Theory of Collusion and Cartels

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Defining Collusion

- **Collusion** is when some or all firms in a market coordinate their prices and quantities. This coordination is typically done with the intent of raising price and earning higher profit.
- "Cartels are cancers on the open market economy ..." [Mario Monti, former European Commissioner for Competition, Sept 2000]
- "... negotiation between competitors may facilitate the supreme evil of antitrust: collusion." [Supreme Court Justice Antonin Scalia, *Verizon Communications, Inc. v. Law Offices of Curtis V. Trinko LLP*, 2004]

Defining Collusion

Legal definitions and practice - United States

- Section 1 of the Sherman Act (1890): "Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is declared to be illegal."
- *Per se* rule - When a practice can have no beneficial effects but only harmful effects, the "inherent nature" of the practice is injuriously restraining trade and is thereby *per se* illegal. Price fixing by a cartel fits this description and is thus illegal by virtue of the behavior regardless of its intent or effect. There is no allowable defense (though some industries are exempted).

Defining Collusion

Legal definitions and practice - United States

- "By operationalizing the idea of an agreement, antitrust law clarified that the idea of an agreement describes a process that firms engage in, not merely an outcome that they reach. Not every parallel pricing outcome constitutes an agreement because not every such outcome was reached through the process to which the law objects: a negotiation that concludes when the firms convey mutual assurances that the understanding they reached will be carried out." [Jonathan Baker, 1993]

Defining Collusion

Legal definitions and practice - European Union

- Article 65 of the Treaty of Paris (1951) prohibited agreements among firms which tend to reduce competition within the Common Market.
- Article 81 of the Treaty of the European Communities (1999) - "The following shall be prohibited as incompatible with the common market: all agreements between undertakings, decisions by associations of undertakings and concerted practices which may affect trade between Member States and which have as their object or effect the prevention, restriction or distortion of competition within the common market," and include:
  - fixing selling prices or any other trading conditions
  - controlling production, markets, technical development, or investment
  - sharing markets or sources of supply

Defining Collusion

Legal definitions and practice - European Union

- "Today pure market 'parallel behavior' without any attempt from the firms involved to communicate with each other or establish practices which help sustain collusion would probably not be judged by the Court of First Instance and the European Court of Justice as a concerted practice within the meaning of Article 81." [Massimo Motta, 2004]

Defining Collusion

Brands of collusion according to antitrust/competition law practice

- Explicit collusion: coordination through direct communication.
  - It occurs when firms directly communicate about price, market allocation, sales quotas, and other information pertinent to coordinating prices and quantities.
  - Legal status: Always illegal.
- Tacit collusion: coordination without direct communication.
  - When a less competitive outcome is achieved through mutual understanding among firms, price leadership, signalling using market instruments such as price, and any other method not involving direct communication.
  - Legal status: Generally legal.

Defining Collusion

Example of tacit collusion: FCC Spectrum Auctions, 1994-98

- Background
  - Sequential bidding over time for each license; bids are public information.
  - Each license had a number. Lubbock, Texas was 264 and Amarillo, Texas was 013.
  - Bids were in dollars and at least six digits.
- Bidders would use the last few bids to signal coordination.
  - For the Lubbock license, bidder Mercury PCS wanted bidder High Plains to stop bidding on Lubbock.
  - To do so, Mercury went in with a high bid on Amarillo, which was a license that High Plains had been the high bidder. To signal its intent, Mercury put 264 as the last three digits. E.g., its bid might have been $1,600,264.
  - To clarify its message, its next bid for the Lubbock license ended with 013.
  - The message was received as High Plains stopped bidding on Lubbock, and Mercury stopped its bidding on Amarillo.

Defining Collusion

Brands of collusion according to antitrust/competition law practice

- Tacit collusion: coordination without direct communication.
- U.S. Supreme Court (1993): "Tacit collusion ... describes the process, not in itself unlawful, by which firms in a concentrated market might in effect share monopoly power, setting their prices at a profit-maximizing, supracompetitive level by recognizing their shared economic interests and their interdependence with respect to price and output decisions."
- European Court of Justice defines "concerted practices" as "a form of coordination between undertakings which, without having reached the stage where an agreement properly so-called has been concluded, knowingly substitutes practical cooperation between them for the risks of competition."

Facts about Cartels

European Commission: 1998-2007 (Veljanovski, 2007)

- Average cartel had 5.4 firms and operated for 7.2 years.

