Advanced Industrial Organization II
Lecture 2: Detecting Cartels

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1 Mechanics

My lectures in this course will discuss empirical methods useful for analyzing cartels, mergers, vertical restraints and predation. Johan Stennek's lectures will cover the same topics but mainly from a theoretical point of view.

Unlike AIO1, there will be no empirical assignments in this course. Instead, we will include student presentations of some of the research papers on the reading list.

All my lectures will start at 13.15 and end at 15.00 - i.e. we have **two-hour** lectures.

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Important message from Florin Maican: On Tuesday April 7th (tomorrow) there will be a lab on cartels. The room has recently been changed from D31 to D43. The time is the same as before, i.e. 13-16.

The schedule for the course, and the reading list for my lectures, are as follows:

[Schedule; Måns' reading list here]

Advanced Industrial Organization II
University of Gothenburg
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Lectures by Måns Söderbom:

Reading List

The main textbook is the following:

Industrial Organization: Contemporary Theory and Empirical Applications, by Lynne Pepall, Dan Richards and George Norman (4th edition, 2008).

Below, and in the lecture notes, I will refer to this book as Pepall et al.

April 6th, 13-15: Cartels 1:2

Selected parts in Pepall et al., Chapters 14-15

Harrington, Joseph E. (2005) “Detecting Cartels,” mimeo. Johns Hopkins University. Baltimore, MD. Available at:
http://www.econ.jhu.edu/pdf/papers/WP526harrington.pdf

April 14th, 13-15: Cartels 3; Mergers 1

Student presentation:
Porter, Robert H., "A Study of Cartel Stability: The Joint Executive Committee, 1880-1886," Bell Journal of Economics, 14 (1983), 301-314.

Pepall et al., Chapter 17

April 27th, 13-15: Mergers 2:3

Student presentation:
Kim, E. Han and Vijay Singal, "Mergers and Market Power: Evidence from the Airline Industry," American Economic Review, 83 (1993), 549-569. Downloadable from: http://www.econ.jhu.edu/People/Harrington/671.htm

Pepall et al., Chapter 17

Neven, Damien and Lars-Hendrik Röller (2002). "Discrepancies between markets and regulators: An analysis of the first ten years of EU merger control," in Konkurrensverket, *The Pros and Cons of Merger Control.*

April 28th, 13-15: Vertical Restraints 1:2

Student presentation:
Hortacsu, Ali and Chad Syverson (2006). "Cementing Relationships: Vertical integration, Foreclosure, Productivity, and Prices," NBER Working Paper 12894-

Selected parts in Pepall et al., Chapters 18-19

May 18th, 13-15: Predation 1:2

Student presentation:
Sass, Tim (2005). "The competitive effects of exclusive dealing: Evidence from the U.S. beer industry," International Journal of Industrial Organization, 23(3-4), pp. 203-225

Selected parts in Pepall et al., Chapters 12-13

Ellison, Glenn and Sara Ellison (2007). "Strategic Entry Deterrence and the Behavior of Pharmaceutical Incumbents Prior to Patent Expiration," mimeo. MIT.

2 Introduction

The reference for this lecture is

- Joseph H. Harrington Jr. "Detecting Cartels".

- Chapters 14-15 in Peppal et al. (2008)

In this lecture we look at the empirics of cartels in IO. The main theme is to discuss empirical methods that can be used to discover cartels in the real world.

Cartels: attempts by two or more firms to coordinate prices as quantities, in order to create rents. Connor (2004) finds that the median increase in price attributable to collusion is about 25%. Cartels exist and they are bad for consumer welfare.

Cartels are typically **illegal**.

How find cartels?

2.1 Methods of discovering cartels

- **Structural methods**: identify the markets with characteristics thought to be conducive to collusion; for example, markets with
  - few, large firms; little exit and entry
  - more homogeneous products
  - more stable demand
- **Behavioral methods**: observe the **means** by which firm coordinate (behavior) or the **end result** of that coordination (outcome).
  - Means of coordination: some form of **direct communication** (e.g. whistle-blower; documentation).

  - End result: suspicions may emanate from the pattern of firms' prices or quantities. For example, if there is parallel movement in prices, buyers may become suspicious - may lead to buyer complaints and investigations.

