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Applications

A comprehensive environment friendly approach for supplier selection

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A B S T R A C T

As the green movement spreads across the globe, organizations are under pressure to reduce the emissions across their supply chain. On the other hand, they need to cut supply costs to gain a competitive edge. This paper proposes Green DEA (GDEA), a comprehensive approach based on Data Envelopment Analysis (DEA) with carbon footprint monitoring. GDEA builds on an existing DEA model with weight restrictions and dual role factors, and introduces carbon footprints as necessary dual role factors with weight restrictions. Unlike other researches, GDEA incorporates heterogeneous suppliers and also takes into account regional emission compliance standards and laws. GDEA encourages suppliers to go green and cut down their carbon footprints and comply with emission norms along with reducing costs in order to survive competition. Results from model validation in a well-known automobile spare parts manufacturer in India are presented to verify the GDEA approach. Overall, GDEA cuts across a huge and varied supplier base, caters to almost all businesses, is environment-friendly and robust.

1. Introduction

Supplier selection is the process by which suppliers are reviewed, evaluated, and chosen to become a part of the organization's supply chain [66]. This area has been highly researched and is of extreme importance, especially in organizations where purchasing has a significant impact on the revenues. For such organizations a comprehensive approach for decision making is highly desirable in order to have the global edge in wake of growing competition.

As the climate change movement gathers momentum, the need of the hour is a comprehensive supplier selection strategy which models supply costs as well as emissions. Traditional supplier selection models focus on supplier's economic efficiency while ignoring the ecological efficiency of the supplier. Such models force suppliers to cut costs in order to survive competition. As more and more environmental norms and compliance standards are enforced into practice, organizations which are simply looking at cutting supply chain costs are most likely to get stranded as there is no guarantee that the suppliers would conform to these norms. On the other hand, organizations should aim towards spreading carbon awareness amongst the suppliers, along with offering incentives to them to become environment-friendly. Carbon footprints provide a precise, accurate and robust measure

that can fit in as an environmental impact criterion for supplier selection. Thus, the decision making approach in suppliers' selection must take into account the environmental impact of the suppliers vis-à-vis their carbon footprints.

Organizations are now demanding that their suppliers reduce their carbon footprints while doing so themselves. The non-profit Carbon Disclosure Project (CDP) in association with consultant firm T. Kearney has cited in a report that some organizations have even gone to the extent of dismissing suppliers who have no carbon management plans of their own. A strong interest in carbon footprinting and management has been indicated by the responses therein. 63% Of these companies have "a formal, documented corporate climate change strategy", as per the report. The remaining 37% have "general guidelines", and 90% of all companies surveyed have plans in place to reduce carbon emissions. Also seen in the report is the desire in these organizations for their partners to turn "green". A total of 89% of all respondents, according to the survey, have an "established strategy" to work on carbon related topics with suppliers [56].

Since there is no surety that suppliers will conform to environmental norms and compliance standards, even as more and more of these are enforced into practice, the organizations most likely to get stranded are the ones looking simply at cutting supply chain costs. Rather, efforts should be made towards spreading carbon awareness among suppliers by organizations, and may be even offer incentives to them on being eco-friendly. This requires, however, a collaborative approach on the part of both the buyer and the supplier. The buyer too, should be prepared to take

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extreme measures and threaten to de-select the supplier, in case the supplier does not pay heed. On the other hand, the approach for decision making in supplier selection should appreciate the element of risk involved here.

This paper aims to propose Green DEA (GDEA), a common integrated approach for supplier selection considering both the objectives, cost cutting, and environmental efficiency, in a flexible manner. The proposed model has a new capability to enforce emission compliance norms and can be tailored to region specific emission constraints. This is primarily a compliance issue which none of the current supplier selection approaches address.

The GDEA approach is applied to a well-known automobile spare parts manufacturer in India. The results demonstrate that the GDEA model considers the environmental factors in a two-pronged approach. Firstly, it lets the carbon footprints determine the efficiency of the supplier and secondly, the model penalizes a supplier for not meeting emission standards. The approach provides the user with the flexibility to adjust the impact of environmental factors in the overall supplier selection process.

The rest of the paper is organized as follows: Section 2 discusses the literature reviewed in brief. Section 3 gives a brief introduction to carbon footprinting and highlights the steps involved in estimation of carbon footprints. Section 4 presents the proposed GDEA model with the mathematical formulation. Section 5 demonstrates a numerical example and the results with the GDEA approach. Section 6 presents research findings, implications and managerial insights from the approach. Finally, the concluding observations and remarks are given in Section 7.

