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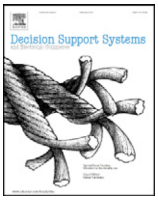

A randomized pricing decision support system in electronic commerce

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ABSTRACT

The Internet has provided great convenience for online shoppers and has presented unprecedented opportunities for online retailers to understand their customers. Getting the pricing right has emerged as one of the ultimate keys to the success of electronic commerce. Although some online retailers have tried some personalized pricing strategies for perishable capacity or inventory in some industries, consumers' resistance to price discrimination is still a great concern. Can we develop other price discrimination strategies for online sellers to sell standard durable products without giving the impression that they are treating their customers unfairly? Randomized pricing, which is proposed in this paper, belongs to this kind of strategy. In this paper, we present a framework that can be used to study the randomized pricing strategy by incorporating some new features into electronic commerce. For example, information asymmetry about the prices of products does not exist across internet users because of easy access to price information and very low searching cost. Consumers' reneging behavior is also considered. Online consumers usually wait up to a certain period of time for deals. Specifically, we model online retailers' price variation as a Markov process in which the price randomly switches between high level and low level. Strategic consumers make a tradeoff between buying immediately at a high price with instant utility or buying later at a low price with a probability and discounted utility. We show in this paper that randomized pricing strategy can always generate more profit than flat pricing strategy. The effects of consumers' patience and discount factor on optimal prices and promotion probability are studied. Finally, we show that the optimal benefit that the retailer can obtain from hiding promotion probability depends on the value of the discount factor.

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1. Introduction

With the development of electronic commerce and the fast growing number of Internet users, Internet has become a vital distribution channel in many industries. In recent years, emerging online stores have become another great source of retailing. Although consumers still purchase nondurable goods in traditional retail stores, e.g., Walmart, many intense Internet users have become accustomed to buying durable products online, such as computers, camcorders, and MP3 players, among others. However, most online retailers still struggle to make money out of the Web after making a huge investment in online business. Therefore, searching for ways to run an online business successfully is a great challenge. According to Baker et al. [2], getting the pricing right has emerged as one of the ultimate keys to success in managing online businesses. They observe two widely disparate approaches to pricing that dominate the online business. Many start-ups offer untenably low prices to capture first-mover advantage. By contrast, many incumbents largely neglect online pricing and simply apply their offline prices to the Internet.

The purpose of this research is to explore some online pricing strategies in electronic commerce. By breaking the barriers of geography and time, Internet has provided great convenience for online shoppers and unprecedented opportunities for online retailers to understand their customers. Through the Internet, consumers can instantaneously obtain all the information they need about the products they intend to buy without incurring a searching cost. Recently, with the development of 3G and 4G telecommunication technology, online retailers have provided more applications based on new operating systems (e.g., Apple OS and Android systems) for cell phones and other mobile devices (e.g., iPad). Users with wireless-connected mobile devices can access real-time commercial environments wherever they are. However, the Internet gives online companies opportunities to test customers' price sensitivity, change prices instantly, and segment customers. In the last decade, electronic commerce provided online sellers a field for experimenting with different alternatives for pricing. For example, Amazon.com experimented with a pricing strategy in which different customers were charged different prices for the same DVD movies. By using the information gathered from the customers' profile, Amazon.com adjusted the price of identical goods to make them correspond to the customers' willingness to pay. Although Amazon.com claimed that the price variations were part of a random

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"price test," many customers responded negatively to the strategy; hence, Amazon.com stopped the pricing tests (Streitfeld [22]). Hotware.com and Priceline.com are two Internet success stories, each of which used a business model based on variations of opaque pricing. Through Hotware.com, customers can buy last-minute unsold seats and hotel rooms at listed prices but with opaque quality. By contrast, Princeline.com offers customers a self-pricing alternative called Name-Your-Own-Price (NYOP) (see Hinz et al. [11]). In this setting, a buyer first places an initial offer. If it is rejected, the buyer updates the offer until it is accepted. Thus, the final price depends on the individual buyer's willingness to pay, which is opaque to the public. The opaque pricing strategy helps hotels and airlines cut losses by offering unsold products at discounted prices without revealing the published fares they promoted. In fact, some empirical research reported that sellers benefit from obfuscated pricing strategies in the electronic marketplace (see Ellison and Ellison [8]). However, designing opaque pricing is tricky, considering the strong buyer's resistance to one-to-one price discrimination. Currently, opaque pricing strategies are usually applied to sell products with perishable capacity and that entail the personal perception of quality, such as hotel rooms and flight seats. Can we develop other price discrimination strategies for online sellers to sell durable products with standard quality without giving the impression that they are unfairly treating their customers? The randomized pricing strategy that we propose in this paper belongs to this kind of strategy.