- Drawing on Harrington's survey chapter, this lecture explores the role of economists as detectives. We discuss how, based on analysis of prices, market shares and other economic data, the economist can look for a 'smoking gun' in the context of cartel formation..

- The focus is on behavioral methods, as the structural approach is not very efficient - there are lots of markets in which there are few firms, homogenous products and stable demand, and far from all of these are cartelized. With structural approach, the likelihood of false positives is rather high.

- The behavioral approach is potentially more informative.

- The overall aim of the economist: distinguish between **collusion** and **competition** (note: not necessarily perfect competition).

- Behavioral approach: Analysis of economic data (prices, quantities, market shares, demand shifters, cost shifters etc.) so as to identify the presence of a cartel.

- The detection process:

  1. Screening - identify markets where collusion is suspected

2. Verification - try to exclude competition as an explanation for behavior in the market

3. Prosecution - develop economic evidence that will convince the court that the law has been broken

- Note: To date, economic analysis has not been very central in court cases ruling on cartel formation. This may change in the future, as the economic methods for cartel detection are becoming more compelling.

3 Empirical methods for detecting cartels

- The objective: find evidence of explicit collusion - where firms have engaged in direct communication and obvious coordination seeking to raise prices and increase profits

- Tacit (="quiet", or "implicit") collusion is not what we are looking for. The law is only broken when there is direct communication. Subtle difference.

- Finding a high price-cost margin is, on its own, not sufficient evidence of collusion (though of course collusion will sometimes result in high price-cost margins).

- Screening - the first stag of the detection process - involves identifying candidates for verification (stage 2). Typically, screening is the result of non-economic analysis, such as buyer complaints or upset competitors. But economic analysis may play a role too; for example, if it is found that company behavior is inconsistent with a class of competitive models then this may be taken as a sign of collusion - but of course more evidence is needed before we can go to court

- Verification - the second stage of the detection process - is data-intensive and time consuming. At this stage, the economist may choose to compare the behavior of the suspected colluders to a competitive benchmark. That is, the starting point is to establish how would firms in this market behave - set prices, quantities, etc. - if the existing firms were competing with each other. Then compare actual behavior of the firms to this, for example by investigating whether a model of collusion fits the data better than a model based on competitive behavior.

- Harrington reviews **four** methods for detecting collusion, based on the following questions

(A) Is behavior inconsistent with competition?

(B) Is there a structural break in behavior? That is, is there any evidence that company behavior has changed in a way that makes the detective economist suspicious?

(C) Does the behavior of suspected colluding firms differ from that of competitive firms? Here, we have a clear benchmark class of competitive firms to which we compare the behavior of the suspects.

(D) Does a collusive model fit the data better than a competitive model?

- (A) and (B): Screening methods - don't provide evidence of collusion, but do suggest that there might be collusion going on here.

- (C) and (D): Verification methods - contrast competition and collusion as alternative explanations of firm behavior.

3.1 (A) Is firm behavior inconsistent with competition?

- General approach: Identify properties of behavior that would always hold under competition, and ask whether they are present for a particular industry.

- Null hypothesis: competition.

- Rejection of the null hypothesis does not "prove" collusion - only that behavior is inconsistent with the competitive model. Can be taken as a first sign that all is not well (screening)

3.1.1 Application: Correlation of bids in a procurement auction

Original source: Abjari and Ye (2003), referenced in Harrington's paper.

- Procurement auction: Sellers compete to obtain business. Primary objective of the buyer is to drive purchase prices downward.

- Assumptions: product is homogeneous; bidders' costs are independent of each other.

- The valuation of the cost for bidder i is stochastic.

- Simplified setting (not in Harrington's paper):

- Suppose there are J bidders. Each bidder has his or her cost valuation c_j drawn from a distribution F, common to all bidders.

- Now suppose you are bidder 1 and suppose you know your own cost valuation c_1. What is the likelihood that you will win? You don't know the cost valuation of the other bidders, but you do know that their draws are from the distribution function F. Hence, bidder 1 can compute the likelihood that he or she will win as follows:

$$
\begin{aligned}
\text{Pr}\left(1 \text{ wins}|c_1\right) &= \text{Pr}\left(c_2 > c_1\right) \times \text{Pr}\left(c_3 < c_1\right) \times ... \times \text{Pr}\left(c_j < c_1\right) \\
\text{Pr}\left(1 \text{ wins}|c_1\right) &= \left[1 - F\left(c_1\right)\right] \times \left[1 - F\left(c_1\right)\right] \times ... \times \left[1 - F\left(c_1\right)\right] \\
\text{Pr}\left(1 \text{ wins}|c_1\right) &= \prod_{j \neq i} \left[1 - F\left(c_1\right)\right]
\end{aligned}
$$

- Now let's generalize this.

