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Quantity discount and handling-charge reduction schemes for a manufacturer supplying numerous heterogeneous retailers

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Abstract

A "manufacturer" supplies a "staple" product to a large number of "retailers" having very different sales volumes. Many models have considered how the "manufacturer" should design a quantity-discount (QD) scheme to induce the retailers to order in larger batch sizes. Our models differ from most existing ones in three aspects. First, we consider situations with a much larger number of retailers. Second, our manufacturer does not need to coordinate her replenishment cycles with those of the retailers. Third, besides "QD" schemes, we also consider "handling-charge reduction" ("HCR") schemes (i.e., a retailer pays a lower handling charge if his order is sufficiently large). We develop models and solution procedures for designing QD and HCR schemes that maximize the manufacturer's expected gain. We consider schemes with one as well as two "price breaks" (i.e., order size(s) needed to qualify for a QD or HCR). Examples of noteworthy characteristics revealed by our analytical and numerical analyses are (i) an optimal QD scheme will have a high enough price break such that extremely few retailers will be big enough to get a "free" discount and (ii) an optimal HCR scheme produces practically the same magnitude of expected total gains as an optimal QD scheme.

Keywords: Quantity discount; Handling-charge reduction; Supply chain contracts; Order incentives

1. Introduction

1.1. General problem statement

We consider the following problem: A manufacturer/wholesaler/supplier (hereafter "manufacturer") supplies a "staple" product (e.g., a packaged food item, a hygienic/cleaning product) to a large number of heterogeneous "retailers" (i.e., hundreds of outlets ranging from large supermarkets to corner convenience stalls); how should the "manufacturer" set incentives (e.g., a quantity discount (hereafter "QD")) to induce the retailers to order in larger batch sizes?

Many earlier "QD" models took the retailer's perspective; i.e., given a QD scheme offered by the manufacturer, how should the retailer make his inventory decisions? See, e.g., Wee (1999) and

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Papachristos and Skouri (2003). Later, researchers recognized the manufacturer's perspective: how should a QD scheme be designed by the manufacturer to either maximize the supply chain's efficiency, maximize the manufacturer's profit or minimize the manufacturer's cost (e.g., Li and Liu, 2006). For reviews of the large number of studies in the latter category, see, e.g., Goyal and Gupta (1989), Benton and Park (1996), Gurnani (2001) and Qin et al. (2007), among many others. Among the studies in this manufacturer-perspective category, some considered the case of a single retailer, while many others (e.g., Chakravarty and Martin, 1988; Drezner and Wesolowsky, 1989; Wang and Wu, 2000; Chen et al., 2001; Klastorin et al., 2002, to name but a few) considered the perspective of a manufacturer serving more than one retailer. Our current study belongs to this last subcategory, but it differs from the published manufacturer-perspective multiple-retailer studies in one or more of the following aspects:

1. Many earlier studies consider the situation of a relatively small number of retailers, each with a unique set of cost and market parameters known to the manufacturer. We consider the situation in which it is impractical to obtain the cost and market parameters of each of the very large number of retailers, and the retailers' attributes are viewed by the manufacturer in the form of random variables.
2. Many earlier studies consider the problem of coordinating the manufacturer's lot size with the retailers' lot sizes. In contrast, we consider either the situation in which the product is produced continuously (as in bottling a major soft drink item) or the situation in which the number of retailers is so large that the manufacturer's replenishments are made independent of any individual retailer's orders—very much like the fact that a grocery store's replenishments of most items are independent of the purchasing pattern of any individual consumer.
3. Most inventory models assume that a retailer's order (or "setup") cost is pre-determined. We will consider a scenario in which the retailers' order cost is not pre-determined but is instead a decision variable of the manufacturer. This applies to the common situation in which a retailer's internal cost of "processing" a replenishment order/delivery of a staple product from the regional manufacturer (or supplier) is typically insignificant; however, the manufacturer could levy a much less insignificant batch-size independent "handling" charge per delivery—which becomes (the major) part of the retailer's order cost. We investigate how the manufacturer might *reduce* this handling charge to encourage her retailers to order in *larger* batches (note that the simple economic order quantity (EOQ) concept would suggest that a handling-charge *reduction* (HCR) leads to a *smaller* instead of a larger batch size).

We do not claim that any single one of the above features is new. However, as far as we can ascertain, very few studies have considered more than one of the above features together. The studies most related to ours are Lal and Staelin (1984) and Wang (2002); the differences between our and their models are outlined in Appendix D. Also, after this paper was completed, we became aware of Chen and Robinson's ("C&R", 2006) working paper that considers a similar problem. The relationship between our and C&R's papers will be summarized in Section 6.1. C&R also provides an excellent review of the relevant literature.

1.2. Overview

Section 2 will consider the design of a "simple" QD scheme (i.e., one with a single price break) for a manufacturer supplying a large number of retailers. Section 3 extends Section 2 by considering a QD scheme with two price breaks. Section 4 considers whether and how the manufacturer should set a "handling-charge break" (like a "price break" in a QD scheme) for a reduction in the handling charge the retailers have to pay the manufacturer. Section 5 extends Section 4 by considering a HCR scheme with two "handling-charge breaks"—one qualifying for a larger HCR than the other. Section 6 gives a summary and some additional conceptual discussions.

2. Designing a "simple" QD scheme

2.1. Problem statement

A manufacturer supplies a product to a large number (say "N") of retailers. Each retailer has his own characteristics:

(i) "annual business volume" D_i (the number of units he buys from the manufacturer and retails to the consumers);