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Price leadership in a vertically differentiated market

Youping Li *

School of Business, East China University of Science and Technology, 130 Meilong Road, Shanghai 200237, China

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ABSTRACT

This paper compares the equilibrium outcomes under simultaneous and sequential price settings in a vertically differentiated market. When the timing of the price game is determined endogenously, it is shown that the sequential play with the high quality firm leading emerges, yielding the highest industry profit but the lowest social welfare among the different timings.

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1. Introduction

Price leadership is a widely observed phenomenon. The following is probably typical. With some changes in market conditions, a firm with a better product or brand recognition (which can be generally referred to as higher quality) cuts or raises its price. Other firms, after learning the action taken by the "leader", would likely follow. However, as will be discussed later, theoretical analyses of vertically differentiated markets like this usually assume that the firms set their prices simultaneously and a Bertrand–Nash equilibrium results. In this paper, we consider both simultaneous and sequential price settings in a vertically differentiated market and compare the resulting market outcomes. By studying the endogenous determination of the timing in the price game, the general intuition is confirmed. Indeed, the firm supplying a higher quality product acts as the price leader.[1]

The importance of the timing of firm actions in oligopolistic markets has been recognized since the seminal work by von Stackelberg (1934). Gal-Or (1985) and Dowrick (1986) both studied first- and second-mover advantages in a duopoly and showed that the relative magnitudes of equilibrium payoffs, being a leader or a follower, depend on the slope of the reaction curves. With downward (upward) sloping reaction curves, being a leader (follower) is preferred and there is a first-mover (second-mover) advantage. Since then, and especially after the work by Hamilton and Slutsky (1990) in which the firms' sequence of actions are endogenized in "extended" games, a large body of work has emerged studying the endogenous determination of the timing in various duopoly games. Specifically, van Damme and Hurkens (2004), employing Hamilton and Slutsky's action commitment model, and Amir and Stepanova (2006), employing the observable delay model, have both studied price competition in horizontally differentiated markets. They found that while both sequential price settings are pure strategy equilibria,[2] the sequential play with the lower cost firm leading is risk dominant (Harsanyi and Selten, 1988). Thus market leadership arises as a result of cost efficiency. Our work adds to the literature by studying a vertically differentiated market and showing that higher quality leads to market leadership.[3] While the literature has focused primarily on the ranking of payoffs of individual firms under each sequence of play, in this paper we also compare the aggregate profit and total welfare of the equilibrium outcomes.[4] It turns out that the high quality firm leading yields the highest industry profit but the lowest social welfare among the different timings.

The literature on vertical product differentiation was first developed by Mussa and Rosen (1978), Gabszewicz and Thisse (1979), and Shaked and Sutton (1982). Later contributions were made by, for example, Tirole (1988), Choi and Shin (1992), Motta (1993), Wauthy (1996),

* Tel.: +86 21 6425 3106.
E-mail address: liyouping@ecust.edu.cn.

[1] Some may have interpreted such a phenomenon as being simply natural or a focal point of the firms. This paper, from a game-theoretic view, shows that this is the outcome chosen by rational firms.

[2] In van Damme and Hurkens (2004), simultaneous price setting in the first period is also an equilibrium but in weakly dominated strategies.

[4] In quantity-setting oligopolies, asymmetric information has been shown to possibly give rise to market leadership. For example, Mailath (1993), Normann (2002), and Gilpatric and Li (2011).

[4] The welfare implication of price leadership is particularly relevant to antitrust regulations. Markham (1951) discussed several cases ruled by the U.S. Supreme Court concerning price leadership in oligopolistic markets.

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Aoki and Prusa (1997), Lehmann-Grube (1997), Zhou et al. (2002), Toshimitsu (2003), Toshimitsu and Jinji (2007), and Boccard and Wauthy (2010). But a common assumption has been that the price game between a high quality firm and a low quality firm is played simultaneously. To our knowledge, the only paper that considered sequential price setting in a vertically differentiated market is Lambertini (1996), in which the firms choose their roles both in the quality stage and in the price stage at the beginning of the game. It was shown that when the market is not fully covered (i.e., some consumers purchase the product while others do not), the mostly commonly used model of vertically differentiated markets, firms play simultaneously in both stages so price leadership does not arise. A major difference of our model is that the choice of the timing in the price game is made *after* the qualities of the firms' products are determined. Specifically, in our model the qualities are modeled as exogenous.[5] This setup is consistent with the literature on endogenous timing and captures the fact that many price settings are only temporary responses to short-term market fluctuations whereas technological investments to improve quality are usually made in a long time horizon. Besides, we follow the recent development in the endogenous timing literature and make the equilibrium selection based on the criterion of risk dominance when multiple equilibria exist. We are able to conclude that the rather intuitive outcome, sequential price setting with the high quality firm leading, emerges endogenously.

The remainder of the paper is organized as follows. In Section 2, the model is set up and the equilibrium outcomes under each sequence of price settings are derived and compared. In Section 3, the extended game with observable delay of Hamilton and Slutsky (1990) is employed to endogenously determine the timing of the price game. Section 4 concludes the paper.