- First, denote the cumulative density function of the cost valuation as

$$F\left(c_i | z_i, \theta\right),$$

where θ is a vector of parameters common across bidders, z_i is a vector of publicly observable explanatory variables, and F is bounded between 0 and 1 Basically, this means that the cost valuation depends on variables z_i, and the parameters θ. Note that F is a probability.

- Second, suppose the bid of bidder j, denoted b_j, can be written as a bidding function:

$$b_j = B\left(c_j, b_1, b_2, ..., b_{j-1}, b_{j+1}, b_J\right),$$

i.e. bidder j's bid depends on his or her own cost valuation and the bids of the other bidders. We invert the function and express bidder j's valuation as

$$c_j = B^{-1}\left(b_1, ..., b_J\right).$$

- Now suppose you are bidder i. You know your own cost valuation c_i. If you bid b_i, the likelihood that you will win is equal to

$$
\begin{aligned}
& \prod_{j \neq i} \left[1 - F\left(c_j | z_j, \theta\right)\right] \\
= & \prod_{j \neq i} \left[1 - F\left(B^{-1}\left(b_i\right) | z_j, \theta\right)\right] \\
= & \prod_{j \neq i} \left[1 - F\left(B_j^{-1}\left(b_i\right)\right)\right].
\end{aligned}
$$

- Hence, bidder i's expected profit from bidding b_i is

$$
\left(b_i - c_i\right) \prod_{j \neq i} \left[1 - F_j\left(B_j^{-1}\left(b_i\right)\right)\right],
$$

where $(b_i - c_i)$ is the gain from winning and

$$\prod_{j \neq i} \left[1 - F_j \left(B_j^{-1}(b_i)\right)\right]$$

is the probability of winning.

- In a competitive model, there is no reason why competitive bids should be correlated, conditional on publicly observable variables z_i. That is, under the null hypothesis that there is competition, the unexplained part of firms' bids are independent. Hence, if we run a regression where the dependent variable is bids, and where the explanatory variables are publicly observable, the residuals should not be correlated across firms.

- A related result is that, under competition, firms' bidding functions B should be identical; for example, the distance between a firm's office and the project site should affect all firms in the same way. This is referred to as **exchangeability**. More on this in a moment.

- **Implementation**. Estimate a pricing equation for each bidding firm, and then test whether independence and exchangeability hold; i.e. investigate whether the residuals are correlated across firms, and whether the effect of observable variables determining bids are the same across (types of) firms.

- Bajari and Ye (2003) analyze procurement auctions for seal coating (highway maintenance) in Minnesota, North Dakota and South Dakota during 1994-98.

- Data on 138 projects, for which there are 11 main companies.

- Contracts are awarded through a sealed bid auction, where the winner is the firm with the lowest bid. The economists use the following equation as a model for bids:

$$\begin{aligned}\frac{BID_{it}}{EST_{it}} &= \beta_0 + \beta_{i1} LDIST_{it} + \beta_{i2} CAP_{it} + \beta_{i3} MAXP_{it} \\ &\quad + \beta_{i4} LMDIST_{it} + \beta_{i5} CON_{it} + \epsilon_{it},\end{aligned}$$

  where EST_{it} is the engineering cost for project t; $LDIST_{it}$ is the distance between firm i and project t; CAP_{it} is utilized capacity (how "busy" is the firm); $MAXP_{it}$ is the maximal free capacity among rivals; $LMDIST_{it}$ is the minimum distance among rivals, and CON_{it} the proportion of work done by firm i in the state where project t is located (measuring familiarity with local regulators & suppliers).

- The estimated β-parameters are not of primary importance to the analysis, though of course it is important that they are economically sensible. That seems to be the case: distance, own capacity and minimum distance among rivals tend increase the bid; concentration seems to decrease bids.

