Dynamic Pricing and Inventory Buildup with Demand Diffusion

INTRODUCTION

It is critical for a firm to manage its demand when launching a new product successfully. It is well studied that demand of a new product diffuses in the market, driven by consumers’ word-of-mouth (Rogers 1995, Mahajan et al. 2000). However, in most previous research on dynamic pricing, the demand diffusion dynamics has largely been omitted (Elmaghraby and Keskinocak 2003). Without consideration of demand diffusion, price skimming strategy has been suggested as an effective way to differentiate heterogeneous consumers so as to increase firms’ expected profit (Besanko and Winston 1990). Narasimhan (1989) is so far the closest paper to ours, who considered monopolistic pricing with strategic customers in diffusion models, without imposing the supply constraint. They assumed that the market size is constant and the demand diffusion occurs in a certain market, and they concluded that the price skimming and price penetration strategies could be optimal with different distributions of customers’ heterogeneity. In our paper, we consider the information dissemination process and the initial supply constraints in the form of inventory buildup cost. Moreover, our model jointly optimizes decisions of the initial inventory level and the pricing strategy.

In fact, price skimming has gained such popularity that in many cases consumers have been trained to wait strategically for future price markdown. Consumers’ strategic waiting could be rather destructive, as it not only defers sellers’ sales revenue but also slows down the demand diffusion. Previous literature has studied the optimal dynamic pricing problem when facing with strategic consumers, under the assumption that the consumer arrival rate is constant (e.g., Su 2007, Aviv and Pazgal 2008). By contrast, we’re interested in how to manage strategic consumer behavior by setting effective pricing strategies in an early stage of product demand diffusion where past sales influence future demand. Specifically, the seller can penetrate the market with an initial low price to encourage strategic consumers to buy now. For example, Lay’s Stax potato chips were introduced at $0.69, and the price later rose above $1 (Kokemuller 2014). How to tradeoff the consumers’ heterogeneity versus the
network externality of sales so as to devise the optimal dynamic pricing strategy is the first key question we try to answer in this paper.

When penetrating market with an initial low price, demand may surge shortly after product introduction. Firms need to build up enough inventory ahead in preparation. It is not uncommon to see delays in delivery or even out-of-stock to during new product introductions. It not only hurts the customer experience but also slows down the diffusion process and loses the market share to competitors. Nexus 4 by Google was sold out on Google Play store within one day after its release in November 2012 (Newton 2012). It was until two months later, Nexus 4 was back again in the store. Yet, the supply problems persisted, with its delivery time ranged from one week to three weeks (Rodriguez 2013). Relatively low price and high quality are identified to be the reason for rapid inventory depletion. How to coordinate pricing strategy with inventory capacity constraint is the second question we pursue to answer in the paper.

**Model and Results**

We consider a stylized two-stage discrete-time model where the firm has no commitment power. Consumers are heterogeneous and their valuations follow a Bernoulli distribution that takes low or high values. We model demand as a modified Bass diffusion process by introducing information flow (Ho et al. 2002). Consumer arrival rate increases with the number of adopters in the market. Not all consumers arrived will purchase the product directly; instead, consumers are assumed to be rational, in that they choose the optimal adopting time so as to maximize their utilities. The firm expects consumers’ strategic behavior, and sets up price accordingly to maximize its expected profit. We solve for the optimal pricing strategy by solving the subgame perfect Nash equilibrium.

We find four distinct pricing strategies: a constant low price, a constant high price, price skimming, and price penetration. When the initial inventory capacity is abundant, the constant low price and constant high price are optimal for low valuation customers and high valuation customers, respectively. The price skimming strategy is optimal with moderately
high customers’ valuation, low word-of-mouth effect, and high self-drive diffusion. The price penetration strategy is optimal with moderately low valuation customers, high word-of-mouth effect, and low self-driven diffusion. Furthermore, the holding cost and the time discounting rate have influences on the optimality conditions of all from pricing strategies.

When there is a inventory buildup cost in the early production stage, the initial inventory at launch may be limited. In this setting, we characterize the optimal initial inventory buildup strategies along with the associated optimal pricing policies. In fact, as the initial inventory becomes limited, the price penetration strategy gradually loses its advantage. Specifically, it can be optimal to limit the initial inventory and deploy price skimming policy when the average customer valuation is high.

References