2. Literature review

This section is structured as follows. Section 2.1 presents the literature on various supplier selection approaches. Section 2.2 presents literature on DEA and DEA for supplier selection. Section 2.3 presents literature on Green Supply Chain Management and green supplier selection approaches. Section 2.4 presents the literature on carbon footprinting. Finally Section 2.5 presents current gaps in literature and motivation for this research.

2.1. Literature on supplier selection approaches

Various mathematical approaches such as linear programming [25,69], fuzzy programming [41], and genetic algorithms [78] have been used to solve the supplier selection problem. A majority of these approaches are based on the fact that supplier selection is a multiple criteria problem, and the aim is to assign weights to all the criteria in order to get an overall supplier rating.

Traditional approaches to supplier selection made use of Analytical Hierarchy Process (AHP) in combination with a mathematical programming approach. Pi and Low [59], Haq and Kannan [31], and Kahraman et al. [41] propose AHP models to solve the supplier selection problem. Chan [10] proposed an AHP based model for supplier selection. Chan and Chan [12] offered an AHP based supplier selection model with a case study in advanced technology industry. Chan et al. [14] proposed an AHP based decision support system for supplier selection in airlines industry. Chan and Chan [13] have applied an AHP based supplier selection model in the apparel industry.

Chan and Kumar [15] used Fuzzy Extended AHP (FEAHP) for a global supplier selection problem. Chan et al. [16] have also used a similar fuzzy AHP approach for global supplier selection with an example from manufacturing industry.

A variety of linear and integer programming approaches have been proposed in literature. Ghodsypour and O'Brien [24] proposed an integration of AHP and linear programming to consider both tangible and intangible factors in choosing the best suppliers and giving them optimal order quantities so that the total purchasing value is maximized. Ghodsypour and O'Brien [25] presented a mixed integer non-linear programming approach to solve the multiple sourcing problem. The approach takes into account the total cost of logistics, including net price, storage, transportation and ordering costs.

Verma and Pullman [82] analyze the differences between managerial perceptions and actual choices in a supplier selection process. An interesting outcome of this study is that though managers perceive quality as the most important attribute in selection, the actual choice is based more on cost and delivery performance.

Humphreys et al. [36] presented the findings from large companies in Hong Kong in terms of supplier criteria requirement and serves as a reference guideline for collaborative relationships from the context of a supplier coming from a diverse background.

Jain et al. [39] proposed a supplier evaluation model using evolutionary fuzzy based approach. This approach is primarily dependent on linguistic nature of attributes associated with the suppliers.

Bayazit [2] proposed an ANP approach to supplier selection. Shyur and Shih [72] proposed a hybrid model for supplier selection in new task situations, which uses the Multi-Criteria Decision Making (MCDM) in combination with Analytic Network Process (ANP). These ANP models go one step ahead of the traditional AHP approaches which tend to assume that the selection criteria are independent of each other.

Kumar et al. [47] presented a Fuzzy Goal Programming approach for Vendor Selection Problem (VSP). In this approach, VSP is formulated as a Fuzzy Multi-Objective Integer Programming problem with three important goals of cost minimization, quality maximization and maximization of on-time delivery.

Ting and Cho [81] proposed an integrated approach using Linear Programming (LP) which integrates AHP with linear programming. The approach considers both tangible and intangible factors in choosing best suppliers and giving them optimal order quantities. The objective is to maximize total purchasing value.

Chan et al. [11] presented a simulation study on Suppliers' Flexibility Levels (SFL). This helped a decision maker to identify the information system automation level and variations in physical characteristics of the alternative suppliers with respect to SFL.

Jain et al. [40] discussed supplier-related issues in modeling a dynamic supply chain. It provided a review of main approaches to these issues. The study provides a groundwork for diverse modeling approaches to be applied to the supplier selection problem.

Deng and Chan [23] presented the new fuzzy dempster MCDM method for supplier selection. The approach combined the Fuzzy Set Theory (FST) and Dempster Shafer Theory of evidence (DST).

Mansini et al. [55] developed an Integer Programming based solution for supplier selection problem with quantity discounts and truckload shipping. Experimental results provide valuable insights into the impact of discounts and shipping on effective sourcing strategies.

A major issue with all these approaches is that they assign arbitrary weights which are subjective and based on surveys and questionnaires. This leads to inaccurate results as it is very difficult to accurately assign numbers to preferences. Also, these models do not scale well as the number of performance criteria are increased.

Danese [21] analyzes the impact of supplier integration on buyer's performance based on measures related to creating a fast supply network structure. The findings provide useful guidelines for managers looking forward to supplier integration and also finds relevance with managers looking at a comprehensive supplier selection approach.