Prepared with SEVISLIDES

Competition Policy - Spring 2005

Collusion II

Antonio Cabrales & Massimo Motta

April 22, 2005

Summary

- Symmetry helps collusion
- Multimarket contacts
- Cartels and renegotiation
- Optimal penal codes
- Leniency programmes (simp. Motta-Polo)

Symmetry helps collusion *(1/2)*

- Market A : Firm 1 (resp. 2) has share $s_1^A = \lambda$ (resp. $s_2^A = 1 - \lambda$).

- $\lambda > \frac{1}{2}$: firm 1 “large”; firm 2 is “small”.

- Firms are otherwise identical.

- Usual infinitely repeated Bertrand game.

- ICs for firm $i = 1, 2$:

$$\frac{s_i^A \left(p_m - c\right) Q(p_m)}{1 - \delta} - \left(p_m - c\right) Q(p_m) \geq 0,$$

Symmetry helps collusion *(2/2)*

- Therefore: $IC_1^A : \frac{\lambda}{1-\delta} - 1 \geq 0$, or: $\delta \geq 1 - \lambda$.

- $IC_2^A : \frac{1-\lambda}{1-\delta} - 1 \geq 0$, or: $\delta \geq \lambda$ (binding IC of small firm).

- Higher incentive to deviate for a small firm: higher additional share by decreasing prices.

- The higher asymmetry the more stringent the IC of the smallest firm.

Multimarket contacts *(1/3)*

- Market B : Firm 2 (resp. 1) with share $s_2^B = \lambda$ (resp. $s_1^B = 1 - \lambda$): reversed market positions.

- ICs in market $j = A, B$ *considered in isolation*:

$$\frac{s_i^j \,(p_m - c)\, Q(p_m)}{1 - \delta} - (p_m - c)\, Q(p_m) \geq 0,$$

- $IC_2^B : \frac{\lambda}{1-\delta} - 1 \geq 0$, or: $\delta \geq 1 - \lambda$.

- $IC_1^B : \frac{1-\lambda}{1-\delta} - 1 \geq 0$, or: $\delta \geq \lambda$.

- By considering markets in isolation (or assuming that firms 1 and 2 in the two markets are different) collusion arises if $\delta \geq \lambda > 1/2$.

Multimarket contacts *(2/3)*

- If firm sells in two markets, IC considers both of them:

$$\frac{s_i^A (p_m - c) Q(p_m)}{1-\delta} + \frac{s_i^B (p_m - c) Q(p_m)}{1-\delta} - 2(p_m - c) Q(p_m) \geq 0, \qquad (1)$$

or:

$$\frac{(1-\lambda)(p_m - c) Q(p_m)}{1-\delta} + \frac{\lambda (p_m - c) Q(p_m)}{1-\delta} - 2(p_m - c) Q(p_m) \geq 0. \qquad (2)$$

- Each IC simplifies to: $\delta \geq \frac{1}{2}$.

- Multimarket contacts help collusion, as critical discount factor is lower: $\frac{1}{2} < \lambda$.

Multimarket contacts *(3/3)*

- Firms pool their ICs and use slackness of IC in one market to enforce more collusion in the other.

- In this example, multi-market contacts restore symmetry in markets which are asymmetric.

Cartels and renegotiation *(1/6)*

- Consider explicit agreements (not tacit collusion).
- McCutcheon (1997): renegotiation might break down a cartel.
- Same model as before, but firms can meet after initial agreement.
- After a deviation, incentive to agree not to punish each other.
- $\Longrightarrow$ since firms anticipate the punishment will be renegotiated, nothing prevents them from cheating!
- Collusion arises only if firms can commit not to meet again (or further meetings are very costly).
- This conclusion holds under strategies other than grim ones.

Cartels and renegotiation *(2/6)*

- Asymmetric (finite) punishment (to reduce willingness to renegotiate):

- for T periods after a deviation, the deviant firm gets 0; non-deviant gets at least $\pi(p^m)/2$. After, firms revert to p^m .

- T chosen to satisfy IC along collusive path:

$$\frac{\pi(p^m)}{2(1-\delta)} \geq \pi(p^m) + \frac{\delta^{T+1}\pi(p^m)}{2(1-\delta)}, \tag{3}$$

- or: $\delta(2-\delta^T) \geq 1$.

- But deviant must accept punishment.

- IC along punishment path (if deviating, punishment restarted):

$$\frac{\delta^T \pi(p^m)}{2(1-\delta)} \geq \frac{\pi(p^m)}{2} + \frac{\delta^{T+1}\pi(p^m)}{2(1-\delta)}. \tag{4}$$

- False, since it amounts to $\delta^T \geq 1$.

- Under Nash reversal or other strategies, no collusion at equilibrium if (costless) renegotiation allowed.

Costly renegotiation: Can small fines promote collusion?

- Every meeting: prob. θ of being found out.
- Expected cost of a meeting: θF ($F =$ fine).
- Benefit of initial meeting: $\pi(p^m)/\left(2(1-\delta)\right)$.
- It takes place if: $\theta F < \pi(p^m)/\left(2(1-\delta)\right)$.