- Central for the analysis:

1. Are the residuals correlated across firms?

$$corr\left(\epsilon_{it}, \epsilon_{jt}\right) \neq 0$$

If this is the case, this suggests firms may have coordinated their bids. Authors do find some evidence that, for two specific firms, the residuals are indeed significantly correlated.

2. Exchangeability: the explanatory variables enter the bid functions in the same way for all firms, so the effects of the explanatory variables do not

differ across firms:

$$\beta_{ik} = \beta_{jk}.$$

Since there are many auctions, it is possible to test this directly. The analysis indicates that the effects are indeed not the same for all firms, indicating that the benchmark competitive model is not supported by the data.

3.2 (B) Has there been a structural break in firm behavior?

- A second general approach for identifying collusion: look for a structural break - i.e. a discrete change in firms' pricing functions, resulting from the formation or demise of a cartel.

- Structural breaks are not necessarily the result of collusion. If you find evidence of a structural break in the data and this is consistent with your theoretical priors as to what would happen **if** a cartel were formed, this would seem worth following up on.

- That is, looking for a structural breaks can be used as part of the screening process.

3.2.1 How test for a structural break?

- Structural break: Suppose we model the data as

$$y_t = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + \varepsilon_t,$$

  and suppose we have time series data $t = 1, 2, ..., T$.

- If, at one point $1 < s < T$ the parameters $\alpha_0, \alpha_1, \alpha_2$ **change**, then we say there is a structural break at time s. In such a case, our model becomes

$$y_t = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + \varepsilon_t \quad \text{if } t < s$$

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + u_t \quad \text{if } t \geq s.$$

  Hence, the effect of a change in the variable x_{1t} may not be the same after the structural break as before the structural break.

- To test for a structural break, we formulate the null hypothesis as follows:

$$H_0 : \alpha_0 = \beta_0, \alpha_1 = \beta_1, \alpha_2 = \beta_2,$$

  i.e. the null hypothesis is that there is no structural break.

- The classical **Chow test statistic** is

$$\frac{N_1 + N_2 - 2k}{k} \left(\frac{S_C}{S_1 + S_2} - 1 \right),$$

  where S_C is the sum of squared residuals from the model that does not allow for a structural break, S_1, S_2 are the sum of squared residuals from the models before and after the break, respectively, N_1, N_2 denote the number of observations before and after the break, respectively, and k is the number of explanatory variables. The Chow test statistic follows an F-distribution.

- Simple intuition: if there is a structural break, then the sum of squared residuals for the model that does not allow for a break will be rather much larger than the sum of squared residuals in the two separate models. Hence $\frac{S_C}{S_1+S_2}$ will be large, and so the Chow test statistic will be large, possibly so large as to indicate rejection of the null hypothesis. In contrast, if there is no structural break, then (in theory) $S_1 + S_2 = S_C$ in which case the test statistic is equal to zero.

- Equivalent: Define a dummy variable $D_t = 1$ for $t \geq s$ and $D_t = 0$ for $t < s$. Construct interaction variables $Dx_{1t} = D_t x_{1t}$, $Dx_{2t} = D_t x_{2t}$, and then estimate the following model:

$$\begin{aligned} y_t &= \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} \\ & \quad \gamma_0 D_t + \gamma_1 Dx_{1t} + \gamma_2 Dx_{2t} + e_t. \end{aligned}$$

The null hypothesis is that there is no structural break:

$$H_0 : \gamma_0 = \gamma_1 = \gamma_2 = 0,$$

and we can easily test this by means of a Wald test after having estimated the model containing the interaction terms.

- Important: To implement a test for a structural break along these lines, you will need to
  - have access to data outside of the time of the suspected collusion
  - have prior information as to when a cartel may have been formed (i.e. you need to know at what point to split up the sample), a so-called "candidate breakpoint".

- Finding candidate breakpoints is not straightforward, and the best approach probably varies from case to case. Some methods that have been used are as follows:
  - Look for events that may coincide with cartel formation. The formation of trade associations has coincided with cartel formation - if you think that's a possibility in your application, then testing for a structural break around the time of the formation of the trade association might be informative.
  - Firm exit or mergers may facilitate the formation of cartels
  - If at some point firms become aware that they are being investigated, then this may change their behavior, potentially leading to a structural break.

