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Supplier evaluation and demand allocation among suppliers in a supply chain

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ABSTRACT

This paper presents a hybrid algorithm that prioritizes the suppliers and then allocates the demand among the suppliers. The objective here is to maximize the total purchase value of the items taking into consideration budget constraint, demand condition, delivery lead-time and supplier capacity. Since the problem is multi-criteria decision making, we solve this problem by integrating the supplier rating with mixed linear integer programming method. The customer demand is allocated by using a hybrid algorithm based on the technique for order preference by similarity to ideal solution (TOPSIS) and the mixed linear integer programming (MILP) approaches. The effectiveness of the proposed algorithm is validated with computational results. Drawing to a case, a supplier S_3 is identified as the best supplier by using the TOPSIS method for demand allocation under no restrictions. On the contrary, under constrained scenario, supplier S_2 is selected as the best supplier by using the hybrid algorithm for demand allocation and maximum units are allocated to S_2.

1. Introduction

Supply chain management, the process of planning, executing and controlling the operations of supply chain network, includes procurement of material, conversion of raw material into finished goods and distribution of finished goods to customers in such a way that it fulfils the demand of customer as efficiently as possible. A typical manufacturer spends approximately 60% of total income from sales on procurement of material such as raw material, intermediate parts, and components (Krajewski et al., 2007). Furthermore, procurement of goods and services constitutes up to 70% of product cost (Ghodsypour and O'Brien, 1998). These stylized facts indicate that procurement of raw materials and components is one of the most important constituents of a supply chain, which facilitates any organization for achieving its goal of increasing the value creation by minimizing the cost. In procurement management, supplier selection is one of the important decision-making areas that enhance the purchase value in term of cost, quality and on-time delivery of the items purchased. Furthermore, companies are also facing tough competition from their rivals. To overcome this competitive pressure, companies are paying more attention to core competencies. They have increased their level of outsourcing, and are relying predominantly on their supply chains as the source of competitive advantage.

Purchasing is an important function of supply chain management. The literature in this context significantly focused on choosing the right suppliers and allocating the appropriate demand of items to these suppliers. In an increasingly competitive environment, firms are paying more attention to selecting the right suppliers for procurement of raw materials and component parts for their products. Choi and Hartley (1996) reported that supplier evaluation and selection together has an important role in the supply chain process and is crucial to the success of a manufacturing firm. The present research work focuses on this issue of supply chain management. The main objective of the study is to address the problem of optimal allocation of demand of items among candidate suppliers in order to maximize the purchase value of items. The purchase value of the items directly relate to cost and quality of raw materials purchased from the supplier. Supplier selection problem is a multi-criteria decision making problem involving both qualitative and quantitative performance measures. Usually, several conflicting criteria make the supplier selection problem a complex problem. It is often desirable to make a compromise among the conflicting criteria.

In this study, a new hybrid algorithm has been developed to solve the problem of multi-criteria customer demand allocation among more suppliers under budget, demand, delivery lead-time and supplier capacity constraints. The remainder of the paper

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comprises seven sections. Section 2 provides the review of literature on supplier selection. Section 3 identifies the research issues, which form the basis for problem formulation in the present research work and further presents the objective of the study. Section 4 discusses the technique for order preference by similarity to ideal solution (TOPSIS) used in the study and proposes the hybrid algorithm to solve the multi-criteria demand allocation problem. Section 5 presents the conceptual model of demand allocation among suppliers. Section 6 reports the case study and the findings of the computational experiments. Section 7 concludes the study along with future research directions.

2. Review of the literature

Supplier selection is one of the growing research areas. Studies show that supplier selection is a complex process involving several criteria such as procurement cost, material quality, delivery lead-time, and reliability of the supplier etc. These criteria can be defined variously as buyers take into account numerous conflicting factors. Illustratively, low price can offset poor quality or delivery lead-time. Dickson (1966) identified 23 criteria in his study of various supplier selection problems. He reported that quality, delivery and performance history are the three most important criteria. Similarly, Weber et al. (1991) in a review of 74 articles obtained similar results pertaining to the multi-criteria nature of supplier selection problem. From a generalized perspective, alternative approaches suggested in the literature may be grouped into three categories: linear weighting models, mathematical programming approaches and probabilistic approaches. However, their study identified very few articles based on the mathematical programming approach for supplier selection. Bhutta (2003) provided a review of 154 supplier selection research articles and alternative methods/techniques adopted. Although, most buyers still consider cost to be their primary concern, new more interactive and interdependent selection criteria are increasingly being used. Table 1 provides a summary of various criteria used by researchers.

