Examining Double Marginalization Effect for Innovative Product Supply Chain

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ABSTRACT

Double marginalization effect refers to the phenomenon that when both upstream and downstream firms have monopolistic power, customers pay higher retail price and firms make less profit than when the supply chain is vertically integrated (Tirole, 1988). Although double marginalization effect has been extensively studied in the context of supply chain management for mature products, very limited attention has been given to innovative products whose demand is generated through word-of-mouth effect. The authors study the pricing decisions in a supply chain that sells innovative products. Using a modified Bass diffusion model to capture demand trajectory over time, the authors identify the optimal way for the retailer and supplier to adjust prices when profit is not discounted, and also provide numerical examples when profit is discounted. The authors show that (1) when profit is not discounted the optimal retail prices are adjusted over time, while the optimal wholesale price should be kept as a constant, and (2) double marginalization effect also exists in an innovative product supply chain, but its degree depends on a number of factors, such as the innovation and imitation coefficients.

Keywords: Bass Diffusion Model, Double Marginalization, Innovative Products, Pricing, Supply Chain Management

INTRODUCTION

Double marginalization effect has received extensive attention since Spengler (1950). In a decentralized supply chain where both the upstream industry and the downstream industry have monopolistic pricing power, “the firms in each industry only see the effect of their output restriction on their own profits, and do not see that their output restriction also affects the profits of the firms in the other industry” (Hamilton & Mqasqas, 1996). Therefore, compared to an integrated supply chain, consumers pay a higher retail price and firms make smaller total profit in a decentralized supply chain (Tirole, 1988). This effect is referred to as “double marginalization” effect, and it provides an incentive for vertical integration. However, these studies have been largely focused on supply chains of “mature” products which have existed in markets long enough. Very limited attention has been given to supply chains of “innovative” products that are new to market. These products include, for example, smart phones, solar power heaters, hybrid cars, etc. Compared with mature products, innovative products have a different demand pattern. More specifically, demand for innovative products is often changing over time.
time, and also, interrelated over time. How popular the product is today influences how popular it will be in the future, because a large portion of the future demand is created by word-of-mouth effect generated from current users (Bass, 1969). Therefore, measures that increase current demand not only have an impact on profit today but also influence profit in the future. These measures often include pricing, advertisement, etc.

In this paper, we focus on pricing decisions in a supply chain that sells innovative products. We are interested in how firms optimally adjust prices to maximize profits, as well as the impact of different supply chain structures (centralized vs. decentralized control) on the optimal pricing decisions. In order to capture the demand trajectory of innovative products, we adopt the classical Bass diffusion model (Bass, 1969) and its variant with price effect (Dolan & Jeuland, 1981). Based on these models that describe customer demand trajectories, we use optimization techniques to study the optimal pricing decisions in a supply chain. We consider two situations: a supply chain under centralized control, and one under decentralized control. In both cases, we identify the optimal demand and price trajectories. Then we compare the two cases and examine the extent of double marginalization effect.

In the rest of the paper, we review relevant literature and present our model and analytical results. Then we provide some numerical examples. Some discussions and conclusions are presented last.

LITERATURE REVIEW

Innovative products have received special attention for very long time. Compared to mature products, innovative products exhibit different demand pattern since demand is changing over time throughout the life cycle. Several papers aim at forecasting demand changes. Among these, Rodgers (1976) reviews relevant marketing research on new product adoption and diffusion process. Gatignon and Robertson (1985) provide a framework for diffusion modeling. Brownstone and Train (1998) study how to forecast product penetration with flexible substitutable patterns. They model customer making a purchasing decision among several substitutable products, and apply choice models including “mixed logits” model. Peres, Muller, and Mahajan (2010) provide a recent review on the progress of innovation diffusion and new product growth model. All of these papers study new product demand as a diffusion process, with theoretical roots found in sociology, geology, etc. (Gatignon & Roberston, 1985).

One of the most recognized model among the works that study new product demand and adoption is Bass model (Bass, 1969). In this model, demand for innovative products is driven by two factors: innovation effect and imitation effect. Innovation effect comes from those customers that make purchase decisions independently, and imitation effect comes from customers whose purchase decisions are influenced by other people through word-of-mouth effect. For a potential market with size \( m \), let \( D(t) \) be the cumulative demand by time \( t \), then among the \( m-D(t) \) customers who have not made purchase decisions, each one may purchase due to innovation effect, or purchase due to imitation effect if he meets a customer who has already purchased the product. The chance of meeting such a customer is \( D(t)/m \).

Therefore, let \( p \) be an innovative factor and \( q \) be an imitation factor which measure the extent of innovation and imitation effects, then the rate of new purchase \( d(t) \) can be expressed as \( d(t) = \frac{dD(t)}{dt} = \frac{m-D(t)[p+qD(t)/m]}{m} \). The cumulative demand \( D(t) \) can then be obtained by solving this differential equation. Figures 1 and 2 in the Appendix plot the shapes of instantaneous demand rate \( d(t) \) and cumulative demand \( D(t) \).

Bass (1969) was voted as one of the Top Ten Most Influential Papers published in the first 50 years of Management Science (Hopp, 2004) because it “has been very influential in the real world of applications and in the theoretical world of basic research” (Bass, 2004). The model is simple yet has surprisingly good predicting power. Bass model is later used to study various issues involved with innovative
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