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Evaluating manufacturer's buyback policies in a single-period two-echelon framework under price-dependent stochastic demand☆

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Abstract

This paper attempts to model the profitability of a secondary market, in a newsvendor setting, to a profit-maximizing manufacturer, who is offering to the retailer a buyback policy for the unsold merchandise left at the end of the selling season. With a buyback agreement, the manufacturer shares the risks of demand uncertainty, thus inducing the buyer to place larger orders. The manufacturer's risk is mitigated to some extent by the availability of an extra market to dispose off the unsold merchandise. Both parties are risk-neutral profit-maximizers and both have the same information about the final demand for the product and its uncertainty. The manufacturer's decision is to arrive at an optimal wholesale price and the buyback price. Based on this offer, the retailer in turn sets the optimal amount of merchandise to purchase, as well as the unit selling price to meet a price-dependent uncertain demand for the merchandise in question. Due to the difficulty of obtaining analytical results, we have undertaken a numerical analysis to (i) compare the optimal policies across demand functions and error structures for three situations namely the no-incentive case and the buyback policies with and without a secondary market; (ii) indicate the conditions whereby the trade incentive is beneficial to both parties; (iii) assess the efficacy of the policies using two other performance indices (probability of achieving a target profit, and pass-through ratios) alternate to profit maximization; and (iv) conjecture the conditions for successful buyback policies and the nature of the benefits from the secondary market.

Keywords: Newsvendor problem; Price-dependent demand; Buyback policy; Secondary market

1. Introduction

The decision problem of a retailer facing uncertain demand in a single period framework, referred to as the News-Vendor Problem (NVP), has been extensively researched over decades. Earlier versions considered the selling price constant, leaving the buyer with the decision of how many units to purchase, so as to maximize expected profit. Under these conditions, the optimal order size corresponds to the quantity that balances the cost of over-stocking vs. that of under-stocking to counteract the negative effects of demand uncertainty. An important stream of new research on the NVP incorporates the pricing decision, in addition to the order quantity decision, of a retailer under different forms of demand functions and error structures. Reviews of this work appear in [1–4], among others. One of the important outcomes of this research consists of authors now looking at the manufacturer's decision problem when dealing with a price-setting retailer operating under the

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NVP framework. These studies cover the pricing policy of the manufacturer when the retailer's price is fixed (e.g., [5,6]), or optimally determined by the retailer [7] under partial and full information settings [5].

An important sales incentive that may be available to the manufacturer to influence the retailer's pricing and ordering decisions is the buyback policy. The retailer, if unable to find a suitable outlet to dispose of the unwanted merchandise, faces the entire risk of uncertainty in terms of losses due to unsold items. A manufacturer, if in a better position to resell/rework the unsold items, may provide the incentive to the retailer of sharing the risk by offering a guaranteed buyback price for all the unsold units. The saliency of a buyback policy as a trade incentive is unquestionable. According to [8], there are estimates [9] that between 5% and 20% of all retail products do not sell. Hence, even if a small percentage of this merchandise finds its way back into the manufacturer's hands, the savings to the retailer in demand-uncertainty costs can be substantial.

As a strategic tool, a buyback policy helps the manufacturer mitigate the effect of demand uncertainty, thereby encouraging the retailer to set lower retail prices, place larger orders (e.g., [10]) and, as an added bonus, lower the promotional outlays needed for their disposal (e.g., [11]). It also requires a closer alignment of the pricing and quantity decisions of both players and hence, potentially increasing the probability of discord among the parties. A recent review of the conflicts embedded in attempting to integrate pricing/inventory decisions within an NVP environment appears in [12] and a recent discussion of the incentive contracts required to achieve some sort of coordination between the manufacturer and the retailer, when the latter is a price-setting link, appears in [13].

A buyback policy also requires the manufacturer to seek other ways to dispose of the returned merchandise. Secondary markets, if available to sell this merchandise at prices exceeding the salvage value, are natural outlets for this purpose. Blackburn et al. [14] presents a thorough review of their nature and saliency and Tibben-Lembke [8] discusses the existence of various types of secondary markets and their importance to the manufacturer's decision process. Within this context, it is worthwhile to distinguish between secondary markets that are lucrative by themselves or those that are not. For the former, the literature provides examples, where the manufacturer buybacks merchandise from the retailer and sells it either "as is" (e.g., [15]) or after some remanufacturing (e.g., [16,17]). The primary purpose of this paper is to incorporate, into the profit-maximizing manufacturer's overall pricing strategy, the pricing policies for secondary markets that are not lucrative by themselves. The point of departure is the model of a buyback policy within the newsvendor framework of [7], where the retailer optimally determines the selling price and the quantity of merchandise to be sold. Our work incorporates into this formulation a secondary market with uncertain demand for the items returned by the retailer and with no possibility to obtain additional merchandise from anywhere else. The primary advantage of such an undertaking is to highlight the role of a buyback policy with a secondary market as a risk-sharing arrangement between manufacturers and retailers and to pinpoint the conditions that may lead to a solution beneficial to both parties.

The paper is organized as follows. Given that the manufacturer's decision is constrained by the optimal decision policies of the retailer, the next section provides three decision models and their respective optimal policies of a retailer under a price-sensitive NVP environment and the basic optimal pricing policies of the manufacturer. They cover the basic case where the manufacturer provides the retailer no incentive, plus the buyback cases, with and without the presence of a secondary market. This sequential presentation of models allows for easier assessment of each factor's marginal contribution, i.e., it simplifies the process to isolate the profit contribution of introducing a buyback policy, from the additional contribution provided by the existence of a secondary market. Section 3 includes numerical analysis, which (i) highlights the optimal policies and the sensitivity of these policies to parameter fluctuations (Sections 3.1 and 3.5); (ii) analyzes the conditions under which both sides benefit from the buyback policies (Section 3.2); (iii) assesses two alternate performance indicators, different from the expected profit, for the buyback models, namely the probability of achieving a target profit (Section 3.3) and the pass-through ratio (Section 3.4); and (iv) synthesizes the analysis with some conjectures as to the conditions for a successful buyback policy and as to the nature of the benefits of a secondary market (Section 3.6). A Conclusions section completes the paper.

It is important to emphasize from the outset the difficulty in finding closed-form solutions, a serious problem also discussed by Emmons and Gilbert [7]. For this reason, most of the comparative analysis of this paper is based upon the numerical experiments of Section 3. This hinders considerably the process of gauging the generality of the results. Such problem is further compounded by the fact that, even though our analysis considers a variety of demand functional forms and error structures, many findings are unique to specific