Journal of Cleaner Production 112 (2016) 2114–2132

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

An integrated model for green partner selection and supply chain construction

Chong Wu [a, 1], David Barnes [b, *]

[a] School of Management, Xiamen University, Xiamen 361005 PR China
[b] Westminster Business School, University of Westminster, London NW1 5LS, UK

ARTICLE INFO

Article history:
Received 19 February 2014
Received in revised form
23 December 2014
Accepted 7 February 2015
Available online 17 February 2015

Keywords:
Partner selection
Green supply chain
ANP
Multi-objective programming

ABSTRACT

Stricter governmental regulations and rising public awareness of environmental issues are pressurising firms to make their supply chains greener. Partner selection is a critical activity in constructing a green supply chain because the environmental performance of the whole supply chain is significantly affected by all its constituents. The paper presents a model for green partner selection and supply chain construction by combining analytic network process (ANP) and multi-objective programming (MOP) methodologies. The model offers a new way of solving the green partner selection and supply chain construction problem both effectively and efficiently as it enables decision-makers to simultaneously minimize the negative environmental impact of the supply chain whilst maximizing its business performance. The paper also develops an additional decision-making tool in the form of the *environmental difference*, the *business difference* and the *eco-efficiency ratio* which quantify the trade-offs between environmental and business performance. The applicability and practicability of the model is demonstrated in an illustration of its use in the Chinese electrical appliance and equipment manufacturing industry.

1. Introduction

Prompted by the concept of the triple bottom line (Elkington, 1998), the integration of environmental, economic and social performances to achieve sustainable development has become a major business challenge (Srivastava, 2007; Verghese and Lewis, 2007). In response to stricter governmental regulations and rising public awareness of environmental protection, many firms are now undertaking major initiatives to make their supply chains greener (Zhu et al., 2013; Mirhedayatian et al., 2014).

Partner selection in a green supply chain (GSC) is a critical activity because the environmental performance of the whole supply chain is significantly affected by its constituent partners (Kuo et al., 2010). In order to reap the greatest benefits from environmental management, firms must integrate the performance of all the members of a supply chain if it is to be truly green (Van Hoek, 1999). In so doing, they face a trade-off between sustainability and cost when selecting new partners (Reuter et al., 2012).

As environmental awareness increases, firms today seek to purchase products and services from suppliers who can provide them with high quality, low cost, short lead time and high flexibility, whilst at the same time displaying high environmental responsibility (Lee et al., 2009). A green partner is expected not only to achieve environmental compliance but also to undertake green product design and life cycle analysis. Thus, in a GSC, companies need to have rigorous partner selection and performance evaluation processes (Kainuma and Tawara, 2006).

The growing worldwide environmental awareness has seen increasing amounts of research on green partner selection (Sarkis, 2003; Seuring and Muller, 2008; Ng, 2008; Bai and Sarkis, 2010a, 2010b; Yeh and Chuang, 2011; Govindan et al., 2013a; Kannan et al., 2013). However, existing research generally considers environmental aspects in isolation (Lee et al., 2009). For a company to select the most appropriate partners when constructing a GSC, it has to consider both contemporary environmental issues and traditional economic factors. On the one hand, as companies feel greater pressures to have a greener supply chain they will wish to place emphasis on, and devote resources to green partner selection

* Corresponding author. Tel.: +44 (0) 20 7911 5000x66531; fax: +44 (0) 20 7911 5703.
E-mail addresses: Chong.Wu@xmu.edu.cn (C. Wu), D.Barnes@westminster.ac.uk (D. Barnes).
[1] Tel.: +86 (0) 592 2180776; fax: +86 (0) 592 2187289.

http://dx.doi.org/10.1016/j.jclepro.2015.02.023
0959-6526/

and development programmes (Bai and Sarkis, 2010a). On the other hand, companies do not want to see their supply chains becoming greener at the expense of poorer business performance. Therefore, they will not wish these green partner selection and development programmes to adversely affect the business performance of the supply chain in terms of cost, quality, customer service and so on.

Furthermore, stricter regulations and directives, such as WEEE (Waste Electrical and Electronic Equipment), RoHS (Restriction of Hazardous Substances), ErP (Energy related Products) and REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals), require companies and their products to become more eco-friendly, especially in the electronics industries (Hsu and Hu, 2008; Kuo and Chu, 2013). On the one hand, there is increased pressure on such companies to adopt more green practices within their supply chains, including souring, manufacturing and logistics (Chien and Shih, 2007). This includes pressure to ensure that only green partners are selected when constructing their supply chains. On the other hand, there are advantages for companies that are capable of meeting global green production standards, as they will be able to participate in global green supply chains. For example, there are significant opportunities for some high-technology electronic companies in mainland China who wish to sell their products overseas within global supply chains (Zhu and Sarkis, 2006).