Facts about Cartels

Data issues

- Biased sample because we only observe *discovered* cartels.
- Suppose only the less effective cartels are caught.
  - Cartel duration has been underestimated.
  - Welfare losses have been underestimated.
- Suppose only the more effective cartels are caught because the less effective ones collapse before being discovered.
  - Cartel duration has been overestimated.
  - Welfare losses have been overestimated.
- Challenge: Measuring how policy affects the fraction of industries that are cartelized.

Theory of Collusion

- Challenges faced by firms that want to collude.
- Challenge #1: Existence of a profitable and stable collusive agreement.
  - Market conditions must be consistent with the existence of a collusive agreement that is profitable (all colluding firms earn higher profit than under competition) and stable (each colluding firm chooses to abide by the collusive agreement).
  - Whenever collusion is an equilibrium, so is competition.
- Challenge #2: Achieving mutual understanding among firms concerning the collusive agreement
  - Explicit collusion - communicate using the spoken and written word.
  - Tacit collusion - how do you coordinate beliefs without talking?

Theory of Collusion

- Role of economic theory
  - *If* firms achieve mutual understanding regarding a collusive agreement, then economic theory identifies market conditions whereby the collusive agreement will persist over time.
  - Economic theory does not address *how such a mutual understanding is achieved*.
  - Economic theory does not show when collusion *will* occur, only when collusion *can* occur.
- Some questions that the economic framework can address.
  1. When is collusion feasible?
  2. What factors facilitate collusion?
  3. What does collusion look like?
  4. How do you distinguish collusion from competition?

Theory of Collusion

- What problems must a cartel solve to be successful?

1. Sustaining a collusive agreement
   - Monitoring for compliance
   - Punishing for non-compliance
   - Controlling the expansion of non-cartel supply
2. Coordinating on a collusive agreement
   - Bargaining
   - Communication
3. Eluding detection by customers and the competition authority

Perfect Monitoring

Theory of Collusion

- Infinitely repeated quantity game
  - Firms simultaneously choose quantities.
  - Price is set so as to clear the market.
  - Infinite horizon
- Inverse demand function, $P(\cdot)$
  - Firms' products are homogeneous
  - $\exists$ finite $\overline{Q} > 0$ such that $P(Q) = 0 \forall Q \geq \overline{Q}$
  - $P(\cdot)$ is twice continuously differentiable and $P'(Q) < 0 \forall Q \in (0, \overline{Q})$
  - Example: $P(Q) = \max\{a - bQ, 0\}$ where $a, b > 0$
- Firm cost function, $C_i(\cdot)$
  - $C_i(\cdot)$ is twice continuously differentiable and $C_i'(q) \geq 0 \forall q > 0$

Theory of Collusion

- Firm profit function

$$\pi_i(q_1, \ldots, q_n) \equiv \pi_i(q_i, Q_{-i}) \equiv P(q_i + Q_{-i})\, q_i - C_i(q_i)$$

  where $Q_{-i} = \sum_{j \neq i} q_j$. $\pi_i(q_i, Q_{-i})$ is quasi-concave in $q_i \forall q_i$.

- Strategy
  - Firms know the entire history; that is, all firms' past quantities.
  - Strategy is of the form $\{f_i^t\}_{t=1}^{\infty}$ where $f_i^t : [0, \overline{Q}]^{n(t-1)} \longrightarrow [0, \overline{Q}]$.
- Payoff is the sum of discounted single-period profits where $\delta_i \in (0, 1)$ is firm $i's$ discount factor:

$$\sum_{t=1}^{\infty} \delta^{t-1} \pi_i\left(q_i^t, Q_{-i}^t\right).$$

Theory of Collusion

- Trigger strategy

$$q_i^1 = q^o$$

$$q_i^t = \begin{cases} q^o \text{ if } q_j^\tau = q^o \forall \tau \leq t-1 \forall j \\ \\ \widehat{q} \text{ otherwise; } t \geq 2, i = 1, \ldots, n \end{cases}$$

where $q^o \in [q^m, \widehat{q})$.

  - $\widehat{q} \in \arg\max \pi\left(q, (n-1)\,\widehat{q}\right)$ is a static Nash equilibrium quantity.
  - $q^m \in \arg\max \pi(q, (n-1)q)$ is the joint profit-maximizing quantity.

