

# *The Current State of the Theory of Collusion: Unexplained Phenomena and Unexplored Directions*

Bergen Competition Policy Conference  
Bergen Center for Competition Law and Economics

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Penn - Wharton

April 23-24, 2015

# Introduction

Some central research questions on collusion

- 1 When and where do firms collude?
- 2 How do firms collude?
- 3 What determines collusive outcomes?

# When and Where Do Firms Collude?

- 1 When is collusion stable?

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- ▶ Participation: When do firms want to shift from a static Nash equilibrium to a profit-improving equilibrium for the repeated game?

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  - ▶ Participation: When do firms want to shift from a static Nash equilibrium to a profit-improving equilibrium for the repeated game?
- 3 When is collusion is achievable?
  - ▶ Coordination: When are firms willing and able to coordinate a shift from a static Nash equilibrium to a profit-improving equilibrium for the repeated game?



# When and Where Do Firms Collude?

## Example

- Assume collusion is sustained with the grim punishment (static Nash equilibrium forever)
- Stability (or incentive compatibility) constraint: Each firm will set the collusive price if

$$\pi^c + \delta V^c \geq \pi^d + \delta V^{nc} \Rightarrow \delta (V^c - V^{nc}) \geq \pi^d - \pi^c$$

- ▶  $\pi^c$  is collusive profit,  $V^c = \frac{\pi^c}{1-\delta}$  is the value of colluding
- ▶  $\pi^d$  is the profit from deviating
- ▶  $\pi^{nc}$  is non-collusive profit,  $V^{nc} = \frac{\pi^{nc}}{1-\delta}$  is the value from not colluding

# When and Where Do Firms Collude?

- Suppose the coordinating practice is price leadership.
  - ▶  $\pi^l (< \pi^{nc})$  is the profit of the leader in the period it is coordinating a move.
  - ▶ Collusion results with probability  $\rho$ .
- Coordination constraint: If no other firm is expected to take the initiative then a firm will lead on price if

$$\begin{aligned}\pi^l + \delta\rho V^c + \delta(1 - \rho) V^{nc} &\geq \pi^{nc} + \delta V^{nc} \\ \Rightarrow \delta(V^c - V^{nc}) &\geq \frac{\pi^{nc} - \pi^l}{\rho}\end{aligned}$$

# When and Where Do Firms Collude?

What is the binding constraint?

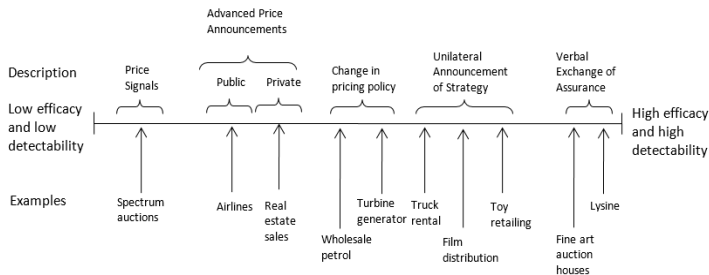
- Stability?

- ▶  $\delta (V^c - V^{nc}) > \pi^d - \pi^c =$  profit gain from lowering price when all other firms set the collusive price

- Coordination?

- ▶  $\delta (V^c - V^{nc}) > \frac{\pi^{nc} - \pi^l}{\rho} =$  profit loss from raising price when all other firms set the non-collusive price divided by the probability that collusion ensues

# When and Where Do Firms Collude?



- What determines which coordinating practice is used?
  - ▶ Effectiveness in producing collusion
  - ▶ Risk of discovery and conviction
- Need to explain the coordinating practice to understand when firms collude

# When and Where Do Firms Collude?

Given stability and coordination constraints are satisfied, when is the participation constraint satisfied? *When do firms want to collude?*

- Profit approach: When is incremental profit from collusion positive?
  - ▶ Fershtman and Pakes (*RAND Journal of Economics*, 2000), Paha (Working Paper, 2013)
- Claim: Collusion does not occur frequently enough by this theory.
  - ▶ Is it due to expected penalties?
  - ▶ Is it due to the difficulty of coordinating?

# When and Where Do Firms Collude?

Given stability and coordination constraints are satisfied, when is the participation constraint satisfied? *When do firms want to collude?*

- Observation: Many cartels form after a significant decline in price and profit. Is cartel formation due to
  - ▶ a change in market conditions that makes collusion stable or desirable?
    - ★ Example: Decline in demand  $\Rightarrow$  excess capacity  $\Rightarrow$  intense price competition
  - ▶ a shift in the equilibrium (breakdown of tacit collusion)
  - ▶ managerial aspirations being unsatisfied unless firms collude?

