ELSEVIER

Int. J. Production Economics 72 (2001) 203–225

international journal of
production
economics

www.elsevier.com/locate/dsw

A study of quantity discount pricing models with different ordering structures: Order coordination, order consolidation, and multi-tier ordering hierarchy

Haresh Gurnani*

Department of Information and Systems Management, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

Accepted for publication 26 August 1999

Abstract

In this paper, we study quantity discount pricing models with different ordering structures in a system consisting of a single supplier and heterogeneous buyers. We start with the case where the ordering schedule of the buyers is not coordinated and determine the optimal parameters that minimize the joint (system) costs. Later, we consider the case where the discount policy is structured such that the buyers are encouraged to coordinate the timing of their orders. For the case of identical buyers, we show that order coordination always leads to a reduction in the system costs. However, with heterogeneous buyers, we derive the sufficiency conditions that determine when "order coordination" would be preferable. A numerical example illustrating the benefit of "order coordination" is also presented. Then, we consider the case when the buyers place a combined (single) order with the supplier (referred to as "order consolidation"). It is shown that if the supplier offers the same discounted price (the price offered when the buyers coordinate their orders), the buyers would prefer "order consolidation" over "order coordination". However, for the supplier, conditions derived indicate that the supplier would prefer that the buyers coordinate their orders. Finally, we consider the case of a multi-tier ordering hierarchy where only one of the buyers (for example, a major wholesaler) places an order from the supplier. The remaining buyers, in turn, place orders only from the major buyer. Optimal ordering decisions are again determined and comparisons made with the case of "order consolidation".

Keywords: Quantity discount; Pricing; Coordination; Negotiations

1. Introduction and problem description

The industrial supplier–buyer relations have undergone radical changes in recent years with increasing emphasis on co-operation and information sharing. In an attempt to reduce transactions-related costs and to seek a larger market share, many suppliers offer volume (quantity) discounts if the buying firms source certain parts solely from them. The benefits to the firms include lower purchasing and transactions-related

* Tel.: 852-2358-7724; fax: 2358-1946.
E-mail address: mnharesh@ust.hk (H. Gurnani).

0925-5273/01/$ - see front matter
PII: S0925-5273(00)00159-6

costs and the opportunity to develop a closer relationship with the supplier. Quoting from a recent report in the Asian Wall Street Journal (see Reitman [1]),

> Toyota used to contract at least two suppliers for each part prior to heavy cost-cutting initiated in the past few years … But some suppliers began offering volume discounts if Toyota sourced certain products solely from them.

The flip side to such cost-cutting efforts is the risk associated with sole sourcing. Recently, Toyota was forced to shut down virtually all assembly operations in Japan due to a fire at one supplier affiliate, Aisin Seiki Co. [1]. It is therefore essential for the buyers to quantify the benefits due to quantity discounts and to weigh them against the risk of single sourcing. In this paper we consider quantity discount pricing models with different ordering structures in a system consisting of a supplier and multiple heterogeneous buyers. The framework presented can be used by the buyers (and the supplier) to determine the savings in the total costs (due to quantity discount) under various ordering situations.

In the absence of any quantity discount, the buyers would select the economic order quantity (EOQ) value as the optimal order size. Since we consider the case of heterogeneous buyers with different demand and cost parameters, the EOQ values would be different which results in unequal ordering frequencies, that is, the order information is received by the supplier at different times. As a result, production (or replenishment) policy of the supplier becomes complicated and the supplier may have to incur higher inventory holding costs in order to effect timely delivery of the orders. In the first part of the paper, we consider the case of uncoordinated ordering by the buyers and determine the optimal parameters of the quantity discount pricing policy that minimize the joint (system) costs. The savings in the joint costs can then be divided between the buyers and the supplier through negotiation. We observe that the structure of the optimal pricing policy is similar to the case of homogeneous buyers [2]. However, now there are restrictions on the negotiation parameters which reflect the incentive-compatibility constraints on the buyers.

Next, we consider the case where the supplier structures the quantity discount such that the buyers are encouraged to coordinate the timing of their orders (note that only the order timing is coordinated and that the order sizes could still be different). This approach, which is commonly used by large companies like Procter and Gamble (P&G), can be easily implemented by setting a time window within which the orders are to be accepted. The benefits, due to order coordination, to the supplier can be substantial. Production planning for the supplier is simplified since all the order information is available at the same time and not at different instants as in the previous case. As a result, part of the savings in these costs can be passed on by the supplier to the buyers in form of a price discount. Also, the order processing costs would be lower and the supplier can achieve better efficiency in distribution planning as well.[1] For the case of identical buyers, we show that order coordination always leads to a reduction in the total system costs. However, for the general case of heterogeneous buyers, forcing order coordination on the buyers could result in an increase in the system costs. Intuitively, if the optimal ordering frequencies for the buyers before any quantity discount are very different, the savings to the supplier (due to order coordination) may not be sufficient to offset the increase in the costs for the buyers. We derive the sufficiency conditions that determine when order coordination would be preferable. A numerical example illustrating the benefit of order coordination is also presented.

Then, we consider the case when the buyers place a combined (single) order with the supplier (referred to as "order consolidation"). This is a common situation when the buyers are part of the same organization sharing a centralized purchasing office. In this case, the various buyers could be outlets at different geographical locations. In order to coordinate purchasing to take advantage of the quantity discount, a consolidated (bigger-sized) order is placed with the supplier. Upon receipt of the order at a centralized

[1] The downside to order coordination is that the supplier should have the capacity to fill all the orders that come during the time window. However, this problem is alleviated if the supplier sets different time windows for various groups of buyers thereby benefiting from coordination within each group.