Theory of Collusion

$$\pi(q) \equiv P(nq)q - C(q)$$

$$\pi^*(q) \equiv P(\psi((n-1)q) + (n-1)q)\psi((n-1)q) - C(\psi((n-1)q))$$

- Consider period 1 or a period t history such that $q_j^\tau = q^o \ \forall \tau \leq t-1$ $\forall j$.
- Subgame perfect equilibrium (SPE) requires:

$$\frac{\pi(q^o)}{1-\delta_i} \geq \pi(q,(n-1)q^o) + \delta_i \left[\frac{\pi(\widehat{q})}{1-\delta_i}\right] \forall q \neq q^o \Leftrightarrow$$

$$\frac{\pi(q^o)}{1-\delta_i} \geq \pi^*(q^o) + \delta_i \left[\frac{\pi(\widehat{q})}{1-\delta_i}\right] \Leftrightarrow$$

$$\delta_i \geq \frac{\pi^*(q^o) - \pi(q^o)}{\pi^*(q^o) - \pi(\widehat{q})}$$

Theory of Collusion

- Consider a period t history such that $q_j^\tau \neq q^o$ for some $\tau \leq t-1$, for some j.

$$\frac{\pi(\widehat{q})}{1-\delta_i} \geq \pi(q,(n-1)\widehat{q}) + \delta_i \left[\frac{\pi(\widehat{q})}{1-\delta_i}\right] \forall q$$

- Strategy profile is a SPE iff:

$$\delta_i \geq \frac{\pi^*(q^o) - \pi(q^o)}{\pi^*(q^o) - \pi(\widehat{q})} \forall i \Leftrightarrow$$

$$\min\{\delta_1, ..., \delta_n\} \geq \frac{\pi^*(q^o) - \pi(q^o)}{\pi^*(q^o) - \pi(\widehat{q})}$$

- Cheating yields higher short-run profit but lower long-run profit.
- A colluding firm must attach sufficient weight to future profits to find it optimal not to cheat.

Optimal Collusion

- Abreu (*Econometrica*, 1988), Abreu (*Journal of Economic Theory*, 1986)
- As a selection device, let us assume firms achieve, for any discount factor, the highest payoff supportable by a SPE.
- What is the maximal degree of collusion?
- What is the most severe credible punishment that can be imposed upon a deviator?
- What can we say about the form of the strategy profile that supports a maximal SPE payoff?

Optimal Collusion

- Define Q^j to be an outcome path for the game: $Q^j \in (A_1 \times \cdots \times A_n)^\infty$ where A_i is the stage game action set for player i.
- $\Omega^o \equiv$ set of SPE outcome paths.
- $\Omega \equiv$ set of all outcome paths.
- Definition: $\sigma(Q^0, Q^1, ..., Q^n)$ is a simple strategy profile if
  - *cooperation phase:* players play according to Q^0 until some player deviates from that outcome path
  - *punishment phase:* for any $j \in \{1, ..., n\}$, players play according to Q^j (starting with the first element) when player j deviates from the current path
  - if two or more players simultaneously deviate then players play according to the current outcome path

Optimal Collusion

- Example — infinitely repeated quantity game
  - Trigger strategy with T period reversion to static NE
  - $Q^0 = \{(q^o, ..., q^o), ...\}$
  - $Q^i = \{\underbrace{(\hat{q}, ..., \hat{q}), ..., (\hat{q}, ..., \hat{q})}, (q^o, ..., q^o), ...\}$
- Theorem: $Q^0 \in \Omega^o$ iff $\exists Q^i \in \Omega \forall i$ such that $\sigma(Q^0, Q^1, ..., Q^n)$ is a SPE.
- Remarks
  - If some outcome path is induced by a SPE then it is induced by a SPE in simple strategy profiles.
  - In characterizing the set of SPE outcomes, we can then limit our attention to simple strategy profiles.

Optimal Collusion

- Assumptions
  - Stage game is two-firm Cournot quantity game with homogeneous goods and constant marginal cost, c.
  - $P(\cdot) : \Re_+ \rightarrow \Re_+$ is strictly monotonic and continuous
  - $P(0) > c > 0$ ($c > 0$ is important; try to find where)
  - $\pi(q) \equiv P(nq)q - cq$ is strictly quasi-concave in q with a maximum of q^m
  - The stage game has a symmetric pure-strategy NE
- Statement of problem
  - $\Gamma \equiv$ set of SPE such that, for every history, the outcome path is symmetric
  - $v(\gamma)$ is the payoff to a (symmetric) player from symmetric strategy profile γ
  - Problem: Find $\gamma^* \in \Gamma$ such that $v(\gamma^*) \geq v(\gamma) \, \forall \gamma \in \Gamma$.

