



Strategic analysis of manufacturer-supplier partnerships: An ANP model for collaborative CO₂ reduction management



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ABSTRACT

The objective of this manuscript is to introduce a decision methodology that allows manufacturing firms to evaluate which supplier is the most suitable partner for the implementation of a collaborative CO₂ reduction management approach. The decision problem is developed for the fast-moving consumer goods (FMCGs) industry, which currently ranks among the ten largest CO₂ emitting industries worldwide. In this paper, the evaluation and selection of the most suitable supplier is performed using the analytic network process (ANP), a decision-making technique that allows practitioners to solve complex decision structures. The key contributions of the present paper reside in the combination of literature and case-based derived decision criteria, aimed at enhancing judgment validity, with particular emphasis on a collaborative setting, which is highly relevant in the present context as the focal firms often lack the necessary skills for sustainability and, at the same time, are responsible for sustainability in the supply chain. The practical application of the ANP model at a major FMCG company yields robust results corroborated through a sensitivity analysis.

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1. Introduction

Companies are well aware of the positive effects of CO₂ reduction management on operational performance in terms of cost savings, reputation building, and risk mitigation (e.g., Hart & Gautam, 1996; Klassen & McLaughlin, 1996). To exploit further emissions reduction potentials, to remain competitive, to meet increasing customer expectations, and in response to pressures from government and stakeholder groups, companies are now increasingly shifting the focus of their environmental strategy from the firm to the supply chain level (Benjaafar, Li, & Daskin, 2010; Carbon Trust, 2011; Foerstl, Reuter, Hartmann, & Blome, 2010; Gold, Seuring, & Beske, 2010; González-Benito & González-Benito, 2006; Lozano, 2007; Seuring & Müller, 2008; Sharfman, Shaft, & Annex, 2009; Sundarakani, de Souza, Goh, Wagner, & Manikandan, 2010).

Companies operating in the fast-moving consumer goods (FMCGs) sector are particularly affected by this trend, as this sector belongs to the ten largest emitters of carbon dioxide emissions in the world (Carbon Trust, 2011). Current examples of companies extending their environmental management strategies to include the supply chain are PepsiCO (2011) and Procter (2010); both

recently began encouraging suppliers to measure emissions and improve environmental performance. The overall goal in this context is to collaborate closely with the suppliers. Firms may engage in joint CO₂ management strategies for manifold reasons, including to lower supply chains emissions by providing a less-skilled partner with assistance, to gain access to a partner's critical resources such as CO₂ management expertise, or because working closely together provides an opportunity to improve processes by investing in joint CO₂ reduction measures.

According to studies of partnership formation, the first steps to be taken when building effective supply chain partnerships are identification of the strategic needs, followed by the evaluation and selection of a partner (Kim & Kumar, 2010). Paying attention to critical success factors such as organizational commitment, relationship closeness, information exchange, and conflict resolution techniques is of particular importance, as most partnerships fail because they are not well organized (Kim & Kumar, 2010; Lambert & Cooper, 2000). Therefore, the introduction of a collaborative CO₂ management approach with suppliers requires a comprehensive evaluation model; models exclusively considering environmental supplier characteristics are not adequate for this purpose. To provide firms with a suitable decision framework for partner selection for joint CO₂ reduction management, the existing supplier selection processes (e.g., Hsu, Kuo, Chen, & Hu, 2011) need to be revised and extended by integrating partnership-related criteria that are directly influenced by the supplier's CO₂ management characteristics as well as indirectly affected by the firm's own carbon management

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characteristics. This gives rise to the following two research problems addressed in this study: (i) devise a decision making framework for supplier selection for the purpose of collaborative CO₂ abatement, and (ii) derive selection criteria in a process that enhances judgment validity.

The development of such a comprehensive evaluation model requires a decision methodology that is able to deal with a large number of influencing factors, including various decision components, interactions among the components, trade-offs, and numerous supplier alternatives; all of these factors make supplier selection complex (Choy, Lee, & Lo, 2002; Teng & Jaramillo, 2005; Yang & Chen, 2006). To choose the most suitable decision method for the present evaluation problem, a set of Operations Research methods frequently used for supplier selection problems was examined. Examples include fuzzy sets, mathematical programming models, outranking methods, and multi-attribute utility theory (MAUT) as well as the analytic hierarchy process (AHP) and analytic network process (ANP). For that purpose, prior studies were consulted such as Guitouni and Martel (1998), Belton and Stewart (2002), Sarkis and Sundarraj (2006) and most recently by Chai, Liu, and Ngai (2013) dealing with the choice of appropriate decision methods. Outranking methods, for instance, were considered to be inappropriate because they do not allow trade-offs among criteria; mathematical programming was also disqualified due to its being limited to quantitative data sets (Yang & Chen, 2006). Finally, the ANP was deemed to be the most suitable approach for the present decision problem for a number of reasons. The ANP incorporates dependence and feedback and allows for the integration of qualitative and quantitative data, which are relevant for realistic decision-making. Furthermore, with this method, judgments are elicited using an experimentally tested and validated scale that reduces errors in decision-making. Finally, the ANP technique is consistent with human thought processes, thus improving management understanding (Saaty, 2005).

