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Collusive price leadership with capacity constraints ☆

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Abstract

In this paper, collusive price leadership in homogeneous good capacity-constrained repeated price competition is examined. In the stage game, firms choose their timing of price setting. Although setting a price early is disadvantageous *per se*, a large firm has an incentive to move early in order to demonstrate its commitment not to deviate. If the discount factor is not too large, this behavior raises the collusive price compared to that arising in collusion with simultaneous moves. As a result, all firms obtain (strictly) higher profits.

JEL classification: D43; L13

Keywords: Price leadership; Collusion; Endogenous timing; Repeated games

1. Introduction

Price leadership has been a popular topic in industrial organization since Stigler (1947) and Markham (1951). In this paper, the role of price leadership in the context of collusion is considered. This type of leadership is called collusive price leadership. Rotemberg and Saloner (1990) define collusive price leadership as a situation in which "one of the firms announces a price change in advance of the date at which the new price will take effect and the new price and date are swiftly matched by the other firms in the industry."

In December 1991, the Coca-Cola Japan Group (CCJ, hereafter), which had the largest share in the Japanese soft drink market,[1] announced that it would change its product prices from 100 to 110 yen in February 1992. Then, all other major firms decided to follow CCJ's price change. As a result, most product prices were 110 yen by early March 1992. In 1998, Japanese soft drink prices rose from 110 to 120 yen. Again, CCJ was the first to announce a change in price.

Rotemberg and Saloner (1990) examine the relationship between collusive price leadership and asymmetric information. They consider a repeated game with product

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[1] The author could not find information on the accurate share in 1991. In 2001, CCJ had the largest share (31%). Several major firms had 39% in total. Small firms had 30% in total. Casual observation suggests that the shares in 1991 were not much different from those in 2001.

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differentiation and asymmetric information concerning demand. They show the existence of an equilibrium in which the better informed firm becomes the leader.

In the present paper, the mechanism by which leadership structure changes the profitability of collusion is examined. Collusive price leadership in homogeneous good capacity-constrained repeated price competition is considered. In the stage game, firms choose their timing of price setting. The stage game consists of two rounds. In the first round, each firm chooses whether it commits to a price or waits until the second round. In the second round, the waiting firms simultaneously choose prices after observing the actions from the other firms in the first round. Therefore, commitment in the first round is disadvantageous *per se*. In this setting, the following result is obtained. If the discount factor is not too large, a large firm has an incentive to commit to a price in the first round in order to commit not to deviate. This behavior raises the collusive price compared to that arising in collusion with simultaneous moves in each stage game. As a result, all firms obtain (strictly) higher profits.

The stage game in our model is closely related to that of Deneckere and Kovenock (1992), who analyze dominant firm price leadership. Deneckere and Kovenock (1992) analyze duopolistic price-setting games, in which firms have capacity constraints and are allowed to choose the timing of their price announcements. They show that a large firm becomes a price leader when capacities are in the range in which the corresponding game with simultaneous moves yields a mixed-strategy equilibrium.[2] The result obtained in the present study is similar to this result, although the driving force is quite different.

The remainder of the paper proceeds as follows. In Section 2, a simple repeated price competition model is presented. There are n firms with capacity constraints and efficiently rationed demand. The range of capacities is restricted so that there exists a pure-strategy Nash equilibrium in the one-shot play of the stage game. In the stage game, each firm chooses its timing of price setting endogenously. In Section 3, we first demonstrate the important property that the set of subgame perfect equilibrium (SPE) outcomes in our game includes the set of SPE outcomes in the corresponding simultaneous move game. Attention is then restricted to the class of equilibria in which one particular firm becomes a price leader in every stage game on the equilibrium path. We demonstrate the mechanism by which collusive price leadership improves the profitability of collusion and provide a condition under which collusive price leadership Pareto dominates collusion with simultaneous moves. Section 4 presents partial results relaxing the assumption in Section 2 that capacities are in the range where a pure-strategy Nash equilibrium arises in the one-shot play of the stage game. Two alternative assumptions are considered. One is that some common price is sustainable in collusion with simultaneous moves. A method for constructing collusive price leadership is demonstrated. The other assumption is that the number of firms is restricted to $n=2$. In this case, a necessary and sufficient condition for the existence of a security level penal code is derived. Section 5 concludes with some extensions of the model. In particular, collusive price leadership by multiple price leaders is discussed.

2. The model

There are n firms that produce a homogeneous product. Firm $i \in I \equiv \{1, 2, \ldots, n\}$ has a capacity k_i. Let I_i be the set with firm i removed from I. The following assumptions on capacities and costs are made: $k_1 \geq k_2 \geq \ldots \geq k_n > 0$ and each firm can produce up to its capacity at a constant marginal cost normalized to 0. The demand function is denoted by $D(p)$: $R \rightarrow R_+$.[3]

We make the following assumptions on $D(p)$.

Assumption 1. There exists $\bar{p} > 0$ such that $D(p)=0$ $\forall p \geq \bar{p}$, $D(p) > 0$ $\forall p < \bar{p}$, and $D(p)=D(0)$ $\forall p < 0$. $D(p)$ is twice differentiable, $D' < 0$, and $D'' \leq 0$ on $(0, \bar{p})$.

Assumption 1 guarantees the existence of a unique monopoly price $p^m (>0)$ that maximizes $pD(p)$. We assume the efficient rationing rule when firms charge different prices. We also make the following assumption relating capacities to demand:

Assumption 2. There exists a price $p^N > 0$ such that $D(p^N) = K$, $D(p^m) < K < D(0)$, and $p^N D'(p^N) + k_1 \leq 0$, where $K = \sum_{i=1}^{n} k_i$.

Two things are stated in Assumption 2; (1) the total capacity is less than the maximal demand (at $p=0$), and (2) p^N is the unique pure-strategy Nash equilibrium in the one-shot game of simultaneous price competition.[4]

[2] There are several similar arguments in different settings. For example, see Furth and Kovenock (1993) and Ono (1978, 1982).

[3] Negative prices are allowed in order to simplify the analysis in Section 4.2, but they are not essential for any of our results.

[4] Differentiating $p(D(p) - K + k_1)$ with respect to p yields $pD'(p) + D(p) - K + k_1$. If this is not positive at $p = p^N$, firm 1 does not deviate upward. Furthermore, because of capacity constraints, firm 1 does not gain by undercutting p^N. Therefore, firm 1 does not deviate. The same argument holds for other firms because $k_1 \geq k_2 \geq \cdots \geq k_n$.