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Joint decision on pricing and advertising for competing retailers under emergency purchasing

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ABSTRACT

This paper investigates an inventory decision problem under the pricing and advertising dependent stochastic demand, and considers a joint decision on pricing and advertising for competing retailers who operate short-life-cycle products under emergency purchasing. The results indicate that the retailer always prefers to advertise whether under a single or dual channel system. However, both the optimal prices and stocks increase, whereas customer welfare decreases.

1. Introduction

Retailers have been executing advertisements and price reductions to lure customers and boost sales. Most firms face the threat of increased competition from globalization, shorter product life cycles, and fragmenting mass markets. Survival in this new economy depends on the ability of a firm to produce and deliver the required products through its operational decisions. Adding to the problem is the fact that the perception of value of modern customers and their purchasing decisions are not only influenced exclusively by the selling price of an item, but also by other non-price attributes that provide value (Baker et al., 2001).

At present, advertising becomes a crucial tool for demand creation and market expansion. According to one estimation, the advertising activity in 2010 totaled more than $300 billion in the United States and $500 billion worldwide.[1] In the third quarter of 2012, SINA microblog's financial statements report that the registered accounts exceeded 400 million, and its advertising revenues reached $120.6 million, representing an increase of 19% compared to the same period last year. Thus, the body of studies on advertising from the empirical and other perspectives that differ from that of the present study (Erickson, 2003; Tellis, 2004) has not focused on the efficacy of emergency purchasing. Rather than going through these studies, we refer the reader to the excellent reviews by Araman and Popescu (2010), Bagwell (2005), Little (1979), Wu et al. (2011), and the references therein. Although higher advertising levels can increase demand, such an action is usually associated with substantial investments, for example, Glaxo allocated a significant amount to advertising expenditure (Slywotzky and Shapiro, 1993).

The current study aims to determine joint decisions on the optimal pricing and advertising level values, as well as analyze the equilibrium of retailers. However, only few scholars have explored the newsboy problem incorporating pricing and advertising investment simultaneously. Ray (2005) assumes that customer demand is random and sensitive toward both the price and the non-price factors. Results show how attribute-sensitivity and randomness of demand affect the optimal decision of firms. Xiong et al. (2009) addresses the newsboy problem by incorporating the effects of pricing and advertising investment. The optimal pricing, advertising, and order policy of the perishable goods are studied in the mixed demand case under an uncertainty environment. The current study is also related to the literature rooted in both advertising and pricing techniques. Nevertheless, the aforementioned two articles have not addressed the issues of competitive market and emergency purchasing.

Another area related to this study is the channel competition of the dual channel system. Cai (2010) studies the influence of channel structures and channel coordination on the retailer, the supplier and the entire supply chain in the two single-channel and two dual-channel supply chains. The analysis suggests that the preference lists of the supplier and the retailer over channel structures with and without coordination are different, and depend on parameters like channel base

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[1] Source: http://www.inc.com/encycloopedia/cooperative-advertising.html.

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demand, channel operational costs, and channel substitutability. Few works have examined the market expansion effect of advertising as modeled in our work. For example, recent studies on competitive advertising involving two retailers/channels typically assume a fixed unit mass of consumers, for example, along a hotelling line, as in Chen et al. (2009) and Iyer et al. (2005); thus, the expansion effect on the market is assumed away. Moreover, a research stream on cooperative advertising does exist, such as Liu et al. (2013); nevertheless, most entries have focused on a vertical channel with a single manufacturer and a single retailer, such as, Berger (1972), He et al. (2009), Huang and Li (2001), Jorgensen et al. (2000) and Xie and Neyret (2009).

For pricing decision in a dual channel, Tsay and Agrawal (2000) analyze the competition between two retailers for substitutable products based on both price and product attributes. The deterministic part of demand $y(p,e)$ in the current study is inspired by this literature. Conversely, given that these models have no randomness of demand, firms are not concerned about overstocking/under-stocking. Zhang et al. (2012) investigate the effects of product substitutability and relative channel status on pricing decisions under different power structures of a dual exclusive channel system, in which each manufacturer distributes its goods through a single exclusive retailer but two goods are substituted. In our research, the stochasticity of demand, and hence the optimal stocking decision, plays a central role. Our analysis is also based on a competitive setting.