In this paper, we propose a comprehensive model for green partner selection and supply chain construction, which combines analytic network process (ANP) and multi-objective programming (MOP) methodologies. The term *partner selection* refers to the process of deciding which firms are to be the constituent members of a supply chain, whereas the term *supply chain construction* refers to the process of organizing the activities of the constituent members of the whole supply chain in order to match supply and demand in any given situation. Its aim is to minimize the environmental negative influence of the supply chain while simultaneously maximizing its business performance.

The rest of the paper is organized as follows. Section 2 reviews the extant research on green supply chain management, green partner selection models and criteria for green partner evaluation and selection. Section 3 introduces the proposed model for green partner selection. Section 4 presents an illustrative application of the model with a sensitivity analysis. In Section 5 some of the issues and implications raised by the use of the proposed model are discussed in more detail. Section 6 closes the paper with some concluding remarks assessing its contribution and limitations, and suggesting future research.

2. Literature review

2.1. Green supply chain management

Research into green supply chain management (GSCM) remains in its infancy, and until recently there has been relatively little published in the leading academic journals (Srivastava, 2007). However, interest in the topic has been growing apace resulting in increased research output (Schoenherr et al., 2012; Govindan et al., 2013b).

2.1.1. Motivations and drivers of GSCM

Testa and Iraldo (2010) summarized three different strategic approaches which are able to favour the adoption of GSCM practices. By using data from over 4000 manufacturing facilities in seven countries, they found that the “reputation-led” and “innovation-led” approaches seem to be the most effective ones for the adoption of GSCM practices, whereas an “efficiency-led” approach is not. One of limitations is that the study only focused on supplier assessment and supplier requirement practices. By using fuzzy DEMATEL methodology, Lin (2013) identified that regulation is the most important cause criterion which influences GSCM. As the cause group criteria have influences on the effect group criteria, managers in GSC need to pay more attention to these cause group criteria. Yet, one of the main limitations of the research is the shortage of respondents when compared with Testa and Iraldo (2010)'s study.

Diabat and Govindan (2011) firstly developed an Interpretive Structural Modelling (ISM) model of drivers of the implementation of GSCM in Indian aluminium industries. The interaction relationships among the 11 types of drivers had been analysed by using the ISM model and MICMAC analysis. Thereafter, Diabat et al. (2014) summarized and analysed the 13 enablers for implementing sustainable supply chain management in Indian textile industries further. By applying similar ISM approach, they found that the adoption of green purchasing enabler occupies the top level. These research findings will be very helpful for easy implementation of effective GSCM if the leading enabler can be identified scientifically in practice.

Based on empirical data from high-tech industry in Taiwan, Lo (2014) analysed the effect of a firm's position in the GSCs on its attitude towards green. The empirical analysis results showed that the further downstream a firm is in the supply chain, the more proactive its attitude towards going green. The further upstream in the supply chain, the more reactive and conservative is its attitude towards going green. These findings indicate that upstream green partner selection will be more important and sensitive compared with downstream partner selection. Furthermore, Mirhedayatian et al. (2014) proposed a novel network data envelopment analysis (DEA) model to evaluate GSC management in the presence of undesirable outputs and fuzzy data. Their findings emphasise that economic and environmental performance in a supply chain are inextricably linked. GSCM should not and cannot improve the environmental performance at the expense of its economic performance.

2.1.2. Performance measures and implementation barriers of GSCM

Based on five case studies from Portuguese automotive industries, Azevedo et al. (2011) found that the most extensively used performance measures are “customer satisfaction”, “quality” and “cost”. Yet, the enablers and drivers regarding the reasons managers of supply chain do or do not implement GSCM practices were not explored at the beginning of the research. Moreover, applying the empirical results from 249 enterprise respondents in Korea, Kim and Rhee (2012) pointed out that “planning and implementation”, “collaboration with partners” and “integration of infrastructure” were dominant antecedent factor in the causal relation between GSCM critical success factors and the balanced scorecard performance. Effective partner selection and collaboration play an important role and result in high GSCM performance.

Dey and Cheffi (2013) proposed a new GSC performance measurement framework by combining supply chain processes with organisational decision levels. Based on the three case studies in manufacturing industries in UK, their research pointed out that internal operations and suppliers activities are the most important factors in environmental performance. In addition, using an intra-organisational collaborative decision-making approach, Bhattacharya et al. (2014) proposed a new GSC performance measurement framework. Based on the empirical investigation into the UK-based carpet manufacturing industries, their research pointed out that internal operations play a key role in assessing the environmental performance of GSCs. More importantly, internal operations were dependent on supplier's activities. Therefore, effective supplier selection is a prerequisite for high environmental performance in GSCs.