Optimal Collusion

- An *optimal symmetric punishment path* (OSP) is a solution to the problem of minimizing firm i's payoff subject to the outcome path being a symmetric SPE outcome path - Find $\widehat{\gamma} \in \Gamma$ such that $v\left(\widehat{\gamma}\right) \leq v\left(\gamma\right) \forall \gamma \in \Gamma$.
- Theorem: $\exists(\bar{q}, q^o)$ such that $\{(\bar{q}, \bar{q}), (q^o, q^o), ...\}$ is an OSP.
  - The punishment is producing $\bar{q}$ which may be rather high.
  - The reward to going through with the punishment is q^o which may be rather low; this is required since we are looking at punishment paths which are induced by SPE.
- Stick-and-carrot strategy
  - $Q^0 = \{(q^o, q^o), ...\}$
  - $Q^1 = Q^2 = \{(\bar{q}, \bar{q}), (q^o, q^o), ...\}$ [OSP]

Optimal Collusion

- Optimal stick-and-carrot strategy
  - It is a strategy profile that maximizes each player's payoff subject to the strategy profile being a SPE and having a symmetric outcome path for all histories.
  - $(\bar{q}, q^o)$ satisfies

$$\delta[\pi(q^o) - \pi(\bar{q})] = \pi^*(\bar{q}) - \pi(\bar{q})$$

$$\begin{aligned} \delta[\pi(q^o) - \pi(\bar{q})] &= \pi^*(q^o) - \pi(q^o) \text{ if } q^o \neq q^m \\ \delta[\pi(q^o) - \pi(\bar{q})] &\geq \pi^*(q^o) - \pi(q^o) \text{ if } q^o = q^m \end{aligned}$$

  - The first condition is to ensure that the punishment is credible. One wants it to be binding so that the worst punishment is inflicted.
  - The second condition generates the best collusive outcome.
  - These conditions feed into one another in that the higher is $\bar{q}$, the lower q^o can be. The lower is q^o, the higher $\bar{q}$ can be.

Optimal Collusion

- Assume $\pi(\cdot)$ and $\pi^*(\cdot)$ are continuously differentiable then $\bar{q} > \hat{q} > q^o$.
- Some collusion is sustainable regardless of δ (this also holds for infinite reversion to the static NE)
- Punishment involves each firm producing above that which maximizes current profit
- Punishment is worse than infinite reversion to the static NE:

$$\pi(\bar{q}) + \delta \left[\frac{\pi(q^o)}{1-\delta} \right] < \frac{\pi(\hat{q})}{1-\delta}$$

which supports a higher degree of collusion.

Imperfect Public Monitoring

Collusion with Price Monitoring

Model

- Green and Porter (Econometrica, 1984), Porter (JET, 1983)
- Demand: $P^t = \theta^t P\left(Q^t\right) = \theta^t(a - bQ^t)$
  - θ is an iid $r.v.$ with cdf $F(\cdot)$.
  - $F(0) = 0$, $F(\theta^o) = 1$, $\theta^o < \infty$
  - $F(\cdot)$ is continuously differentiable and convex
- Cost: $C(q) = c_o + c_1 q$
- Informational structure
  - In period t, a firm knows all past prices and all of its past quantities
  - Only past prices are common knowledge.

Collusion with Price Monitoring

Model

$$\pi\left(q_i, Q_{-i}\right) \equiv \int \left[\theta P\left(q_i + Q_{-i}\right) - c_o - c_1 q_i\right] F'\left(\theta\right) d\theta$$

$$\pi\left(q\right) \equiv \int \left[\theta P\left(nq\right) - c_o - c_1 q\right] F'\left(\theta\right) d\theta$$

- $\hat{q} \in \arg\max \pi\left(q, \left(n-1\right)\hat{q}\right)$ (static Nash equilibrium quantity)
- $q^o \equiv$ generic collusive quantity
- $q^* \equiv$ equilibrium collusive quantity

Collusion with Price Monitoring

Equilibrium Strategy

- Trigger strategies with imperfect monitoring
  - If in the *cooperative phase* in period $t-1$ and
    - ★ $P^{t-1} \geq \widetilde{P}$ then $q_i^t = q^o$ and remain in the cooperative phase
    - ★ $P^{t-1} < \widetilde{P}$ then $q_i^t = \hat{q}$ and go to the punishment phase
  - If in the τ^{th} period of the *punishment phase* in period $t-1$ and
    - ★ $\tau < T-1$ then $q_i^t = \hat{q}$ and remain in the punishment phase
    - ★ $\tau \geq T-1$ then $q_i^t = q^o$ and go to the cooperative phase
- Variables
  - $\widetilde{P}$ is the trigger price
  - $T-1$ is the length of the punishment or T is the time between when a punishment starts and when firms return to the cooperative outcome

