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A Summary on "Collusion, Fluctuating Demand, and Price Rigidity"*

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Abstract

We study an infinitely repeated Bertrand game in which an i.i.d. demand shock occurs in each period. Each firm receives a private signal about the demand shock at the beginning of each period. At the end of each period, information about both the underlying demand shock and the rivals' prices becomes public. A firm's pricing schedule can be either a sorting scheme, in which its price depends on its private signal, or a price-rigidity scheme, in which the firm charges the same price regardless of its private signal. We consider the optimal symmetric perfect public equilibrium (SPPE). The optimal SPPE consists of a profile of price-rigidity schemes if the accuracy of the private signals is low. Moreover, the lower the variance of the demand shock, the more likely that a price-rigidity scheme is optimal. These results contribute to our understanding of which industries, and under what conditions, should exhibit rigid prices.

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1 Introduction

Although price rigidity is frequently-observed evidence in many oligopolistic industries, it is still puzzling why collusive firms are sometimes reluctant to change price if demand is fluctuating. We explore a repeated-game framework to demonstrate that firms in tacit collusion optimally adopt rigid-pricing in the presence of demand fluctuation. We focus on imperfect, private information about the underlying demand state. Specifically, we consider the following questions: How does information asymmetry among firms limit colluding firms' ability to respond to demand shocks? Under what condition does price rigidity arise as an equilibrium phenomenon in a collusive industry?

Our main result is that, if the accuracy of private demand predictability is low, the optimal collusion within a class of symmetric equilibria exhibits repetition of pooling pricing, i.e., price rigidity.

2 Model

We consider infinitely-repeated price competition by two firms. Time line in a stage game is as follows.

Demand state drawn	Receive a private signal	Choose a price	Observe prices and demand
↓	↓	↓	↓

⟶

The products are homogeneous so that a firm that charges the lowest price wins the whole market. We assume that there are two demand states $\{H, L\}$ in each stage, whose distribution is i.i.d., i.e., $\Pr(H) = \Pr(L) = .5$. Let $D^H(p) > D^L(p)$ denote the demand functions for each state. We normalize each firm's marginal cost is zero. This implies that the stage game Nash equilibrium is $p = 0$ regardless of the realized state. Let $s_i \in \{h, \ell\}$ denote the private signal each firm receive. This signal is conditionally independent across firms, and $\Pr(h|H) = \lambda, \Pr(\ell|H) = 1 - \lambda$, $\Pr(\ell|L) = \lambda, \Pr(h|L) = 1 - \lambda$, where $\lambda \in [.5, 1]$ (accuracy). Signals have no information if λ is .5, and have perfect info if λ is 1. It is important that collusion is tacit, so that communication is absent. Each firm's stage game strategy thus takes a mapping from signals to prices, i.e., $p_i(s_i)$. This is either pooling, in which the same price is charged regardless of signals, or sorting. Each firm's payoff is the discounted sum of stage-game profits, with a discount factor $\delta < 1$.

3 Symmetric Perfect Public Equilibrium

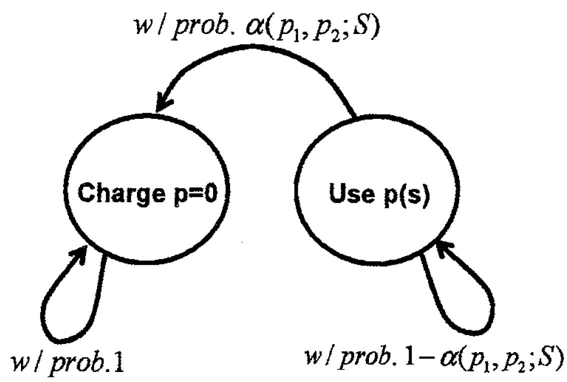
Our solution concept, SPPE, is defined by a strategy profile satisfying the following two conditions.

Perfect Public Equilibrium: *Each firm adopts a sequentially rational strategy for which the stage game pricing schedule at each point depends only on what has been publicly observed.* Although private information is present within each stage, firms use only public information to coordinate their pricing schedule before they receive info at the beginning of the period.

Symmetry: *At each point, stage game pricing schedules do not depend on identity of the firm.* Symmetry implies that, if firms impose punishments on a potential deviator, all firms suffer.

4 Optimal Collusion

We suppose that collusive firms choose an optimal SPPE. The next argument shows that an optimal SPPE value is attainable by the following bang-bang equilibrium



For an optimal SPPE (existence can be shown), firms use some $p(s)$ at the initial stage. By optimality of the equilibrium, the continuation payoff from the next stage is a convex combination of the optimal SPPE payoff and the minmax payoff, 0, (by $p = 0$ forever). Using public randomization $\alpha(*, *, *)$, the above bang-bang equilibrium can achieve the same SPPE payoff.

To characterize an optimal SPPE, it is convenient to category incentive constraints into the following two parts.

Incentive Constraints I (off-schedule): *firms have no incentive to charge p other than $p(h)$ or $p(\ell)$.* This deviation is immediately detected, so that the harshest punishment ($p = 0$ forever) deters it for a high discount factor.

Incentive Constraints II (on-schedule): *after receiving a private signal, each firm has no incentive to charge price that is assigned for a different signal.* This deviation is relevant only if firms adopt a sorting pricing schedule.

5 Results

Is $p(s)$ for an optimal (bang-bang) SPPE pooling or sorting? If pooling, no future punishment is imposed unless a firm commits off-schedule deviation. In such equilibrium, firms therefore charge the same price over time on the equilibrium path.

Proposition 1 *Repetition of pooling pricing, i.e., price rigidity, arises in an optimal SPPE, if private signal accuracy is low.*

Intuition: The benefit of sorting pricing is to reap informational gain contained in signals. This gain is increasing as signal accuracy improves. Private, imperfect signals cause coordination costs of sorting: to deter on-schedule deviations, price distortion or future price war must be built in. These costs are decreasing in accuracy since the statistical test power of public outcomes improves as accuracy is enhanced. If signal accuracy is low, informational gain $<$ coordination costs, and pooling is therefore better.

Other results: We derive price war implications when rigid-pricing is not optimal, negative relationship between price-rigidity and variance of demand fluctuation, and negative relationship between rigidity and concentration, within oligopolistic regime.

6 Related Literature

Athey, Bagwell, and Sanchirico (2004) demonstrate optimal tacit collusion may exhibit price rigidity in the presence of i.i.d. private cost shocks. Their independent-private-value (IPV) setting is qualitatively different from ours in which shocks commonly affect all firms' profits and information is correlated. Other related works are listed in the references.

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