To address the second research problem, it is worth noting that Saaty and Tran (2007) argue that fuzzifying judgments in AHP (and hence, by extension, in ANP), frequently done to account for uncertainty and ambiguity, while increasing consistency, does not enhance validity of judgments and is therefore to be discouraged. It may be argued that decision criteria derived from an explicit empirical research process, based on primary and secondary data, are indeed a means of enhancing validity of judgments. The approach selected in the present paper is furthermore in response to Singhal and Singhal (2012) who point out that the combination of multiple research methods, here case-based research and theoretical modeling, is a fruitful direction in OM and SCM research.

The theoretical contributions of this paper are twofold. First, to enhance the validity of judgments in ANP, a hierarchical decision model was specifically developed, through case-based research, which enables partner selection for collaborative CO₂ reduction. Hence this model is, contrary to prior research, not entirely based on criteria reported in the literature (for instance, the Green SCM literature), but rather the criteria emerged from the case studies undertaken for theory development and the ensuing hypotheses (Theißen, Spinler, & Huchzermeier, 2013). Second, a novel direction is pursued in the present paper by focusing on a collaborative mechanism for CO₂ reduction, in the sense that both the focal firm and the supplier are going to benefit upon entering the partnership. Only two previous papers aiming in a similar direction could be identified. Wu, Shih, and Chan (2009) provide an ANP model for partner selection in strategic alliances. The criteria derived therein are, contrary to the present research, derived from the literature and encompass a much broader range of characteristics and capabilities. Verdecho, Alfaro-Saiz, Rodriguez-Rodriguez, and Ortiz-Bas (2012) provide an ANP model for managing inter-enterprise collaborative relationships. Again, the factors relevant for collaboration,

such as strategic and cultural factors, are, necessarily, less context-specific and derived exclusively from the literature.

In terms of practical contribution, the application of the model at a major fast-moving consumer goods (FMCG) manufacturing company and direction setting for its supplier selection approach are illustrated. In particular, the relevancy of the criteria, based on the case studies in the FMCG industry, was commended by practitioners and thus applicability and transparency of the model welcomed.

The paper proceeds as follows. Section 2 provides a comprehensive literature review of environmental supplier selection problems, whereupon a brief description of the ANP is presented. The decision network model, with the criteria derived from case-based research, is then derived and subsequently applied to a leading FMCG manufacturer that is facing a CO₂-based supplier selection decision. Finally, the resulting scores of the alternatives are computed, which are shown to be robust by a limited sensitivity analysis. Managerial implications and limitations of this study as well as important future research directions close this paper.

2. Review of the literature

Reviewing the literature on collaborative CO₂ reduction management and environmental supplier selection problems shows that a systematic decision model that incorporates both CO₂-based supplier selection criteria and related partnership metrics is lacking.

2.1. Collaborative CO₂ reduction management

The growing body of literature in this field illustrates that environmental supply chains and collaborative CO₂ management strategies are of increasing interest for practitioners and scholars alike (Chiou, Chan, Lettice, & Chung, 2011; Giurco & Petrie, 2007; Sundarakani et al., 2010; Weinhofer & Hoffmann, 2010). For example, Sundarakani et al. (2010) suggest taking supply chain processes into account to increase visibility and implement CO₂ reduction measures. Scholtens and Kleinsmann (2011) emphasize that understanding the individual firm's CO₂ management characteristics, such as reduction goals, is relevant to initiating CO₂ abatement strategies on the supply chain level. Chiou et al. (2011) suggest that firms should devote substantial efforts to addressing environmental issues by working closely with supply chain partners. According to the Carbon Disclosure Project (2010), suppliers are of particular importance in efforts to curb the amount of emissions because around fifty percent of a product's emissions are caused by the manufacturing processes.

2.2. Environmental supplier selection problems

Among the first studies in the area of environmental-based supplier selection is the study by Noci (1997), who emphasizes the importance of incorporating suppliers to manage environmental issues more efficiently. To assess environmental performance, a vendor rating system was developed to evaluate the supplier's environmental competence, efficiency, and image as well as the net life-cycle cost. Another kind of decision-making support tool focusing on procurement management was developed by Handfield, Walton, Sroufe, and Melnyk (2002). Using the AHP, the authors introduced qualitative and quantitative environmental aspects into the supplier selection process. To develop the model only managers from Fortune 500 companies were chosen; small companies were not integrated in the construction process of the decision model. Likewise, Humphreys, Wong, and Chen (2003) proposed a knowledge-based system to evaluate the environmental

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