



Strategic pricing with reference effects in a competitive supply chain



Jie Zhang^{a,b,*}, Wei-yu Kevin Chiang^b, Liang Liang^a

^a University of Science and Technology of China, The School of Management, Jinzhai Road 96#, Hefei, China

^b City University of Hong Kong, Department of Management Sciences, Hong Kong

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ABSTRACT

The reference-price effect refers to the demand deviation caused by consumers' perceived losses or gains when the current market price of a product differs from a cognitive benchmark (known as a reference price) formed by the customers based on past prices. The impact of such a reference effect on the dynamic pricing policy of a monopolist has been widely studied in the literature. However, despite the importance of the topic due to the growing transparency of price information in the Internet era, its relevance in the context of a distribution channel has never been explored. In this study, we consider a supply chain consisting of a manufacturer and a retailer in a bilateral monopoly setting. The two channel members independently choose their pricing strategies to optimize their own benefits in the presence of consumers' reference-price effects. Based on a deterministic demand function, we derive the equilibrium prices and analyze the resulting profit sensitivity with respect to various factors that crucially shape the reference effects. We conclude that both the centralized and decentralized channels should want consumers to have a higher initial reference price, be more sensitive to the reference-price effect, and be more loyal to their product.

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1. Introduction

Reference prices are cognitive price benchmarks that consumers form based on past product prices, and they play a decisive role in consumers' purchase decisions [1,2]. Previous empirical studies have consistently demonstrated that reference prices significantly affect consumer demand for many products, such as coffee and orange juice [3,4]. The marketing literature refers to the impact of reference prices on demand as the "reference-price effect": current prices that are lower/higher than consumers' reference price cause consumers to feel gains/losses, which accelerates/restrains demand [5,6]. Companies have been aware of this effect, with the intention to take full advantage of it to achieve maximal profits. For instance, during its entrance into the United States market, Maxwell House priced its product lower than consumers' reference price for coffee, which helped them get a foothold in the market.¹ Hence, it is essential to derive the firms' optimal pricing strategy while considering reference-price effects.

In 1995, Kalyanaram and Winer [7] propose several empirical generalizations about reference prices. After that, researchers start to derive optimal pricing strategies for firms [8–10]. For example, Kopalle et al. [8] propose that managers, who recognize the presence of

reference-price effects, should use a hi-lo cyclical pricing policy or a constant price strategy to avoid making consumers feel a sense of loss. Fibich et al. [9] obtain explicit solutions to optimization problems with reference-price effects and suggested that retailers dealing with reference-price effects use either of two kinds of pricing strategies in the initial stage: price skimming and price penetration, under different circumstances. Price skimming is the policy in which retailers initially set a high price and then gradually decrease it. Price penetration is the phenomenon in which retailers initially set the price low and then gradually increase it. In their studies, Kopalle et al. [8], Fibich et al. [9], and Popescu and Wu [10] focus on retailers' pricing decisions, but they assume that the manufacturer is unaware of the reference-price effects and provides a constant wholesale price. We extend their insights by relaxing the assumption of a constant wholesale price and considering the competition between manufacturer and retailer.

In this study, we consider a supply chain consisting of a manufacturer and a retailer in a bilateral monopoly setting. The two channel members independently choose their pricing strategies to optimize their own benefits, and both recognize the impact of the reference price on demand. Prior studies on distribution channels commonly assume that consumers decide to buy the product as soon as its price is lower than their valuation [11–13]. But there is little understanding of how the reference price, which is based on past prices of the product, impacts channel members' decision making.

In this paper, by using a linear demand function that captures the main features of demand which vary with the current price and past prices, we address the following questions: First, in the presence of reference-price effects, what are the equilibrium pricing strategies of the manufacturer and the retailer? Second,

* Corresponding author at: University of Science and Technology of China, The School of Management, Jinzhai Road 96#, Hefei, China. Tel.: +86 137 5715 0679; fax: +852 3442 0189.

E-mail address: zjhlqy@mail.ustc.edu.cn (J. Zhang).

¹ Considering Other Pricing Strategies, <http://www.uschamberssmallbusinessnation.com/toolkits/guide/P035-290>, (last access date: 15-March-2013).

what are the impacts of reference-price parameters (the initial reference price, the reference-price coefficient, and the memory effect) on channel members' decisions? Third, do managers benefit when consumers are subject to the reference-price effect? If yes, do they benefit when consumers are highly sensitive to the discrepancy between the reference price and the current price?

To answer these research questions, this paper develops a Stackelberg differential game in a bilateral monopoly supply chain where consumers have a reference price for the product and where the manufacturer distributes the product through an independent retailer. In this game, the manufacturer, who acts as the Stackelberg leader, tries to predict the retailer's reaction and offers an optimal wholesale price to maximize his profits. At the same time, the downstream retailer sees the wholesale price and pursues an optimal retail-pricing policy. In addition, both the manufacturer and the retailer have to react to the fact that market demand varies based on the reference-price effects.