2. Model setup

Consider a vertically differentiated market in which two firms, 1 and 2, supply a product that differs only in one characteristic called quality. Firm 1 is the high quality firm whose product has quality level s_1 and Firm 2 is the low quality firm whose product has quality level s_2, $s_1 > s_2 > 0$. They have zero production cost and compete in price. Denote the price that Firm i charges for its product by p_i, $i = 1,2$. There exists a continuum of consumers who differ in their taste for quality, indexed by θ, with θ being uniformly distributed on [0,1].[6] Consumers either purchase one unit of the product or none. The utility from consuming the product is dependent on both one's type of taste and the quality of the product. For a consumer with taste parameter θ, her utility can be represented by

$$U(\theta, v_i, p_i) = \begin{cases} \theta s_i - p_i & \text{if she purchases the product from Firm } i, \\ 0 & \text{if she does not make a purchase.} \end{cases}$$

Define two cutoff levels of the taste parameter, θ_1 and θ_2, as

$$\theta_1 s_1 - p_1 = \theta_1 s_2 - p_2, \tag{1}$$

$$\theta_2 s_2 - p_2 = 0. \tag{2}$$

Consumers with a taste parameter $\theta \in [\theta_1,1]$ buy the high quality product, consumers with a taste parameter $\theta \in [\theta_2, \theta_1)$ buy the low quality product, and consumers with a taste parameter $\theta \in [0, \theta_2)$ buy neither. Given the prices, the firms' demands are then represented by:

$$q_1 = 1 - (p_1 - p_2)/(s_1 - s_2), \tag{3}$$
$$q_2 = (p_1 - p_2)/(s_1 - s_2) - p_2/s_2. \tag{4}$$

Using superscript N to denote the simultaneous play, L to denote the leader and F to denote the follower, the equilibrium prices and quantities under each sequence of play (simultaneous price settings, sequential price settings with Firm 1 being the leader, and sequential price settings with Firm 2 being the leader) are shown below:

$$\begin{aligned} p_1^N &= \frac{2s_1}{4s_1 - s_2}(s_1 - s_2), \quad q_1^N = \frac{2s_1}{4s_1 - s_2}, \quad \pi_1^N = \frac{4s_1^2}{(4s_1 - s_2)^2}(s_1 - s_2); \\ p_2^N &= \frac{s_2}{4s_1 - s_2}(s_1 - s_2), \quad q_2^N = \frac{s_1}{4s_1 - s_2}, \quad \pi_2^N = \frac{s_1 s_2}{(4s_1 - s_2)^2}(s_1 - s_2). \end{aligned} \tag{5}$$

$$\begin{aligned} p_1^L &= \frac{s_1}{2s_1 - s_2}(s_1 - s_2), \quad q_1^L = \frac{1}{2}, \quad \pi_1^L = \frac{s_1}{2(2s_1 - s_2)}(s_1 - s_2); \\ p_2^F &= \frac{s_2}{2(2s_1 - s_2)}(s_1 - s_2), \quad q_2^F = \frac{s_1}{2(2s_1 - s_2)}, \quad \pi_2^F = \frac{s_1 s_2}{4(2s_1 - s_2)^2}(s_1 - s_2). \end{aligned} \tag{6}$$

$$\begin{aligned} p_1^F &= \frac{4s_1 - s_2}{4(2s_1 - s_2)}(s_1 - s_2), \quad q_1^F = \frac{4s_1 - s_2}{4(2s_1 - s_2)}, \quad \pi_1^F = \frac{(4s_1 - s_2)^2}{16(2s_1 - s_2)^2}(s_1 - s_2); \\ p_2^L &= \frac{s_2}{2(2s_1 - s_2)}(s_1 - s_2), \quad q_2^L = \frac{1}{4}, \quad \pi_2^L = \frac{s_2}{8(2s_1 - s_2)}(s_1 - s_2). \end{aligned} \tag{7}$$

Comparisons of the equilibrium outcomes for each firm are summarized as follows.

Observation 1.

(i) $p_1^L > p_1^F > p_1^N$; $q_1^F > q_1^N > q_1^L$; $\pi_1^F > \pi_1^L > \pi_1^N$.
(ii) $p_2^L = p_2^F > p_2^N$; $q_2^F > q_2^N > q_2^L$; $\pi_2^F > \pi_2^L > \pi_2^N$.

Except that the low quality firm's prices under the two sequential plays are equal, the other results are similar to those in a horizontally differentiated market (Amir and Stepanova, 2006; van Damme and Hurkens, 2004). Generally, a firm charges a higher price while leading than while following, both higher than that under a simultaneous play. Given that a firm's reaction curve is upward sloping, the price leader should charge a higher price than it would under Bertrand competition, expecting that its competitor would also raise the price. Observing a higher price charged by the leader, the follower raises the price but by a lesser amount, such that it also sells more than before. The quantity a firm sells is the lowest (highest) when leading (following). Both firms prefer sequential price settings to simultaneous price settings and there is a second-mover advantage (i.e., following is preferred to leading).

Use Q to denote total output, Π to denote industry profit, and W to denote the Marshallian social welfare, which is defined by $W = \int_{\theta_1}^{1} \theta s_1 d\theta + \int_{\theta_2}^{\theta_1} \theta s_2 d\theta$. In addition, use superscript 1 (superscript 2) to denote the equilibrium outcome with Firm 1 (Firm 2) being the leader. As before, the superscript N denotes the Bertrand–Nash equilibrium. The following proposition compares the total output, industry profit and social welfare under the three different timings. All proofs are in the Appendix A.

Proposition 1.

(i) $Q^1 = Q^2 < Q^N$.
(ii) $\Pi^1 > \Pi^2 > \Pi^N$.
(iii) $W^1 < W^N < W^2$.

The total output is the same under the two sequential plays, smaller than when the firms play the price game simultaneously. This stems from the fact that the low quality firm, Firm 2, charges identical

[5] Some discussions on the possible effect of price leadership on the firms' quality choices are provided in the conclusion.
[6] This is the most commonly used assumption on the distribution of consumer taste (e.g., Aoki and Prusa, 1997; Boccard and Wauthy, 2010; Toshimitsu, 2003; Toshimitsu and Jinji, 2007; Zhou et al., 2002) and the lower bound, zero, ensures that only a subset of the consumers purchase the product.

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