- Of course, there may be structural breaks that have nothing to do with collusion. The approach is thus best viewed as an indirect way of looking for suggestive evidence of collusion.

3.3 (C) Does the behavior of suspected colluding firms differ from that of competitive firms?

- **Anecdote**: The Oklahoma Highway Department (OHD) awarded asphalt contracts to the bidder with the most favorable (=lowest) bid (period: 1954-65). Firms were suspected of colluding, by coordinating their bids.

- Bids by potential suppliers were identical at 10.25 cents/gallon. The OHD then awarded the contract to the firm nearest to the job site.

- The same firms were bidding for, and winning, contracts in other states - at the average price of 6 cents/gallon. Bids were not uniform across the firms. The freight cost was less than the price difference between Oklahoma and the other states - rather suggesting that these firms should be able to offer a lower price than 10.25 cents/gallon in Oklahoma.

- This is an example of a comparison of the behavior of suspected colluders with some competitive benchmark (which in this case was provided by the "other" states).

- Alternatively, if you know that some firms in the market are not colluding, then the behavior of these firms may form your competitive benchmark.

- A common implementation: estimate price regressions, e.g.

$$price = \beta_0 + \beta_1 \text{cost} + \beta_2 (\text{demand shifters}) + \text{residual},$$

  separately for the suspected cartel firms, and for the non-colluding firms. Then test whether the coefficients in the price equation are common across the two groups of firms.

- You can use exactly the same statistical technique as discussed above for structural breaks - explain how.

- If the evidence suggests the coefficients of the price equation are **different** across the two groups, then this indicates the behavior of the suspected cartel firms is different from that of the non-colluding firms.

- Suppose that's what you find. What do you do next?

3.3.1 Application: Bid rigging in procurement auctions

Original source: **Porter and Zona** (1993), referenced in Harrington's paper.

- Setting: sealed bid procurement auction, where the bidding rule is assumed linear:

$$\ln b_{it} = \alpha_t + \beta X_{it} + \epsilon_{it},$$

where i is the firm and t is the project. α_t is a project specific effect, and X_{it} is a vector of observable variables affecting cost and the probability of winning.

- Data: 116 auctions; New York State Department of Transportation for highway construction contracts; 1979-85.

- Prior information on who might be engaged in collusive activities. Candidate cartel consists of five firms. The other firms are assumed to be acting competitively.

- First question: Do the determinants of firms' bid levels differ between potential cartel firms and competitive firms?

- To investigate this, the bidding equation is estimated separately for the two groups of firms.

- The authors conclude that the estimated model fits the bids of competitive firms well; and that the bids of the cartel firms are significantly different from those of competitive firms.

3.3.2 Application: Collusion at procurement auctions for school milk

Original source: **Porter and Zona** (1999), referenced in Harrington's paper.

- Market: School districts in Cincinnati area. Three defendants, who testified that the cartel used an **incumbency scheme**: if a cartel member had served a particular district in the previous year, then the other firms were either not to bid, or submit high bids.

- The empirical approach is similar to that described in the previous application. The starting point is a regression model of the following form:

$$\ln b_{it} = \alpha_t + \beta X_{it} + \epsilon_{it}. \tag{1}$$

  The authors have detailed cost data - e.g. the distance between the processing plant and the school district.

- [An aside: These authors also model the probability of submitting a bid - we don't need to go into detail on this]

- Two types of regressions:

$$\ln b_{it} = \alpha_t + \beta X_{it} + \delta D_i + \epsilon_{it},$$

where D_i is a dummy equal to 1 for cartel firms and zero for competitive firms; and

$$\ln b_{it} = \alpha_t + \beta X_{it} + \delta D_i + \theta \left(D_i \times X_{it} \right) + \epsilon_{it}.$$

Note that the second of these includes interaction terms $(D_i \times X_{it})$, implying that the effects of the X-variables are allowed to differ across competitive and cartel firms. In other words, the slope coefficient in the underlying regression model (1) are allowed to differ depending on the category of firm.

- The regressions above are estimated using data for all competitive firms and a particular defendant (cartel firm).

- The null hypothesis is that all firms are competitive; if true, there should be no systematic difference in how bids are determined across firms. Hence, $H_0 : \theta = 0$.

- For **each** of the three cartel firms, the null hypothesis is rejected, indicating that suspected cartel firms' bids are determined by a different process than that of competitive firms.

