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An optimization approach for supply chain management models with quantity discount policy

Jung-Fa Tsai *

Department of Business Management, National Taipei University of Technology, No. 1, Sec. 3, Chung Hsiao E. Road, Taipei 10608, Taiwan

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Abstract

Owing to the difficulty of treating nonlinear functions, many supply chain management (SCM) models assume that the average prices of materials, production, transportation, and inventory are constant. This assumption, however, is not practical. Vendors usually offer quantity discounts to encourage the buyers to order more, and the producer intends to discount the unit production cost if the amount of production is large. This study solves a nonlinear SCM model capable of treating various quantity discount functions simultaneously, including linear, single breakpoint, step, and multiple breakpoint functions. By utilizing the presented linearization techniques, such a nonlinear model is approximated to a linear mixed 0–1 program solvable to obtain a global optimum.

Keywords: Logistics; Optimization; Supply chain management; Quantity discount model

1. Introduction

Supply chain management (SCM) is a control of material flow among vendors, facilities, warehouses and customers such that the total cost in the supply chain can be minimized [27]. Considerable efforts have been expended in developing SCM decision models in the last decade. Specifically, the topic on the determination of optimal supplier-oriented quantity discount policies for a given type of quantity and with a constant demand has attracted much attention. For instance, Monahan [19] analyzed an all-unit quantity discount policy that maximized the vendor's gain without adding cost to the buyer. Lal and Staelin [11] presented a fixed order quantity decision model which assumed special forms of discount pricing structure with multiple buyers and constant demands. Lee and Rosenblatt [12] generalized Monahan's model to increase supplier's profit by incorporating constraints imposed on the discount rate and relaxing the assumption of a lot-for-lot supplier policy. Weng and Wong [29] developed a general all-unit quantity discount model for a single buyer or multiple buyers to determine the optimal pricing and replenishment policy. Weng [28] later presented models for

* Tel.: +886 2 27712171x3420; fax: +886 2 27763964.
E-mail address: jftsai@ntut.edu.tw

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determining optimal all-unit and incremental quantity discount policies and investigated the effect of quantity discounts on increasing demand and ensuring Pareto-efficient transactions under general price-sensitive demand functions. Hoffmann [8] also analyzed the impact of all-unit quantity discount on channel coordination in a system consisting of one supplier and a group of heterogeneous buyers. Chang and Chang [3] presented a mixed integer optimization approach for the inventory problem with variable lead time, crashing cost, and price-quantity discount. Yang [31] recently proposed an optimal pricing and ordering policy for a deteriorating item with price sensitive demand. Related papers on this topic are far too many to be listed here. However, some reviews are available in the literature such as Min and Zhou [18] and Narasimhan and Mahapatra [21].

Currently, many optimization models of SCM [20,22,32] assume that the average prices of related expenditures are constant, which implies that the average prices are fixed at a specific value independent of the scale of quantity. This is far beyond the real situation. In fact, vendors usually offer quantity discounts to encourage the buyers to order more, and the producer would like to discount the unit production cost if the amount of production is large. For dealing with the difficulty, this study proposes an SCM model capable of treating various quantity discount functions. By utilizing the linearization techniques, the nonlinear SCM model can be approximated to a linear mixed 0–1 program solvable to obtain a global optimum.

The rest of this paper is organized as follows: The next section formulates an SCM model in solving the four types of quantity discount functions. Then the linear strategies for solving the SCM model to obtain a global optimum are proposed. A numerical example is illustrated in Section 4 and concluding remarks are made in the last section.

2. A supply chain management model

There are three traditional stages in the supply chain, including procurement, production and distribution. Each of these stages may be composed of several facilities located in different countries around the world. The general structure of a supply chain network has been outlined in Fig. 1. For simplifying presentation, only the facilities covered in the dashed rectangle, including manufacturers, warehouses, and distribution centers, are considered in this paper. Basically, there are four kinds of costs involved in this model:

(i) product procurement cost from manufacturers;
(ii) transportation cost from manufacturers to warehouses;
(iii) inventory cost in warehouses;
(iv) transportation cost from warehouses to distribution centers.

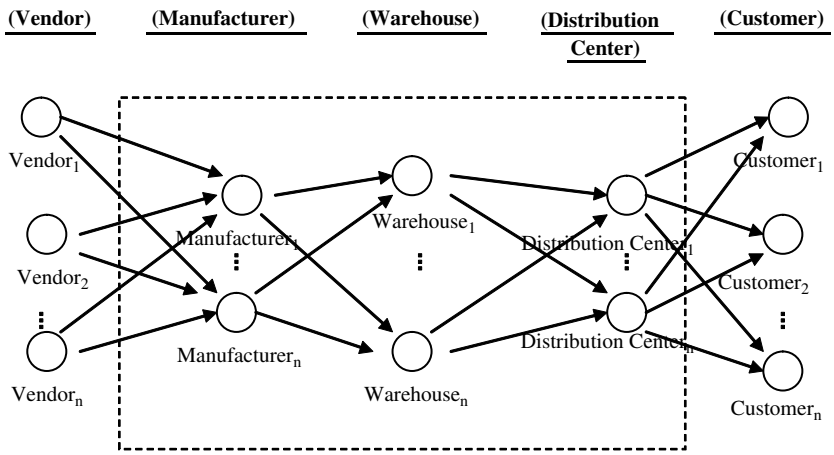

Fig. 1. Schema of an SCM model.