The literature shows a variety of methodologies and approaches used for the supplier selection problem. The brief description of alternative approaches in terms of general application, features and limitations is as follows.

Table 1
Criteria used in literature for supplier selection.

Sr. no.	Criteria	Sr. no.	Criteria
1	*Green Competencies*	21	*Relationship*
2	*Product Quality*	22	*Technological capability*
3	*Price (Cost)*	23	*Financial Performance*
4	*Purchasing Cost*	24	*Quality of service*
5	*Age and position in the market*	25	*Competitive Priority*
6	*Top Management Support*	26	*Strategic Purchasing*
7	*Environmental Engagement*	27	*Demand*
8	*On time delivery*	28	*Management and organization*
9	*Delivery Capability*	29	*Attitude*
10	*Customer focus*	30	*Labor Relation*
11	*Consistency*	31	*Training Aids*
12	*After sale Service*	32	*Communication System*
13	*Warranty and Claim*	33	*Production Capability*
14	*Research and Development*	34	*Packaging capability*
15	*Information Technology*	35	*Operational Control*
16	*Service Innovation*	36	*Amount of past business*
17	*Location*	37	*Reciprocal arrangements*
18	*Political and Economical stability*	38	*Impression*
19	*Flexibility*	39	*Business attempt*
20	*Reliability*	40	*Maintainability*

2.1. Linear weighting models

In the linear weighting models, weights are given to the criteria and simultaneously scores are assigned to each alternative against each criterion. Scores of alternative criterions are multiplied by their weights and then, summed up to obtain a cumulative score for each supplier. The decision maker selects the supplier based on overall highest score. This basic linear weighting model is available in most purchasing textbooks. The linear weighting models, however, share some important limitations. From the perspective of mathematical scaling, it is unavoidable to treat evaluation on a scale defined over real numbers that multiply with each other and summed up. Illustratively, if 3 means a high score and 2 means a medium score, we know that 3 is better than 2, but we do not know by how much. Furthermore, we cannot assume that the difference between 3 and 2 is the same as the difference between 2 and 1.

2.2. Total cost approach

According to the total cost approach, companies use item cost for comparing the suppliers. Unit Total Cost is the total cost to purchaser for single unit of item after inclusion of all relevant factors. However, this approach neglects non-monetary issues such as delivery and quality performance, lead time, services, and social policies (Monckza and Trecha, 1988).

2.3. Multiple attribute utility theory

Multiple attribute utility theory is typically suitable when a variety of uncontrollable and unpredictable factors affect the decision-making. The approach is capable of handling multiple conflicting attributes inherent in international supplier selection. It also enables the purchasing managers to evaluate 'what if' scenarios associated with changes in company policy (Bard, 1992; Von and Weber, 1993).

2.4. Total cost of ownership (TCO)

Total cost of ownership methodology looks beyond the price of the product and includes many other purchase-related costs relating to order placement, research, transportation, receiving, inspection, inventory etc. (Ellram, 1995). Handfield et al. (1999) explored the understanding of TCO using the product life-cycle approach. They noted that the cost of a product directly relates to the stage of the product in its life cycle. Though there are other selection and evaluation approaches closely aligned with TCO such as the life cycle costing (Ellram, 1993), Zero base pricing (Monckza and Trecha, 1988) and cost-based supplier performance evaluation (Handfield et al., 1999), none of these approaches has received significant support in the literature or in practice for a variety of reasons (Soukup, 1987).

2.5. Optimization techniques

The popular techniques are dynamic programming (Masella and Rangone, 2000), linear programming (Ghodsypour and O'Brien, 1998), and multi-objective programming (Weber and Ellram, 1993). Zhang and Zhang (2011) used the MILP approach to solve the supplier selection problem under stochastic demand. They selected the suppliers and allocated the ordering quantity properly among the selected suppliers to minimize the total cost including selection, purchasing, holding and shortage costs. Sawik (2011) also applied the MILP approach to study the problem of order allocation of parts among the suppliers in a customer driven supply chain. The study suggested that future research could

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