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Integration of supplier selection, procurement lot sizing and carrier selection under dynamic demand conditions

Zhiying Liao[a,*], Jens Rittscher[b]

[a]Chair of Factory Organization, University of Dortmund, 44221, Dortmund, Germany
[b]Soptim AG, Heinrich-Held-Str. 33, 45133 Essen, Germany

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Abstract

This paper develops a multi-objective programming model, integrating supplier selection, procurement lot sizing and carrier selection decisions for a single purchasing item over multiple planning periods while demand quantities are known but inconstant, i.e. dynamic demand conditions. A genetic algorithm with problem specific operators is developed and a numerical example is presented.

Keywords: Supplier selection; Procurement lot sizing; Carrier selection; Multi-objective programming; Genetic algorithm

1. Introduction

In the last several decades, the supplier (or vendor) selection problem has gained great attention in business literature and practices. The supplier selection problem is defined as two joint decisions—which supplier(s) should be selected and how much should be ordered from the selected supplier(s) (Weber and Current, 1993). It is a typical multi-criteria decision problem, as reviewed by Dickson (1966), Weber et al. (1991), Wilson (1994), and Swift (1995). Price, quality and delivery are the most frequently and widely studied criteria in the supplier selection process (Weber et al., 1991; Weber and Current, 1993; Weber et al., 1998; Narasimhan et al., 2001).

In the context of supply chain management, the supplier selection decision is necessary to be integrated in the supply chain. However, most of the existing literature of the decision methods for the supplier choice does not consider other decisions beyond the source department (de Boer et al., 2001). Only a few models incorporate the supplier selection to the procurement lot sizing under deterministic demand conditions, i.e. the demand quantity is known and fixed. Degraeve and Roodhooft (1999) established a mathematical programming model using the total cost of ownership (TCO) to simultaneously select suppliers and to determine the order quantities over a multi-period time horizon. Degraeve and Roodhooft (2000) further developed a multi-period, multi-item, multi-vendor mixed integer programming model based on the TCO, to determine an optimal ordering and inventory police and jointly to decide the best combination of suppliers. Their model covers the

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*Corresponding author.
E-mail address: liaozhiying@hotmail.com (Z. Liao).

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total cost incurred, including the purchasing cost, the ordering cost, the transportation costs and so forth. The above models greatly improve the objectivity of the supplier selection decision; however an extensive management accounting system is required, such as the TCO or the activity based costing (ABC). As investigated by Ellram (1995), most firms using the TCO approach in her study seldom implemented the ABC or had plans for it. Ghodsypour and O'Brien (2001) built single-objective and multi-objective mathematical programming models minimizing the total cost of logistics in the process of the supplier selection, including the aggregate price, the ordering cost and the inventory costs, subject to capacity, budget, quality and delivery requirements. Their models assume deterministic demand conditions and therefore apply the economic ordering quantity (EOQ) model to determine the procurement lot sizing decision.

Most of the literature in the area of the supplier selection neglects the inbound transportation for simplicity. However, Gentry and Farris (1992) reported an increasing effort to integrate and strategically coordinate the inbound transportation and the purchasing functions. It is estimated that more than 50% of the total logistic cost of a product can be attributed to transportation, therefore any consideration of the purchasing quantities should consider the transportation cost (Swenseth and Godfrey, 2002). The integration of the inbound transportation and the procurement lot sizing has been found in the following papers (Swenseth and Godfrey, 2002; Carter and Ferrin, 1996; Russell and Krajewski, 1991). It is noted that the variability of the transit time could lead to different procurement ordering points, and/or the transportation cost might affect the purchasing quantities (Constable and Whybark, 1978). Also, the supplier selection decision could influent the supplier choice and the order splitting ratio, and/or the carrier selection decision. Such interactions suggest that these three decisions could be jointly decided. However, a few studies have been found to integrate the supplier selection, the procurement lot sizing and the carrier selection especially under dynamic demand conditions, i.e. the demand rate is known but not fixed. This paper is motivated to develop a multi-objective programming model for the integration of the three decisions—when and how much to order under dynamic demand conditions (i.e. dynamic procurement lot sizing or replenishment); in each replenishment cycle, which supplier(s) should be selected and how much should be ordered from the selected supplier(s) (i.e. supplier selection decision); and which transportation carrier should be chosen for each selected supplier in each replenishment cycle (i.e. carrier selection decision). The multiple objectives include the total cost of logistics, the total quality rejected items and the total late deliveries.

The rest of the paper is organized as follows. Preliminaries for the model development are introduced in Section 2. A multi-objective mathematical programming model is developed in Section 3. A genetic algorithm (GA) application is explained in Section 4. A numerical example and computational results are reported in Section 5. Conclusions are drawn in Section 6.

2. Preliminaries

The lot sizing literature normally assumes that the transportation costs are managed by the suppliers. However, it is reported that an organization can benefit in many ways by purchasing on an FOB (Free on board) origin basis, such as: (1) control and selection of carriers; (2) negotiation of special commodity or discount rates with carriers; (3) ability select private carriage whenever the vendor's pickup can be offset with a loaded outbound movement; and (4) isolation and identification of freight as a cost separate from the piece-price for the parts or materials (Gentry and Farris, 1992). Therefore, the inbound transportation cost could be managed by the buying company and included as an explicit parameter in the integration. The inbound transportation consideration (carrier selection) factors in this paper involves the transit time and the transit cost. The transit time factor is important because it determines the lead time affecting the intransit holding cost, the inventory holding cost on the safety stock and the expected inventory stock-out costs (Buffa, 1987). The transit cost factor is also important because it determines the shipping cost and the inventory holding cost. In this paper, the safety stock cost is neglected since there is no uncertainty of the demand conditions, and the stock-out and over-stock cases are not accepted. Hence, the transit time influences only the intransit holding cost, and the transit cost affects the shipping cost and the inventory holding cost.