Collusion with Price Monitoring

Most severe punishments

- Abreu, Pearce, and Stachetti (JET, 1986)
- Strategy profile
  - If in the *cooperative phase* in period $t-1$ and
    - ★ $P^{t-1} \geq \bar{P}$ then $q_i^t = q^o$ and remain in the cooperative phase
    - ★ $P^{t-1} < \bar{P}$ then $q_i^t = \overline{q}$ and go to the punishment phase
  - If in the *punishment phase* in period $t-1$ and
    - ★ $P^{t-1} \leq \underline{P}$ then $q_i^t = q^o$ and go to the cooperative phase
    - ★ $P^{t-1} > \underline{P}$ then $q_i^t = \overline{q}$ and remain in the punishment phase
- Price path
  - First-order Markov process
  - Regime switching with endogenous duration

Imperfect Monitoring with Flexible Production

Model

- Sannikov and Skrzypacz (AER, 2007)
- If firms can adjust their output more rapidly, is collusion more or less difficult?
  - With perfect monitoring, it is more difficult.
  - What about with imperfect monitoring (Green-Porter)?
- Quantity game: two firms, constant (zero) marginal cost, homogeneous goods.
- Infinitely repeated game is parameterized by period length, Δ.
  - Firms choose their quantities at $t = 0, \Delta, 2\Delta, 3\Delta, ...$
  - q_{it} is the rate of production so profit earned over $[t, t + \Delta)$ is $\Delta q_{it} p_t$.
  - As Δ shrinks, firms are able to adjust their supply rate more quickly.

Imperfect Monitoring with Flexible Production

Model

- Firms' quantities are private information.
- Price is public information:

$$p_t = P\left(Q_t\right) + \varepsilon_t, \text{ where } \varepsilon_t \sim N\left(0, \sigma^2/\Delta\right)$$

  - Distribution on price shocks is generated by a Brownian motion process.
- Firm i's expected payoff:

$$E\left[\sum_{t=0,\Delta,2\Delta,\ldots} e^{-rt} q_{it}\left(P\left(Q_t\right) + \varepsilon_t\right)\right]$$

- Trade-off on ability to collude from smaller Δ
  - Collusion is less difficult because a deviation is responded to more quickly.
  - Collusion is more difficult because price is a less informative signal which makes it more difficult to provide incentives to comply.

Imperfect Monitoring with Flexible Production

Maximal Symmetric Perfect Public Equilibrium

- Consider a symmetric collusive strategy profile with collusive quantity $\widehat{q}$.
- For some $D > 0$, deviation yields an instantaneous gain of $D\Delta$. Example: $D = \max_q qP\left(q + \widehat{q}\right)$.
- Deviation reduces average price from $\mu = P\left(2\widehat{q}\right)$ to μ^o. Example: $\mu^o = P\left(\arg\max qP\left(q + \widehat{q}\right) + \widehat{q}\right)$.
- Deviation reduces a firm's future payoff by

$$e^{-r\Delta} \int v\left(p\right)\left(g\left(p\right) - g^o\left(p\right)\right) dp$$

  - $v\left(p\right)$ is the expected continuation payoff where p is the previous period's price.
  - $g\left(p\right)$ is the normal density with mean μ and variance σ^2/Δ.
  - $g^o\left(p\right)$ is the normal density with mean μ^o and variance σ^2/Δ.

Imperfect Monitoring with Flexible Production

Maximal Symmetric Perfect Public Equilibrium

Lemma

If it exists, the solution to

$$\begin{aligned} & \max_{v(\cdot)} \int v(p)\, g(p)\, dp \\ \text{subject to } D\Delta &\leq e^{-r\Delta} \int v(p)\, (g(p) - g^o(p))\, dp \\ v(p) &\in [\underline{v}, \overline{v}] \ \forall p \end{aligned}$$

is

$$\begin{aligned} v(p) &= \begin{cases} \overline{v} & \text{if } p > c \quad \text{(continued collusion)} \\ \underline{v} & \text{if } p \leq c \quad \text{(price war punishment)} \end{cases} \\ \text{for some } c &\leq (\mu + \mu^o)/2. \end{aligned}$$

Imperfect Monitoring with Flexible Production

Maximal Symmetric Perfect Public Equilibrium

Theorem

As $\Delta \longrightarrow 0$, *the maximal SPPE payoff converges to the stage game NE payoff:* $\lim_{\Delta \to 0} \overline{v}(\Delta) = v^{Nash}$.