- Furthermore, for competitive firms the results are sensible - distance, for example, tends to increase bids for competitive firms.

- For colluding firms, however, it is hard to reconcile the results with competitive behavior - distance tends to **decrease** bids for this class of firms. As cost is increasing in distance, this is inconsistent with competitive models. Why do these firms submit higher bids for projects close to their processing plants? Suspicious.

- Furthermore, it was found that the residual ϵ_{it} in the bids regression was correlated across the suspected cartel firms - a high bid by one of these firms tended to coincide with a high bid by the other colluding firms. This suggests parallel behavior.

- Now - collusion is a **possible** reason why the determinants of bids differ across the two categories of firms. But, of course, this doesn't prove there is collusion. To build up a more compelling case, it is helpful to show that the patterns we observe in the data are consistent with a theoretical model of collusion. Or, at least, offer some theoretically sound explanation as to why the results should be interpreted as evidence of collusion.

- The story in this application is that firms may be submitting higher bids in districts for which they have a distance advantage - so collusion works - whereas in more distant markets they are forced by competition to submit lower bids.

3.4 (D) Is firm behavior more consistent with collusion than with competition?

- This approach compares collusive and competitive model with regards to their ability to fit the data. The idea is to specify competitive and collusive models of firms' **prices** or **bids**, and then investigate how these variables vary with cost and demand shifters. If the collusive model better fits the data (perhaps exhibiting a higher R-squared) than the competitive model, then this is taken as evidence of collusion.

- Of course, one needs to have a fair amount of faith in the underlying theoretical models to be convinced.

3.4.1 Application: Porter (1983)

The following paper will presented in the lecture on April 14th:

Porter, Robert H., "A Study of Cartel Stability: The Joint Executive Committee, 1880-1886," Bell Journal of Economics, 14 (1983), 301-314.

I will therefore just briefly summarize it here, since it is a good example of an application investigating how well collusion models and competitive models fit the data.

- The paper uses weekly time series data on the Joint Executive Committee railroad cartel from 1880 to 1886. The JEC railroad cartel was created to coordinate the price charged for transporting grain from Chicago to the east coast.

- The paper tests empirically the proposition that observed prices reflect **switches** from collusive to competitive behavior.

- The basic idea is that sharp changes in price - changes that are inexplicable in view of cost and demand shifts - are unlikely to be generated in a competitive market. However, models of **collusive pricing** under **imperfect monitoring** can generate such patterns. The reason is that, because of imperfect monitoring, the cartel may occasionally need to **punish** noncompliers by drastically lowering the prices for a short period of time in order to sustain the cartel.

- So if one firm cheats (lowers the price in violation of the agreement) then this will be followed by a price war.

- General approach: explain the determination of **price** and **quantity** using cost and demand shifters:

$$\begin{aligned} \ln Q_t &= \alpha_0 + \alpha_1 \ln P_t + \alpha_2 LAKES_t + \epsilon_{1t} \quad \text{(Demand eq.)} \\ \ln P_t &= \beta_0 + \beta_1 \ln Q_t + \beta_2 S_t + \beta_3 I_t + \epsilon_{2t} \quad \text{(Supply eq.)}, \end{aligned}$$

  where Q is the volume of grain shipped, P is the rate for rail services, $LAKES$ is a dummy variable equal to 1 (0) if the Great Lakes are (not) open for shipping (if they are open, then this provides an alternative way of transportation, thus reducing the demand for rail services; hence we expect $\alpha_2 < 0$); S captures composition of the cartel (changes due to entry etc.).

- Key variable: I_t. This is equal to 1 if firms are in the collusive phase (low quantity, high price), and 0 if firms are in punishment phase (high quantity, low price).

- What's unusual here is that I_t is **not observed** by the econometrician. This is a problem, since the coefficient β_3 - measuring the effect of a regime switch - is the key coefficient in the analysis.

- Porter considers two solutions to this problem:

  - Create a dummy variable, denoted PO, equal to 1 unless the *Railway Review* (a trade magazine) reported that a price war was occurring in which case it is equal to 0.