# When and Where Do Firms Collude?

## Takeaways

- Theory describes the types of collusive arrangements that are stable.
- Theory does not address when
  - ▶ firms are able to coordinate expectations on a collusive arrangement
  - ▶ firms seek to shift expectations
- Until this is done, theory will not adequately explain
  - ▶ in which markets cartels are likely to form
  - ▶ when a cartel is likely to form in a market

# How Do Firms Collude?

- There are many collusive equilibria. What are the properties of the collusive equilibrium that firms settle upon?
  - ▶ What is the collusive outcome? market allocation? price?
  - ▶ How is it monitored?
  - ▶ What is the form of punishment?
- Overview
  - ▶ What have we recently learned about collusive practices?
  - ▶ What are some promising theoretical directions?
  - ▶ What are some phenomena that are yet to be adequately explored and explained?



# How Do Firms Collude?

Recent understanding

Traditional features of theoretical and empirical models

- Coordinate on prices (and/or quantities)
- Monitor firms' prices for compliance
- Punishment has all firms reduce prices
  - ▶ Temporary or permanent return to competitive pricing
  - ▶ Price war - temporary implementation of prices below competitive level

# How Do Firms Collude?

Recent understanding

**Property 1: In many cartels, monitoring is in terms of sales, not price.**

- Common properties of many recent cartels in intermediate goods markets
  - ▶ Price is not public information.
  - ▶ Collusive agreement is a market allocation in terms of, for example, sales quotas.
  - ▶ Monitoring involves comparing sales to the agreed-upon quotas.

# How Do Firms Collude?

Recent understanding

Lysine Cartel: Annual Market Allocation (tons)

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

- Each company telephoned or mailed their sales volumes to Kanji Mimoto of Ajinomoto.
- Mimoto prepared a spreadsheet that was distributed at the quarterly maintenance meetings.

# How Do Firms Collude?

Recent understanding

## **Property 2: In many cartels, punishments are asymmetric and not symmetric price wars.**

- Asymmetric punishments include
  - ▶ transfers such as through inter-firm sales
    - ★ Lysine: guaranteed buy-ins
    - ★ Citric acid: buy-backs
  - ▶ focused price war on a deviator's customers
- Why are punishments asymmetric?
  - ▶ Pareto improvement for firms relative to symmetric punishments
  - ▶ Symmetric punishments are far less effective when monitoring is in terms of sales.

# How Do Firms Collude?

Recent understanding: Harrington and Skrzypacz (*RAND Journal of Economics*, 2007)

- Model
  - ▶ Firms simultaneously choose prices
  - ▶ Each firm's price is private information
  - ▶ A firm's demand depends stochastically on all firms' prices
  - ▶ Firms' sales are publicly revealed
- Inference problem: Are a firm's low sales due to a demand shock or a rival undercutting the collusive price?
- **Result:** When market demand is highly inelastic, almost no collusion is sustainable with symmetric punishments.

# How Do Firms Collude?

Recent understanding: Harrington and Skrzypacz (*RAND Journal of Economics*, 2007)

- Consider a duopoly in which there is a symmetric punishment ("price war") if either firm has a market share above  $\hat{s}$ .
- If firm 1 undercuts the collusive price,
  - ▶ it *increases* the probability that firm 1's market share exceeds  $\hat{s}$  which makes a price war *more* likely.
  - ▶ it *decreases* the probability that firm 2's market share exceeds  $\hat{s}$  which makes a price war *less* likely.
- These offsetting effects cancel each other out so a firm's price does not affect the probability of a price war.
- A firm then cheats as there is no future profit loss  $\Rightarrow$  all collusive agreements are unstable.

# How Do Firms Collude?

Recent understanding: Harrington and Skrzypacz (*RAND Journal of Economics*, 2007)

Two-tier asymmetric punishment will sustain collusion.

- Penalties for overproduction support higher prices.
  - ▶ A firm makes a payment of  $x$  to its rivals for each unit it sells.
  - ▶ Collusive price is the static Nash equilibrium when "marginal cost" is  $MC + x$ .
  - ▶ Transfers can be consummated through inter-firm sales.
- Threat of collapse of collusion ("price war") support the making of transfers.
  - ▶ If firms do not honor the compensation scheme then collusion collapses.
  - ▶ Firms then find it optimal to make these transfers.