- When Δ is small,
  - the gain from deviation is on the order of Δ
  - the probability of type I error - $\int_{-\infty}^{c} g(p)\, dp$ - is on the order of $\sqrt{\Delta}$.
- As Δ gets smaller,
  - the statistical test becomes less informative
  - which makes inadvertent price wars more likely
  - which reduces the collusive payoff and the incentive to collude.

Cartel Case Studies

Lysine (1992-95): Collusive Outcome

- Ajinomoto and Sewon wanted to have exclusive geographic markets.
- Terry Wilson (ADM) argued against customer allocation because a "don't touch [each other's] customers policy" could create suspicions.
- Firms settled on a market sharing agreement with sales quotas.

Market Allocation (tons)

Company	Global	Europe
Ajinomoto	73,500	34,000
ADM	48,000	5,000
Kyowa	37,000	8,000
Sewon	20,500	13,500
Cheil	6,000	5,000

Cartel Case Studies

Lysine (1992-95): Monitoring

- Each company telephoned or mailed their sales to Kanji Mimoto of Ajinomoto.
- Mimoto prepared a spreadsheet that was distributed at the quarterly maintenance meetings.
- Terry Wilson (ADM): "... if I'm assured that I'm gonna get 67,000 tons by the year's end, we're gonna sell it at the prices we agreed to and I frankly don't care what you sell it for." (March 10, 1994 meeting of the lysine cartel)

Cartel Case Studies

Lysine (1992-95): Enforcement and Performance

- Enforcement
  - "Guaranteed buy-ins" - A company that sold more then its quota would have to buy product from producers who were below quota.
- Collusion was effective.
  - By the end of 1994, reported sales volume were only 1.4% higher than the targeted amount.
  - Sewon was farthest from its allotted share - selling 14.3% instead of 14.7%.
  - Mark Whitacre (ADM): "And that total for us for the year, calendar year is 68,000; 68,334. 68,334 and our target was 67,000 plus alpha. Almost on target." (January 18, 1995 meeting of the lysine cartel)

Cartel Case Studies

Citric acid (1991-95): Cartel Organization

- Hierarchical structure
  - "Masters" meetings: Presidents, CEOs, and General Managers would meet about twice a year to decide on price and a market allocation.
  - "Sherpa" meetings: Sales managers would meet to implement the agreement.
- Standard format
  - Discuss the latest cartel sales reports.
  - Discuss price levels and decide whether to raise prices.
  - Share information about non-cartel competitors.
  - Discuss "problems affecting the group" (cheating).

Cartel Case Studies

Citric acid (1991-95): Collusive Outcome

- Prices
  - Agreed to "floor" and "target" prices to be implemented.
  - Discount of up to 3% off the list price for major customers.
- Quantities
  - Sales quotas were allocated to each firm and fixed on a worldwide basis.
  - Quotas were based on the average of the previous three years' sales (1988-90).

Allocation of Market Shares

Company	Market Share
Haarman & Reimer	32.0%
ADM	26.3%
Jungbunzlauer	23.0%
Hoffman LaRoche	13.7%
Cerestar Bioproducts	5.0%

Cartel Case Studies

Citric acid (1991-95): Monitoring and Enforcement

- Monitoring of volume agreement
  - Monthly, each company's sales was reported to an executive of Hoffmann-La Roche.
  - Data was assembled and then reported back to the members by telephone.
  - Annual checking by independent Swiss auditors.
- Enforcement
  - Buy-back system: If a company exceeded its assigned quota in any one year, it would be obliged to purchase output from the companies with sales below their quota during the following year.
  - Example: At the meeting in Nov 1991 in Brussels, it was determined that Haarmann & Reimer had to buy 7,000 tons from ADM.

Cartel Case Studies

Zinc phosphate (1994-98)

- Coordination
  - Prices: Set "minimum" and/or "recommended" prices.
  - Market share allocations were based on market shares over 1991-93.
  - Some customer allocation: Large customer Teknos was sequentially allocated to the cartel members.
- Monitoring
  - Monthly, each producer sent its sales data to the trade association.
  - The trade association aggregated them and sent the market size to all five producers.
  - On an annual basis, market shares closely followed allocated shares.
- Enforcement
  - Allocation of Teknos was used as a form of compensation: "SNCZ seemed to have undersold and was 'allocated' Teknos for 6 months."