  - Adopt econometric techniques (switching regressions) that treat I_t as a stochastic variable, being equal to 1 with probability λ and 0 with probability $1-\lambda$. The econometrics involved is clearly beyond the scope of the course, but the intuition is fairly straightforward: by allowing for a discrete switch in I_t from 0 to 1, or from 1 to 0, this may fit the data better than if I_t is omitted altogether. [Illustrate graphically]

- Also, he takes into account the standard problem that prices and quantities are endogenous. In the model with the PO dummy this is done by means of two-stage least squares, as usual.

- Reassuringly, the estimate of β_3 doesn't differ very much depending on which of the two techniques are being used; the estimated β_3 is positive and statistically significant, indicating that prices are higher, and quantities lower, in periods where there is collusion.

- How much lower are prices in the noncooperative phase compared to the collusive phase? [Table 3 in Porter here]

- Building on Porter's work, Ellison (1994), cited in Harrington, p.17, generalizes the approach, linking the probability of a regime switch to "triggers", e.g. whether a firm produces a lot more than its cartel quota.

Key table in Porter (1983)

TABLE 3 Estimation Results*

Variable	Two Stage Least Squares (Employing *PO*) Demand	Supply	Maximum Likelihood (Yielding *PN*)** Demand	Supply
C	9.169	−3.944	9.090	−2.416
	(.184)	(1.760)	(.149)	(.710)
LAKES	−.437		−.430	
	(.120)		(.120)	
GR	−.742		−.800	
	(.121)		(.091)	
DM1		−.201		−.165
		(.055)		(.024)
DM2		−.172		−.209
		(.080)		(.036)
DM3		−.322		−.284
		(.064)		(.027)
DM4		−.208		−.298
		(.170)		(.073)
PO/PN		.382		.545
		(.059)		(.032)
TQG		.251		.090
		(.171)		(.068)
R^2	.312	.320	.307	.863
s	.398	.243	.399	.109

* Monthly dummy variables are employed. To economize on space, their estimated coefficients are not reported. Estimated standard errors are in parentheses.

** *PN* is the regime classification series $(\hat{I}, \ldots, \hat{I}_T)$. The coefficient attributed to *PN* is the estimate of β_3.

- Harrington discusses a number of other studies in the same vein. Read if you are interested.

3.5 The pitfalls of using a high price-cost margin as a screen for collusion

- It makes sense to suppose that the objective of colluding firms is to mimick a monopoly, so that the cartel firms can divide up the resulting monopoly rents.

- We saw in AIO1 how the Lerner index, defined as the price-cost margin

$$L = \frac{\text{price - marginal cost}}{\text{price}},$$

is often used to assess the degree of market power that a monopolist enjoys. It is therefore tempting, perhaps, to use the price-cost margin as a screen for collusion.

- However, we also know that there is a lot of variation in the price-cost margin across industries (see for example Table 3.3 in Pepall et al.). There are many industries for which the price-cost margin is fairly high, but for which there is no evidence or even suspicion about collusion.

- Other reasons - not related to collusion - for a high price-cost margin include differentiated products, high entry costs, patent protection, high search costs for consumers, etc.

- Thus, a high price-cost margin doesn't imply collusion - far from it, actually.

- Furthermore, there may well be collusion in markets characterized by low price-cost margins. Of course, we expect the competitive benchmark price-cost margin to be lower than that under collusion, but it's perfectly possible that the competitive price-cost margin is close to zero and that the price-cost margin under collusion is no higher than under Cournot competition, for example. In such a case, if you rely exclusively on the price-cost margin as a screen for collusion, you are going to miss out on existing cartels. This underscores the importance of having a good benchmark, when assessing whether collusion is likely present.

- However, if the price-cost margin changes abruptly and seemingly without good reason (i.e. no corresponding change in demand shifters or costs), then this may indicative of a structural break due to collusion.

3.6 Discussion

- Four methods for detecting collusion have been reviewed:

(A) Is behavior inconsistent with competition? (For example, are the unexplained part of firms' bids - the residual - correlated across firms?)

(B) Is there a structural break in behavior? (Check if the parameters change at some predefined point in time.)

(C) Does the behavior of suspected colluding firms differ from that of competitive firms? Similar to (B) but investigates whether parameters are stable in the cross-section rather than over time. You need a clear benchmark class of competitive firms to which we compare the behavior of the suspects.