# How Do Firms Collude?

Recent understanding: Harrington and Skrzypacz (*American Economic Review*, 2011)

**Challenge:** In practice, monitoring was in terms of *self-reported* sales which, generally, were not verifiable.

- Stability requires that these reported sales be truthful.

Extensive form

- Firm chooses its price (private information)
- Firm learns its sales (private information)
- Firm submits sales report (cheap talk)
- Firm makes transfers (based on sales reports)



# How Do Firms Collude?

Recent understanding: Harrington and Skrzypacz (*American Economic Review*, 2011)

- Stability requires that firms find it optimal to
  - 1 set the collusive price
  - 2 truthfully report sales (binding constraint)
  - 3 make transfers
- How is a firm induced to truthfully report high sales?
  - ▶ Price war is more likely when the aggregate sales report is lower.
  - ▶ A firm that reports lower sales makes a lower transfer but then it enhances the likelihood of a price war.
- Collusion is stable when market demand is not too volatile.

# How Do Firms Collude?

Recent understanding: Chan and Zhang (*Journal of Economic Theory*, 2015)

**Challenge:** Can we extend this scheme to when firms' costs are private information?

Extensive form

- Firm learns its cost (private information)
- Firm submits cost report (cheap talk)
- Firms chooses its price (private information)
- Firm learns its sales (private information)
- Firm submits sales report (cheap talk)
- Firm makes transfers (based on cost and sales reports)

# How Do Firms Collude?

Recent understanding: Chan and Zhang (*Journal of Economic Theory*, 2015)

- **Result:** A transfer scheme is constructed such that if firms are sufficiently patient and firm demand is sufficiently stable then profits close to the joint maximum can be sustained in equilibrium.
- How the transfer scheme works:
  - ▶ A firm's transfer is decreasing in other firms' reported profits.
  - ▶ Reports are then truthful because they do not affect a firm's payoff  $\Rightarrow$  firms' profits are revealed
  - ▶ If a lower price reduces other firms' profits more than it raises a firm's own profit, it will not want to deviate.
- Very general: private cost shocks, many common demand functions, quantity choice
- Transfer scheme differs from that in Harrington and Skrzypacz (AER, 2011) in that a firm's transfer
  - ▶ does not depend on its own sales report
  - ▶ is non-linear in firms' reports

# How Do Firms Collude?

Recent understanding: Communication

## Frequency of Meetings

(Source: European Commission Decisions)

Market	Monitoring	Allocation
Choline chloride	2-3 weeks	6 months
Zinc phosphate	monthly	3 months
Citric acid	monthly	6 months
Organic peroxides	3 months	3-6 months
Sorbates	6 months	6 months

- Communication is a critical component of cartels
- These communication practices are *part of an equilibrium* rather than *lead to an equilibrium*.

# How Do Firms Collude?

Recent understanding: Communication

- Private monitoring setting
  - ▶ Firms' prices and sales are private information.
  - ▶ Sales are stochastic due to unobserved demand shocks.
  - ▶ Consider equilibria with and without a communication (cheap talk) phase.
  - ▶ Cheap talk can be used to share sales data (Do firms have the incentive to provide accurate reports?)
- Questions
  - ▶ When is profit higher by communicating?
  - ▶ What types of communication schemes are effective?
  - ▶ What is the optimal frequency of information sharing (meetings)?

# How Do Firms Collude?

Recent understanding: Awaysa and Krishna (Working Paper, 2014)

- **Result:** There exists an equilibrium with communication that is strictly more profitable than any equilibrium in which firms do not communicate.
- Step 1: When firms cannot communicate and sales are sufficiently noisy, equilibrium payoff is bounded below Pareto frontier.
- Step 2: If firms' sales are highly correlated - but only when their prices are similar - then this bound can be exceeded when firms communicate
  - ▶ If firms sales are highly correlated when they all set the collusive price then their sales reports will also be highly correlated. There is no punishment as long as their reports agree.
  - ▶ When a firm deviates, sales are less correlated which makes a punishment more likely as sales reports are not highly correlated.