Cartel Case Studies

Common Features

- Product is homogeneous.
- Demand is largely from industrial buyers.
- Price is set bilaterally between seller and buyer and is generally not public information.
- Collusive agreement is monitored in terms of sales compared to quotas.
- Punishment involved transfers.

Cartel Case Studies

International Steel Agreement (1926)

- Articles 3 and 4: Fixed sales quotas.

Country	Allocated Market Share
Germany	40.45%
France	31.89%
Belgium	12.57%
Luxemburg	8.55%
Saar Territory	6.54%

- Article 5: "Every month each country's actual net production of crude steel during that month shall be ascertained ..."
- Articles 6 and 7: "If the quarterly production of a country exceeds [its] quota, that country shall pay in respect of each ton in excess a fine of 4 dollars ... If the production of any country has been below [its] quota, [it] shall receive in compensation ... the sum of two dollars per ton short."

Collusion with Sales Monitoring

Harrington and Skrzypacz (Rand 2007)

- Theoretical findings
  - Symmetric price wars cannot sustain collusion.
    - ★ Robust to market demand being highly price-inelastic.
  - Asymmetric punishments in the form of transfers can sustain collusion.
    - ★ Robust to when firms set customer-specific prices.
- A transfer can be consummated through inter-firm sales.
- Examples of cartels using inter-firm sales as a punishment device.
  - Citric acid (1991-95)
  - Graphite electrodes (1992-97)
  - Vitamins A and E (1989-99)

Collusion with Self-Reported Sales

Harrington and Skrzypacz (AER 2011)

- If firms' sales are public information then collusion can be supported using asymmetric punishments.
- Cartel practice: Firms report their sales in cartel meetings but are these reports truthful?
- Theoretical exercise
  - Assume prices and quantities are private information.
  - Firms exchange messages (sales reports) prior to making transfers.
  - Characterize an equilibrium in which firms truthfully report their sales and collusion is sustained.
  - Feature of the equilibrium resemble cartel practices

Collusion with Privately Observed Cost Shocks

- Suppose firms have different traits which are private information.
- This poses a number of challenges for a cartel
  - Miscoordination
    - ★ Given private information, it is may be more difficult for firms to agree to a particular outcome.
    - ★ This problem is assumed away with an equilibrium analysis.
  - Inefficiency
    - ★ Firms may not achieve an ex post Pareto efficient outcome because, due to lack of common information, the collusive outcome has the less efficient firm producing too much.
    - ★ Private information may create greater incentives to deviate which requires lower collusive profit or makes collusion unsustainable.
    - ★ Typical consequence: price rigidity
- Set up: cost is independent across firms
  - Cost is independent across time (Athey and Bagwell, 2001)
  - Cost is persistent across time (Athey et al. 2004, Athey and Bagwell 2009)

Outline

1. Properties of cartel price paths - What do we need to explain?
2. Collusive pricing with customer/competition authority detection - exogenous detection technology
3. Collusive pricing with customer/competition authority detection - endogenous detection technology
4. Endogenizing cartel formation

Properties of Cartel Price Paths

Frozen Perch Cartel

- Transition phase in which price gradually rises.

Connor (2001)

- Transition phase in which price gradually rises.
- Cartel formation is preceded by price decline.

Levenstein and Suslow (2001)

- Low price variance.

Abrantes-Metz, Froeb, Geweke, and Taylor (2005)

Properties of Cartel Price Paths

Summary (Tentative)

1. Cartel formation is preceded by price decline.
2. Transition phase in which price gradually rises.
3. Stationary phase in which price variance is low.

Developing a Theory of Cartel Pricing that Fits the Facts

- Collusive pricing theories do not generate anything that look like these price paths. Why has theory failed?
- Objectives of a cartel
  1. Raise price
  2. Maintain the internal stability of the cartel.
  3. Avoid creating suspicions that a cartel has formed.
- Theory has focused on the role of internal stability to the exclusion of detection avoidance
- Modelling Objectives
  - Integrate the possibility of detection and antitrust penalties into a model of cartel pricing.
  - Take account of the endogeneity of detection and penalties to cartel behavior.