Guaranteeing availability is another important aspect for firms that deal with short-life-cycle products (Fisher, 1997). This aspect requires effectively planning for stocking decisions. The optimal solution to this problem is characterized by a balance between the expected costs of under-stocking and overstocking. For under-stocking, many companies take emergency products to make up for the lack of inventory losses. Although the unit costs of emergency products are higher, firms are often willing to use this method to meet sales and prevent the loss of credibility. This study assumes that firms can purchase emergency products, and they have an opportunity to increase the order quantity. Hence, the investigation of the model developed by Tagaras and Vhchos (2001) is important. They propose and analyze a periodic review inventory system with two replenishment modes. Chi (2001) develops a dynamic programming model for a periodic review inventory system in which emergency orders can be placed at the start of each period, whereas regular orders are placed at the beginning of an order cycle (which consists of a number of periods). Yu et al. (2011) introduce CVaR (Value-at-Risk) to depict the enterprise's emergency goal under disruption, and then establish the decision model of supply chain emergency assistance. They analyze the emergency assistance conditions of supplier and retailer under disruption, and prove the optimal strategy under certain confidence control level.

Based on the above literature, this paper develops analytical models for helping firms to determine the optimal pricing, and stocking and advertising investment values under emergency purchasing, as well as reveals how demand randomness and advertising investment shape the competitive strategy of firms. Generally, better performance in either lower price or better advertising levels increases the demand; however, higher advertising levels require more investment. In particular, this paper addresses the following two general questions:

- Would retailers that operate short-life-cycle products with emergency purchasing prefer to choose an "advertisement model"?
- Would retailers that operate short-life-cycle products with emergency purchasing prefer to choose an "advertisement model" in a competing market?

To address these questions, this paper considers a single risk-neutral retailer that sells a short-life-cycle product. Given the characteristics of the item, the retailer needs to consider customer demand, which is random and depends on the "bundle" of price and non-price advertising levels (Ray, 2005).

2. Model framework

A common modeling approach used in the literature to capture the trade-off between overstocking and under-stocking in the face of random demand for short-life-cycle products is the formalism of single-period inventory models, which is popularly known as the newsvendor problem. We adopt this modeling paradigm. The risk-neutral retailer in our model stocks and sells a single product to end customers. Retailers charge a price p and provide an advertising level e. The actual customer demand D for the single period is random. The exact form of the demand is represented as the sum of a deterministic function $y(p,e)$, which is decreasing in the retail price and increasing in the advertising level, and x, a random variable, i.e., $D(p,e,x) = y(p,e) + x$. One interpretation of this function is that the shape of the demand curve is deterministic, whereas the scaling parameter, representing the size of the market, is random (Petruzzi and Dada, 1999). Let the advertising investment cost incurred by the retailer be denoted by $C(e)$. The per unit operating cost is denoted by c (≥ 0); any excess stock has a salvage cost (or value) of v per unit; meanwhile, any emergency product has a higher cost of g (≥ 0) per unit as the demand is met. The objective of the retailer is to maximize its expected profit for the period by the proper selection of price, advertising investment level, and stocking quantity. The problem can be expressed in the newsvendor framework as

$$\text{Max}\prod(p,Q,e) = E\left[pD + v(Q-D)^{+} - g(D-Q)^{+} - cQ - C(e)\right], \tag{1}$$

where Π and Q represent the expected profit and the stocking level for the retailer, respectively. The above formulation is referred to as the "basic" model for the rest of this paper. We denote the density function, distribution function, and mean of the random variable x by f, F, and μ, respectively. Three remarks are in order here. Firstly, we model not only the single channel problem, but also the competition; our focus is on the optimal decisions of firms in a random demand environment. Secondly, we assume $v \geq c$ (the v implies salvage value). This assumption is standard in the literature (Agrawal and Seshadri, 2000; Petruzzi and Dada, 1999). Thirdly, Eq. (1) implies that all customer demands are to be satisfied, which is different from the classic newsboy problem. The literature (Chen, 2005) uses a similar assumption. The last but no less important, the lead time of inventories purchased emergently is assumed to be zero and hence there is no "wait" for "stock-out".

3. Joint decision of single retailer with emergency purchasing

In this Section, we consider only one retailer (monopoly) and determine its joint decision on the optimal pricing, stocking, and advertising level values. Retailer advertising can manifest in two different ways: the retailer advertises ($S1$), or does not advertise ($S0$). This section aims to find the retailer profit for these two types of behavior, and determine whether putting advertising investment on the market is profitable.

3.1. No Advertising (S0)

The deterministic portion of the demand function, $y(p,e)$ is assumed to be $y(p) = A - \beta p$, where A represents the base demand, and β (>0) represents customer sensitivity toward price. This type of linear demand function is quite common in the literature [refer to Tsay and Agrawal (2000) and references therein]. Hence, $D(p,x) = A - \beta p + x$. The expected profit for the retailer will then be

$$\Pi^{S0}(p,Q) = E\left[pD + v(Q-D)^{+} - g(D-Q)^{+} - cQ\right]. \tag{2}$$

And x is a random variable defined on the range [a, b]. In order to assure that positive demand is possible for some range of p, we require that $a > -A$ (Petruzzi and Dada, 1999).