# How Do Firms Collude?

Recent understanding: Spector (Working Paper, 2014)

- Firms learn their own sales at a high frequency (e.g., monthly)
  - ▶ If firms use these signals to provide incentives, there are inefficiencies due to the noise.
  - ▶ Punishment is quick but is used too much
- Firms learn all firms' actual sales at a low frequency (e.g., annually)
  - ▶ If firms use these signals to provide incentives, inefficiencies are reduced because of less noise.
  - ▶ Punishment is delayed.
- If firms share those private signals through cheap talk messages then they can have precise public signals at high frequency.
  - ▶ Messages are truthful because the truth will be revealed in the future and it can be harshly punished at no cost (perfect monitoring)
- **Result:** Firms can more effectively collude by sharing their private sales information.

# How Do Firms Collude?

Some unexplained phenomena

- Episodes of collusion for which firms appear to effectively collude through rather constrained and limited means
  - ▶ Fuel surcharges
  - ▶ List prices
- Questions
  - ▶ How does collusion work?
  - ▶ What market conditions are necessary for it to work?



# How Do Firms Collude?

## Some unexplained phenomena: Surcharges

Price-fixing has occurred or been suspected in several transportation markets in which firms coordinated on a common fuel surcharge

- Air freight (global), 2000-06
  - ▶ Lufthansa applied for leniency in the US and EU
  - ▶ Over 40 air cargo companies
  - ▶ Fine and damages (so far): 2.7B€
- Air passenger (inter-continental), 2004-06
  - ▶ Virgin Atlantic applied for leniency and reported that it was colluding with British Airways
- Rail freight (U.S. - Burlington Northern Santa Fe, Union Pacific, Norfolk Southern Corp., CSX)
  - ▶ On-going litigation; not yet determined whether they did collude on fuel surcharges

# How Do Firms Collude?

## Some unexplained phenomena: Surcharges

- Air freight
  - ▶ Surcharge was per kilogram; independent of origin, destination, and distance
  - ▶ British Airways increased fuel surcharge from 4 cents/kilogram to 72 cents/kilogram
- Air passenger
  - ▶ Surcharge was per ticket
  - ▶ For a transatlantic round-trip, it rose from \$10/ticket in 2004 to \$110/ticket in 2006
- Rail freight
  - ▶ Surcharge was a % of the rail freight transport base rate.
  - ▶ During 2001-07, surcharges increased 55% more than the rise in fuel costs

# How Do Firms Collude?

## Some unexplained phenomena: Surcharges

- These markets have many customers and products which makes coordination and monitoring on price very difficult
  - ▶ Freight - each customer is defined by volume, weight, distance
  - ▶ Passenger - many different flights, airlines price discriminate and engage in dynamic pricing
- How can collusion in one component of price be effective?
  - ▶ Why couldn't an air cargo company reduce its base rate in order to get more business? Such "cheating" would be difficult to observe.
  - ▶ Why couldn't BA and VA cut its base rate by 50% of the surcharge? With many flights and many pricing schemes, it would be difficult to detect.

# How Do Firms Collude?

## Some unexplained phenomena: Surcharges

Under what conditions is collusion effective when firms coordinate on only one component of price, such as fuel surcharges or shipping fees?

- Sales monitoring - Was the collusive outcome to increase competitive prices by the surcharge? Was it monitored in terms of sales?
- Bargaining - Did this common fuel surcharge convey a common cost to buyers which impacted bargaining under competition?
- Internal organization
  - ▶ Pricing complexity - With complicated pricing formulas (especially air passenger), could it be difficult to adjust prices to offset a surcharge?
  - ▶ Delegation - Is it difficult (or would it create suspicions) to instruct personnel to offset a surcharge?

# How Do Firms Collude?

Some unexplained phenomena: List prices

Firms collude on list prices, offer discounts, and do not collude on final transaction prices.

- *In re: Urethane Antitrust Litigation* (10th Cir., 2014)
  - ▶ On-going private litigation
  - ▶ Plaintiffs' statement: "The alleged conspirators announced identical price increases simultaneously or within a very short time period. ... Purchasers could try to negotiate down from the increased price but the increase formed the baseline for any negotiations."
- *Lum v. Bank of America* (2004)
  - ▶ Plaintiffs claimed that banks coordinated on a common prime rate for lending but admitted that the actual interest rate varied.
  - ▶ District Court dismissed the case (and 4th Cir. upheld) on the grounds that evidence of parallel movements in the base rate, but not the final rates, is insufficient evidence.

# How Do Firms Collude?

Some unexplained phenomena: List prices

How could colluding on list prices result in higher transaction prices?

