaneously (e.g., Govindan et al., 2013; Tseng, 2013; Tseng and Hung, 2014). However, firms are deploying various SSCM criteria derived from cross-operational sections, preventing resources wasting or preventing excesses in operational functions. The existing literature fails to identify the proper criteria within a hierarchical structure. This clearly suggests that determining key SSCM criteria aligns with supplier selection.

What are the key SSCM aspects of and criteria for the hierarchical structure and interrelationships? Which supplier is the best alternative according to SSCM aspects and criteria? The available natural resources and the interrelationships between suppliers and customers are always a sustainability issue (Chaabane et al., 2012; Schaltegger, 1997). The SSCM decision-making process always has a hierarchical structure, and interrelationships exist between its aspects and innate criteria (Govindan et al., 2013; Mafakheri et al., 2011; Tseng, 2013). Appropriate fit between SSCM and supplier selection requires a basis for analyzing how aspects and criteria fit into hierarchical structures within interrelationships. Few prior studies have considered the hierarchical structure with interrelationships to resolve incomplete information (Tseng, 2009a, 2010). In the SSCM literature, Carter and Rogers (2008) presented a framework and developed research propositions based on resource dependence theory, transaction cost economics and the resource-based view of the firm; however, the practical qualitative and quantitative information and innate hierarchical structure are omitted. Govindan et al. (2013) determined a multi-layer structure with dependent and driving powers but omits a discussion on incomplete information. Nonetheless, one distinctive feature of SSCM emerges: a focal firm is pressured and, in turn, pressures its suppliers (Seuring and Muller, 2008; Tseng et al., 2013, in press). Here, the focal firm must utilize a set of hierarchical structures with incomplete information measures to identify the key criteria preventing resource overuse.

However, qualitative and quantitative information exists in operational functions. Hence, this information is necessary to scale. Moreover, either the hierarchical structure or incomplete information is always presented in previous studies (Koplin et al., 2007; Tseng and Hung, 2014; Lin and Tseng, 2016., Govindan et al., 2013; Tseng et al., 2014; Tseng et al., in press). For instance, Tseng et al. (in press) proposed a balanced scorecard to evaluate SSCM performance with hierarchical structure and uncertainty; the interrelationship of aspects, criteria and supplier selection are ignored. However, supplier selection is critical to SSCM, and the formation of the hierarchical structure from operational attributes is usually omitted (Büyükoğkan and Çifçi, 2011; Kahraman et al., 2003; Lee et al., 2009; Sarkis and Talluri, 2002; Tseng et al., 2009; Govindan et al., 2013). Büyükoğkan and Çifçi (2011) proposed a novel, fuzzy multi-criteria decision-making (MCDM) model for an effective sustainable supplier selection problem; this model considers the increasing complexity and uncertainty of the socio-economic environment. Seuring and Gold (2013) presented a focal firm's supplier selection and interrelationships among the supplier, customers and stakeholders. However, the previous studies fail to address hierarchical structure with interrelationships, supplier selection and incomplete information.

In summary, this study's objective is to assess SSCM and supplier selection by utilizing the proposed grey decision-making trial and evaluation laboratory method (DEMATEL) in a focal electronic firm

in Taiwan. Thus, this study fills the existing literature gap and proposes a hierarchical structure that is based on a systematic approach to SSCM. This study's objective is to integrate the grey theory and DEMATEL methods in the focal firm, which has rarely occurred in SSCM literature. Concerning scientific contributions in the literature, this proposed criteria set will use factor analysis to clarify the structure's validity and reliability; in addition, the proposed set will show the origins and the initial assessment of the model's aspects and criteria. This analytical method will characterize SSCM as a hierarchical structure with interrelationships and incomplete information issues. The contribution includes (1) modeling the decision problem within the context of a proposed SSCM hierarchical structure; (2) incorporating hierarchical structure with interrelationships and incomplete information for decision-maker weighted relation schemes; and (3) transforming the qualitative and quantitative information into a comparable scale and applying grey theory to evaluate the incomplete information and the DEMATEL in measuring the interrelationships among the criteria.

This paper is organized as follows. This study discusses the shortcomings of the SSCM literature; the definitions of the grey theory, the DEMATEL and the proposed hybrid method are discussed in section 2. Section 3 presents the methods applied in this study. Section 4 shows the results of aspects, criteria and data analysis, which are based on the proposed steps. This discussion focuses on a hierarchical grey-DEMATEL model; aspects and the criteria are presented in quantitative and qualitative scales using a hierarchical structure with interrelationships and incomplete information. Section 5 presents the managerial and theoretical implications. The last section presents the discussion, implications, contributions, limitations, and conclusions.

2. Literature review

This session discusses the theoretical background of prior SSCM studies and the proposed method and measures.

2.1. Sustainable supply chain management

Sustainability management is defined as “strategic business activities to minimize risks from environmental, economic, and social sustainability, to maximize corporate value including shareholder value” (WBCSD, 2000; Tseng et al., 2008; Wong et al., 2014). Diaz-Garrido et al. (2011) noted that the competitive priorities in SSCM refer to the manufacturing units' objectives, which enable firms to compete, achieve capabilities established for the activity, and reinforce the firm's competitive advantage. Lin and Tseng (2016) determined that dynamic flexibility in operations has become a competitive necessity for firms in SSCM. Chardine-Baumann and Botta-Genoulaz (2014) noted that sustainable development in supply chain management has been identified to be not only a constraint but also an approach for improving performance; this impacts a firm's competitiveness and its supply chain organizations. Although the SSCM concept and framework have been developed, the combination of incomplete information methods and interrelationships exist to distort the decision-making process at the firm and industry levels; this decision-making involves the monitoring and evaluation of business operations' impact on the environment and society (Koplin et al., 2007; Lee, 2011; Lee and Saen, 2012). The firm must address MCDM problems, such as sourcing green materials, green-technology applications and supplier selection, to enhance their competitive advantage. The evaluation approach must consider incomplete information and interrelationships as a whole; however, incomplete information and interrelationships are innately present in an organization.

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