(D) Does a collusive model fit the data better than a competitive model? Theory-oriented: begin by writing down a model under collusion and competition, then check which of these fits the data best.

- It's probably fair to say that none of these methods provides conclusive evidence on whether or not there is collusion in a market. Potential weaknesses:
  - (A): The model must be correctly specified and there must be no **omitted variables**. For example, if you have omitted a relevant publicly observable determinant of bids, then firms' residual bids may be correlated because of this omission; this may have nothing to do with collusion.

- (B): It may be difficult to know exactly around what time to test for a structural break; and structural breaks may occur independently of collusion. You need supporting evidence.

- (C): It may be difficult to find a competitive benchmark. Why, exactly, are those firms that are behaving competitively not part of the cartel? Perhaps there is tacit collusion in the market you define as competitive. Cartel formation may be endogenous. Moreover, this method is clearly inapplicable to an all-inclusive global cartel for which data are only available during the time of suspected collusion.

- (D): This method is often more convincing than (A)-(C), primarily because it contains both competitive and collusive models (the other methods don't offer much in terms of insights into behavior under collusion). The major disadvantage is strong assumptions and potential misspecification - i.e. that the models you write down are poor approximations of firm behaviour. In such a case, there is a general sense amongst economists that "all bets are off" regarding what we can and can't learn from the analysis. For example, if the collusive model is misspecified, this may bias the results in such a way as to suggest there is no collusion in the market when in fact there is. So motivating your modelling framework - for example by referring to ancillary evidence on firm behaviour - is very important for the analysis to be convincing.

4 Introduction to Collusive Markers

- What behavioral patterns are indicative of collusion? Behavior that distinguishes collusion from competition are often referred to as a **collusive marker.** If we know what constitutes a collusive marker, we know what to look for.

- Collusive markers are developed through theoretical models or by documenting the behavior of price-fixing cartels.

- **Theory** plays an important role in providing collusive markers. If you pursue some empirical method of contrasting the behavior of suspected colluders with that of competitive firms, you need to know whether these differences are consistent with some collusive story.

- For example, if you look for structural breaks in order to identify the formation of a cartel, having collusive markers can tell you what kind of change in behavior to look for.

- In this section we look at distinguishing features of collusion and competition, focusing on patterns in **prices** and **market shares**. It's important to remember that interpretation should be done in light of the underlying theoretical model. When we find evidence of collusion, there is always the possibility that there actually is no collusion and the problem is we've misspecified the non-collusive model, for example. Still, collusive markers can serve to screen industries to determine whether they are worthy of more intense investigation.

- Here is an example of a collusive marker referring to price movements (Harrington, p.29):

Under certain conditions, price and quantity are negatively correlated, price leads a demand cycle, and the stochastic process on price is subject to regime switches under collusion; while price and quantity are positively correlated, price follows a demand cycle, and price is not subject to regime switches under competition.

- Next time we will discuss the theoretical basis for this and other collusive markers. Please read Section 3 and 4 in Harrington before we meet next time.

5 Student presentations

Four papers to be presented by students:

1. **Cartels:** Porter, Robert H., "A Study of Cartel Stability: The Joint Executive Committee, 1880-1886," Bell Journal of Economics, 14 (1983), 301-314.

2. **Horizontal Mergers**: Kim, E. Han and Vijay Singal, "Mergers and Market Power: Evidence from the Airline Industry," American Economic Review, 83 (1993), 549-569.

3. **Vertical mergers**: Hortacsu, Ali and Chad Syverson (2006). "Cementing Relationships: Vertical integration, Foreclosure, Productivity, and Prices," NBER Working Paper 12894

4. **Vertical restraints**: Sass, Tim (2005). "The competitive effects of exclusive dealing: Evidence from the U.S. beer industry," International Journal of Industrial Organization, 23(3-4), pp. 203-225

5. (reserve) **Predation**: Ellison, Glenn and Sara Ellison (2007). "Strategic Entry Deterrence and the Behavior of Pharmaceutical Incumbents Prior to Patent Expiration," mimeo. MIT.

Student presentations

- What is the question?
- Why is it interesting?
- What method is used to answer the question?
- What is the answer given in the paper?
- Do you believe in the answer?
- What could have been done better?

Organization:

- Presentation should last for about 20 minutes
- It is a good idea to prepare powerpoint (or pdf) slides.