- Could a common list price affect search and negotiation and thereby impact transaction prices?
- Under what market conditions is collusion effective when they coordinate on list prices but not discounts?

# How Do Firms Collude?

Some unexplored phenomena: Price signalling

- Advance price announcements as a (near-costless) coordinating practice
  - ▶ A firm announces a future price increase through some public medium
  - ▶ If rivals respond with similar announcements then proposed price increases are implemented.
  - ▶ If rivals do not respond in kind then the initial firm retracts the proposed price increase before any transactions occur
- Examples
  - ▶ Steel (U.S., 1950s) - announced through executive speeches, interviews with trade publications, etc.
  - ▶ Airlines (U.S., 1980s) - announced through airline reservation system
  - ▶ Diesel and petrol fuel (Taiwan, 2000-02) - announced through the media

# How Do Firms Collude?

Some unexplored phenomena: Price signalling

- Australia - June 2012
  - ▶ Instituted law prohibiting anti-competitive price signalling and information disclosures for the banking sector.
  - ▶ May be extended to other sectors of the economy.
- European Commission - December 2013
  - ▶ Container liner shipping: Since 2009, these companies have made regular public announcements of price increase intentions through press releases
  - ▶ EC is concerned that "this practice may allow the companies to signal future price intentions to each other and may harm competition and customers by raising prices."
- Israel - August 2014
  - ▶ Issued for public comment a proposed policy regarding "public statements that harm competition"



# How Do Firms Collude?

Some unexplored phenomena: Price signalling

## Policy challenge

- Advance price announcements may "reduce strategic uncertainty" and thereby promote coordination on higher prices
- Advance price announcements can have an efficiency benefit
  - ▶ Consumers may benefit from knowing what future prices might be
  - ▶ But these are only intentions and actual future prices could be different.
- How do we distinguish between announcements intended to inform consumers and announcements intended to coordinate with other firms?

# How Do Firms Collude?

Some unexplored phenomena: Price signalling

## Theoretical issues

- Derive market conditions for which
  - ▶ public announcements will have little value to consumers so the efficiency benefit can be dismissed
  - ▶ collusive equilibria exist
- Multiple audience cheap talk model where a firm may be communicating with other firms and/or customers

# How Do Firms Collude?

Is recent research in the theory of repeated games helpful?

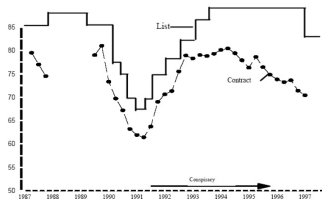
- Repeated game theorists continue to focus on proving folk theorems, which are generally of little relevance to applied work because
  - ▶ they can be predicated on highly complex and unrealistic strategies
    - ★ Example: belief-free equilibria for repeated games with private monitoring
  - ▶ almost all applied questions pertain to behavior (prices and quantities), not payoffs (profits)
- Needed directions
  - ▶ Focus on strategies, not payoffs
  - ▶ Return to thinking about and modelling complexity (see computational complexity literature in the 1990s)

# What Describes and Determines Collusive Outcomes?

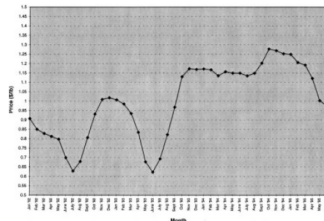
- Price
  - ▶ What determines pricing dynamics?
  - ▶ **What determines the steady-state collusive price?**
- Other features of outcomes
  - ▶ Market allocation
  - ▶ Cartel duration

# What Describes and Determines Collusive Outcomes?

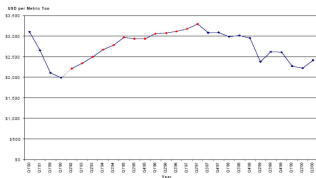
What determines the collusive price?



Citric Acid

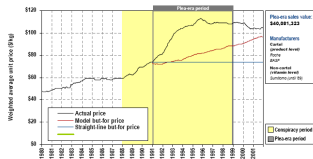


Lysine



Graphite Electrodes

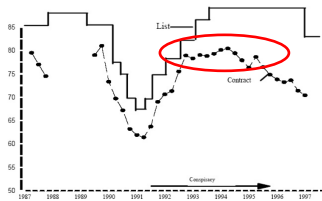
Figure 12-18: Beta Carotene 10% Cold Water Soluble USP price and but-for price



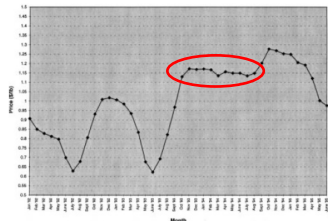
Vitamins (Beta Carotene)

# What Describes and Determines Collusive Outcomes?

What determines the collusive price?