In this paper, we construct a randomized pricing strategy for online retailers by borrowing long-standing promotion methods from traditional retailing and incorporating some new characteristics into electronic commerce. Under this promotional pricing strategy, the online retailer can randomly provide promotions by reducing the price temporally over an infinite horizon. The temporary price reduction or promotion is a common strategy in brick-and-mortar stores. Sellers can provide price discount on selected packages of goods or seasonal products for a short period of time. Promotion generates a price discrimination effect because of the information asymmetry on promotions and the differentiation in searching and transportation costs across consumers. However, the Internet has brought double-edged effects on traditional promotion strategies. On the one hand, without advertising on traditional media, online retailers can instantly change posted prices on websites. This type of advertisement gives online retailers more flexibility to launch promotions (e.g., promotion frequency and duration) at low cost. On the other hand, because of low transportation cost in electronic commerce (e.g., free-shipping policy offered by online sellers), potential consumers are more likely to wait before they make final purchases. Moreover, they are unlikely to miss deal chances during their waiting period because of the low cost that searching incurs. Some online retailers even email promotional newsletters or send SMS to registered users regularly. In other words, online product and price information visibility are equal to all potential consumers; therefore, information asymmetry across consumers does not exist. Given the fact that online sellers encounter more sophisticated consumers who are more patient and are well-informed, designing new promotion strategies oriented toward electronic commerce elicits some interesting research questions.

We now summarize our research model and questions. Using a randomized pricing strategy, we focus our study on the online retail selling of durable products over an infinite horizon. In view of this pricing strategy, the retailer randomly switches the price between regular level and low level; thus, we assume that customers are heterogeneous in terms of reservation price and patience. When the current price is high, consumers evaluate the tradeoff between buying at high price with an instant utility and buying later at low price with a probability and a discounted utility. The questions we raise and answer in this study are as follows. First, what are the optimal promotion probabilities and high/low prices in this pricing strategy? Second, how is optimal pricing strategy affected by consumers' discount factor and patience? Finally, how can the retailer benefit from hiding the pricing pattern?

The remainder of the paper is organized as follows. In Section 2, we briefly review the related literature and identify the contributions of our work. Then, we present the pricing model and derive optimal solutions in Section 3. In Section 4, we analyze the effects of information asymmetry on the retailers' pricing strategy. Section 5 concludes the paper with a brief summary and suggestions for further research.

2. Literature review

Although no explicit evidence shows that price promotion improves the retailers' long-term profit, compared with flat price strategy, it is still a widely used strategy by practitioners (see Blattberg et al. [4] and Blattberg and Neslin [3]). Earlier studies in economics and marketing determined different kinds of price reduction strategies. For example, Varian [25] identifies price variation as a way to price discriminate between informed consumers and uninformed consumers. His study reveals that price variation is viewed as the economic outcome of mixed strategies given that a pure equilibrium strategy does not exist. In contrast to Varian's monopoly setting, Rao [20] models promotion competition as a multistage game in an asymmetric duopoly consisting of a national brand and a private label. In this game, regular prices are chosen first, followed by the choice of promotion depths and then frequencies. Similarly, Kinberg et al. [16] explore the optimal promotion strategy to use when one premium brand faces competition from one private label given the assumption that price is the only indicator of quality. Lazear's [18] study reveals that price variation over time can be used to identify reservation prices in the presence of ex ante uncertainty regarding consumer reservation prices. Lazear's model demonstrates that consumers are segmented by different reservation prices. Courty and Li [6] extend Lazear's model by explicitly considering the timing of promotion, product variety, and store competition. The main result is that promotion starts earlier in the presence of competition. Generally, from the perspective of these sales models, price is non-increasing toward the end of a selling season. Some promotion models include more dimensions of consumers' variation. Jeuland and Narasimhan [14] assert that consumers are separated by different consumption rates and that promotion is viewed as a buyer discrimination mechanism. Kinberg and Rao [15] derive the optimal promotion duration from a model in which discount price is provided only once and in which stochastic consumptions are affected by price. Iyer and Ye [12] derive the optimal promotion price for a retailer who encounters segmented consumers with heterogeneous reservation prices and inventory holding cost, given that promotion prices are offered at intervals of time following a negative-binomial distribution. This model considers consumers' stockpiling behavior during promotion periods. Almost all existing promotion models are oriented toward traditional brick-and-mortar retailing stores. Through temporal price reduction, sellers benefit from price discrimination mainly because of consumers' difference in the reservation price and searching or transportation cost.

However, we consider a promotion strategy in an electronic commerce setting where very low searching and transportation cost exist. Consumers need not buy instantly at first visit of an online store; thus, we add a new dimension, that is, patience, to segment consumers. From the perspective of this model, we assume that consumers are heterogeneous in both reservation price and patience. Thus, this model can be applied to online retailers who sell durable products without immediate consumption after the purchase, such as electronic products.

The existing literature so far has ignored the initial incentive for retailers to create a given pattern of price variation. Whether a temporary promotion truly increases long-term profits for companies is not certain. After studying the promotion patterns of Coca-cola and Pepsi, Krishna [17] finds that, although both were promoted in alternative weeks in New York supermarkets, smart and well-informed consumers easily guessed their promotion patterns. The effect of this kind

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