Collusive Pricing and Customer Detection

Model

- Harrington (IER, 2005; RJE 2004)
- Stage game is a symmetric oligopoly price game.
  - Differentiated products price game
    - ★ $\pi\left(P_i, P_{-i}\right) : \Omega^2 \rightarrow \Re$ is continuously differentiable in its own price, P_i, and in the common price of rivals, P_{-i}, and is quasi-concave in P_i.
  - Bertrand price game - homogeneous products with constant marginal cost.
- $\exists$ unique symmetric equilibrium price, $\widehat{P}$. Let $\widehat{\pi} \equiv \pi\left(\widehat{P}, \widehat{P}\right)$.
- $\pi\left(P\right) \equiv \pi\left(P, P\right)$ is quasi-concave in P and $\exists P^m > \widehat{P}$ such that $\pi\left(P^m\right) > \pi\left(P\right) \; \forall P \neq P^m$.
- Infinite horizon game of perfect monitoring.

Collusive Pricing and Customer Detection

Model: Sequence of Events

- Firms decide whether to form a cartel.
  - If they decide not to form a cartel, they receive a payoff of $\widehat{\pi}/(1-\delta)$.
  - If they decide to form a cartel, they choose price.
- Suppose a cartel is active as of period t.
  - Firms agree to a common price P^t and each realizes profit of $\pi(P^t)$.
  - With some probability, the cartel is detected.
    - ★ Each firm pays a penalty of $X^t + F$ and receives $\widehat{\pi}$ in all future periods.
    - ★ X^t is accumulated damages at the end of period t.
    - ★ F is the level of fines.
  - If the cartel is not detected then collusion continues to period $t+1$.

Collusive Pricing and Customer Detection

Model: Evolution of Damages

- X^t is accumulated damages as of t.

$$X^t = \beta X^{t-1} + \gamma x\left(P^t\right)$$

- $x\left(P^t\right)$ is the level of damages incurred in period t.
- $x : \Omega \longrightarrow \Re_+$ is bounded, continuous, and non-decreasing.
- Damages are assessed only in periods for which the cartel is active and effective.

Collusive Pricing and Customer Detection

Model: Evolution of Damages

- Current U.S. antitrust practice:

$$x\left(P^t\right) = \left(P^t - \widehat{P}\right) D\left(P^t\right).$$

  where $D(P)$ is firm demand and $\widehat{P}$ is the "but for" price.
- $\gamma \geq 0$ is the damage multiple (U.S.: $\gamma = 3$)
- $1 - \beta \in (0, 1)$ is the depreciation rate of damages.

Competition Policy

Leniency Programs

- A *leniency program* offers reduced penalties to corporations and/or individuals involved in collusion, in exchange for cooperating with enforcement authorities.
- U.S. Department of Justice
  - 1993: Revised corporate and individual leniency program.
  - Three major revisions:
    - ★ amnesty is automatic if there is no pre-existing investigation
    - ★ amnesty may still be available even after an investigation has started
    - ★ all officers, directors, and employees who cooperate are protected from criminal prosecution.
  - Annual number of leniency applications increased 20-fold.

Leniency Programs

- European Commission
  - 1996: introduced leniency program
  - 2002: revised leniency program
- Spain
  - 23 Feb 2008: A company's lawyer camps outside the Comisión Nacional de la Competencia (CNC) offices awaiting activation of the leniency program.
  - 28 February 2008: Leniency program is activated. Seven applications are received on the first day.
  - 21 January 2010: First sanctions decision adopted by the CNC based on a leniency application. Cosmetics firms Sara Lee, Puig, and Colgate Palmolive received a total fine of EUR8.3 million for taking part in a cartel in the bath and shower gel industry.

Before an Investigation	U.S.	EU/Spain	Japan
First firm	100%	100%	100%
Second firm	Plea	30-50%	50%
Third firm	Plea	20-30%	30%
Fourth or later firm	Plea	0-20%	0

After an Investigation	U.S.	EU/Spain	Japan
First firm	100%	30-100%	30%
Second firm	Plea	20-30%	30%
Third firm	Plea	0-20%	30%
Fourth or later firm	Plea	0-20%	0

Plea - Reduced fine from plea bargaining (In the U.S., the second cartel member to plead guilty received a mean discount from the maximum recommended sentence of 75% - Connor, 2007.)

- Veljanovski, 2007
- EC provided partial or full leniency in 45 of 50 cartel cases.
- Leniency lowered average fines per cartel by almost 40% from 199 million to 123 million euros.

European Commission - Fines and Leniency
Monochloroacetic Acid Cartel (1984-99)

Company	Fine Paid (millions €)	% Reduction
Hoechst	74.03	0%
Akzo	84.38	25%
Atofina	58.50	40%
Clariant	0	100%