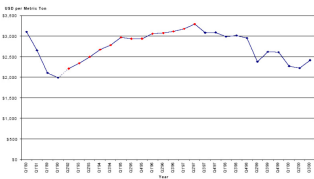


Citric Acid

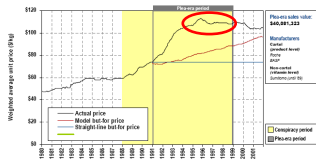


Lysine

Figure 12-18: Beta Carotene 10% Cold Water Soluble USP price and but-for price



Graphite Electrodes



Vitamins (Beta Carotene)

# What Describes and Determines Collusive Outcomes?

What determines the collusive price?

*What determines cartel pricing dynamics?*

*What determines the ultimate level to which price is raised? What determines comparative statics?*

The cartel may stop increasing price because a higher price is

- **unstable** (inconsistent with equilibrium) - ICC is binding
- **unprofitable** (consistent with equilibrium but is unprofitable) - ICC is not binding
  - ▶ monopoly price or constrained by the price of the next best substitute or non-cartel suppliers
  - ▶ concerned that further price increases may create suspicions of unlawful collusion
  - ▶ buyer resistance
- uncertainty over how high a price is stable - will the ICC be satisfied?

# What Describes and Determines Collusive Outcomes?

What determines the collusive price?

Cartel stability - Is it reasonable to assume that the ICC binds?

$$\text{discount factor} > \frac{\text{deviation profit} - \text{collusive profit}}{\text{deviation profit} - \text{competitive profit}}$$

- Given the usual period length and a firm's cost of funds, the discount factor would seem to be close to one.
- It has been suggested that it is implausible that it is a binding ICC that determine the collusive price.
- Joe Farrell posed this criticism at CRESSE 2012



# What Describes and Determines Collusive Outcomes?

What determines the collusive price?

- ICC may be binding because of imperfect monitoring
  - ▶ With imperfect monitoring, there is a smooth trade-off from raising price - higher current profit but a smaller chance of a punishment.
  - ▶ Collusive price  $<$  Monopoly price: A small reduction in price below the monopoly price would have
    - ★ no first-order effect on current expected collusive profit
    - ★ a first-order effect on future expected collusive value because the incentive to deviate is weakened which reduces the required likelihood of a punishment
- ICC may be binding if it is a manager's discount factor that is relevant
  - ▶ Managers may have short horizons because periods of low profit could cause them to be dismissed

# What Describes and Determines Collusive Outcomes?

What determines the collusive price?

Unlawful collusion and detection: Exogenous detection technology

- Higher prices, bigger price changes, price changes less correlated with cost changes - all may raise the likelihood of being caught by customers or the competition authority
- Steady-state price  $<$  monopoly price has been shown in
  - ▶ Block, Nold, and Sidak (JPE 1981) - static model
    - ★ Probability of paying penalties is increasing in price level
  - ▶ Harrington (RJE 2004, IER 2005, IJIO 2006) - dynamic model
    - ★ Probability of paying penalties is increasing in price change
    - ★ Pricing dynamics: collusive prices are less volatile than competitive prices in response to cost variability

# What Describes and Determines Collusive Outcomes?

What determines the collusive price?

Unlawful collusion and detection: Endogenous detection technology

- Static game of incomplete information between firms and competition authority (or customers)
  - ▶ Competition authority is uncertain whether firms are colluding but know how firms price if they are colluding
  - ▶ Common cost is private information to firms
  - ▶ Firms act as a monopolist
  - ▶ Besanko and Spulber (EJ 1989, AER 1990), LaCasse (RJE 1995)
- Dynamic analysis - no research
  - ▶ Introduces ICCs
  - ▶ Introduces time-series data to test whether there is collusion

# Concluding Remarks

In spite of the great wealth of work on the theory of collusion, there is still a need for research that

- models cartel pricing dynamics and identifies the determinants of the steady-state cartel price
- explains observed collusive practices including communication practices
- takes account of the variety of coordinating practices
- models cartel formation and provides testable hypotheses regarding when and where cartels form