The remainder of the paper is organized as follows. Section 2 reviews the literature. In Section 3, we explain how we model demand dynamics under the reference-price effect and then establish the vertically integrated channel as a benchmark. In Section 4, we study the equilibrium of a decentralized distribution channel. Section 5 describes parameter-sensitivity analysis of channel profits. Section 6 offers conclusions.

2. Literature review

Plenty of papers have studied the reference-price effect in consumers. In their comprehensive survey of earlier empirical studies in the marketing literature, Kalyanaram and Winer [7] propose several empirical generalizations about reference-price formation and its effects on demand that have been widely used in later studies. Mazumdar et al. [6] review the reference-price literature in both the behavioral and modeling streams and offered summaries of prior findings on how reference-price effects influence consumers' decisions. These two reviews form the basis of our summary here.

The idea of a reference price dates back to adaptation level theory [14], which argues that consumers observe the past prices of a product to come up with a reference price that they compare to the current price of the product. Numerous empirical studies document this effect [4,15], proposing that a positive gap between the reference price and current price accelerates demand for the product demand; otherwise demand slows. Researchers studying the reference-price effect look at its effect on marketing strategies, such as promotion strategies [16], policies of product quality [17], cooperative advertising [18] and pricing policies [8]. These studies provide efficiency strategies to improve firm profits by understanding the reference-price effect in consumers.

The papers most relevant to our study are those of Kopalle et al. [8] and Fibich et al. [9], which focus on the optimal policies for product pricing. Their models assume that the retailer trades with a constant wholesale price. Kopalle et al. [8] investigate the effects of reference price in different scenarios, including monopolies, duopolies, and monopolist retailers managing two brands. They find that two kinds of retail-pricing strategies (hi-lo pricing or everyday low pricing) are optimal under different circumstances.

Fibich et al. [9] explore explicit solutions to the problem of how to optimally set retail pricing strategies under reference-price effects. Using a linear demand model and linear reference-price effects on demand, they find that the initial reference price plays a critical role in retail-pricing policy. Our research follows up on the idea of linear reference-price effects on demand. We use the reference-price effect model in a different setting, where the manufacturer acknowledges the effect of reference prices. We do

this because “manufacturers ... understand how reference price effects influence retailer profits” [16] and because the manufacturer acts to maximize profits, which further impacts the retailer's pricing decisions. For instance, previous researches study the supply chain management with consideration of demand disruptions [19], sharing inventory risk [20] and so on. We extend the reference-price literature by investigating dynamic pricing policies of the manufacturer and the retailer in a decentralized channel.

Another stream of research focuses on vertical competition in decentralized distribution channels. Previous related studies contribute on product design strategies [21], information sharing [22], returns policy [23] and discount pricing decision [24]. Chintagunta and Jain [12] conduct a similar study that uses a differential game-theoretic model to understand optimal pricing trajectories under vertical competition. Gutierrez and He [13] construct a Stackelberg game model to investigate dynamic pricing policy under a Bass-type diffusion function. Our model is similar to their work except that, in our case, the reference-price effect influences product demand.

He et al. [25] are some of the first researchers to investigate this for manufacturers; however, their model holds the optimal wholesale and retail prices constant. Benchekroun et al. [26] present a similar channel structure with reference-price effects, except that the retailer in their model is assumed to be myopic. We expand on this by studying the pricing strategies of manufacturers and retailers when they maximize profits in the long run. In general, our model bridges the gap between the stream of research that focuses on traditional vertical competition in dyadic channels and the stream that focuses on the inter-temporal effect caused by reference prices.

3. Model formulation

Consider a bilateral monopoly supply chain in which a manufacturer distributes a product through an independent retailer, both of whom face a reference-price effect over an infinite selling horizon.

3.1. Demand dynamics under reference-price effects

Before investigating the influence of reference-price effects on product demand, it is necessary to understand the formation of reference prices. As previously indicated, the reference price evolves over time based on past prices of the product [7]. Consumers adjust their reference price when they encounter a new price based on the memory effect. The memory effect is simply consumers' memory of past prices. To form the reference price, we use the exponential smoothed past prices process, which the marketing literature frequently uses to test the effect of reference prices [5,9,27]. We model reference-price formation with the following differential equation ($\dot{r}(t) = dr(t)/dt$)

$$\dot{r}(t) = \beta(p(t) - r(t)), \quad (1)$$

where $r(t)$ represents the reference price and $p(t)$ product price. We use β as the “memory effect” parameter ($0 \leq \beta \leq 1$). If $\beta = 0$ (i.e., consumers never remember any past prices), consumers' reference price $r(t)$ will remain at the initial reference price $r(0) = r_0$, which is constant (r_0 might be determined by various factors, like consumers' understanding of the product technology or prices of similar products). On the other hand, a higher memory parameter β implies a more short-term memory, which implies less loyalty to the product.

We now consider the impact of reference prices on product demand. To represent consumers' reactions to the gap between the current price and reference price ($p(t) - r(t)$), we use a linear relationship between demand and the price gap, which numerous

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