Cartels and renegotiation *(5/6)*

- Benefit of a meeting after a deviation (asymmetric punishments):

$$\sum_{t=0}^{T-1} \delta^t \frac{\pi(p^m)}{2} = \frac{\pi(p^m)}{2} \left(\frac{1-\delta^T}{1-\delta} \right).$$

- It takes place if: $\theta F < \pi(p^m)(1-\delta^T)/\left(2(1-\delta)\right)$.

1. $\theta F \geq \pi(p^m)/\left(2(1-\delta)\right)$. Each meeting very costly: no collusion.

2. $\pi(p^m)/\left(2(1-\delta)\right) > \theta F \geq \pi(p^m)(1-\delta^T)/\left(2(1-\delta)\right)$. Initial meeting yes, renegotiation no: collusion (punishment is not renegotiated).

3. $\pi(p^m)(1-\delta^T)/\left(2(1-\delta)\right) > \theta F$. Expected cost of meetings small: renegotiation breaks collusion.

Discussion

- Importance of bargaining and negotiation in cartels.

- No role in tacit collusion.

- But such further meetings might help (eg., after a shocks occur, meetings might avoid costly punishment phases).

- Genesove and Mullin (AER, 2000):

  - renegotiation crucial to face new unforeseeable circumstances;

  - infrequent punishments, despite actual deviations...

  - ... but cartel continues: due to such meetings?

Abreu: Nash forever not optimal punishment, if $V_i^p > 0$.

Stick and carrot strategies, so that $V_i^p = 0$: max sustainability of collusion.

An example of optimal punishments

Infinitely repeated Cournot game.

n identical firms.

Demand is $p = \max\{0, 1 - Q\}$.

Nash reversal trigger strategies

IC for collusion: $\pi^m/(1-\delta) \geq \pi^d + \delta\pi^{cn}/(1-\delta)$,

$$\rightarrow \quad \delta \geq \frac{(1+n)^2}{1+6n+n^2} \equiv \delta^{cn}.$$

Under Nash reversal, $V^p = \delta\pi^{cn}/(1-\delta) > 0$.

Optimal punishment strategies

Symmetric punishment strategies might reduce V^p.

Each firm sets same q^p and earns $\pi^p < 0$ for the period after deviation, then reversal to collusion:

$$V^p(q^p) = \pi^p(q^p) + \delta\pi^m/(1-\delta).$$

If q^p so that $V^p = 0$, punishment is optimal.

Credibility of punishment if:

$$V^p(q^p) \geq \pi^{dp}(q^p) + \delta V^p(q^p), \ or$$

$$\pi^p(q^p) + \frac{\delta\pi^m}{(1-\delta)} \geq \pi^{dp}(q^p) + \delta\left(\pi^p(q^p) + \frac{\delta\pi^m}{(1-\delta)}\right).$$

(If deviation, punishment would be restarted.)

Optimal penal codes *(4/9)*

Therefore, conditions for collusion are:

$$\delta \geq \frac{\pi^d - \pi^m}{\pi^m - \pi^p(q^p)} \equiv \delta^c(q^p) \qquad \text{(ICcollusion)}$$

$$\delta \geq \frac{\pi^{dp}(q^p) - \pi^p(q^p)}{\pi^m - \pi^p(q^p)} \equiv \delta^p(q^p) \qquad \text{(ICpunishment).}$$

Harsher punishment: ICcollusion relaxed: $\frac{d\delta^c(q^p)}{dq^p} < 0$,

...but IC punishment tightened: $\frac{d\delta^p(q^p)}{dq^p} > 0$.

Linear demand Cournot example:

$$\pi^p(q^p) = (1 - nq^p - c)q^p, \quad \text{for } q^p \in (\frac{1-c}{n+1}, \frac{1}{n})$$
$$\pi^p(q^p) = -cq^p, \quad \text{for } q^p \geq \frac{1}{n}.$$

(for $q \geq 1/n$, $p = 0$).

$$\pi^{dp}(q^p) = (1 - (n-1)\,q^p - c)^2\,/4, \quad \text{for } q^p \in (\frac{1-c}{n+1}, \frac{1-c}{n-1})$$
$$\pi^{dp}(q^p) = 0, \quad \text{for } q^p \geq \frac{1-c}{n-1}.$$

(Note that $0 = V^p \geq \pi^{dp} + \delta V^p$ which implies $\pi^{dp} = 0$.)

$$\delta^c(q^p) = \frac{(1-c)^2(n-1)^2}{4n(1-c-2nq^p)^2}, \quad \text{for } \frac{1-c}{n+1} < q^p < \frac{1}{n}$$

$$\delta^c(q^p) = \frac{(1-c)^2(n-1)^2}{4n(1-2c+c^2+4ncq^p)}, \quad \text{for } q^p \geq \frac{1}{n},$$

and:

$$\delta^p(q^p) = \frac{n(1-c-q^p-nq^p)^2}{(1-c-2nq^p)^2}, \quad \text{for } \frac{1-c}{n+1} < q^p < \frac{1-c}{n-1}$$

$$\delta^p(q^p) = \frac{4nq^p(-1+c+nq^p)}{(1-c+2nq^p)^2}, \quad \text{for } \frac{1-c}{n-1} \leq q^p < \frac{1}{n}$$

$$\delta^p(q^p) = \frac{4ncq^p}{1-2c+c^2+4ncq^p}, \quad \text{for } q^p \geq \frac{1}{n}.$$

Figure: intersection between ICC and ICP, $\tilde{q}^p$, determines lowest δ .

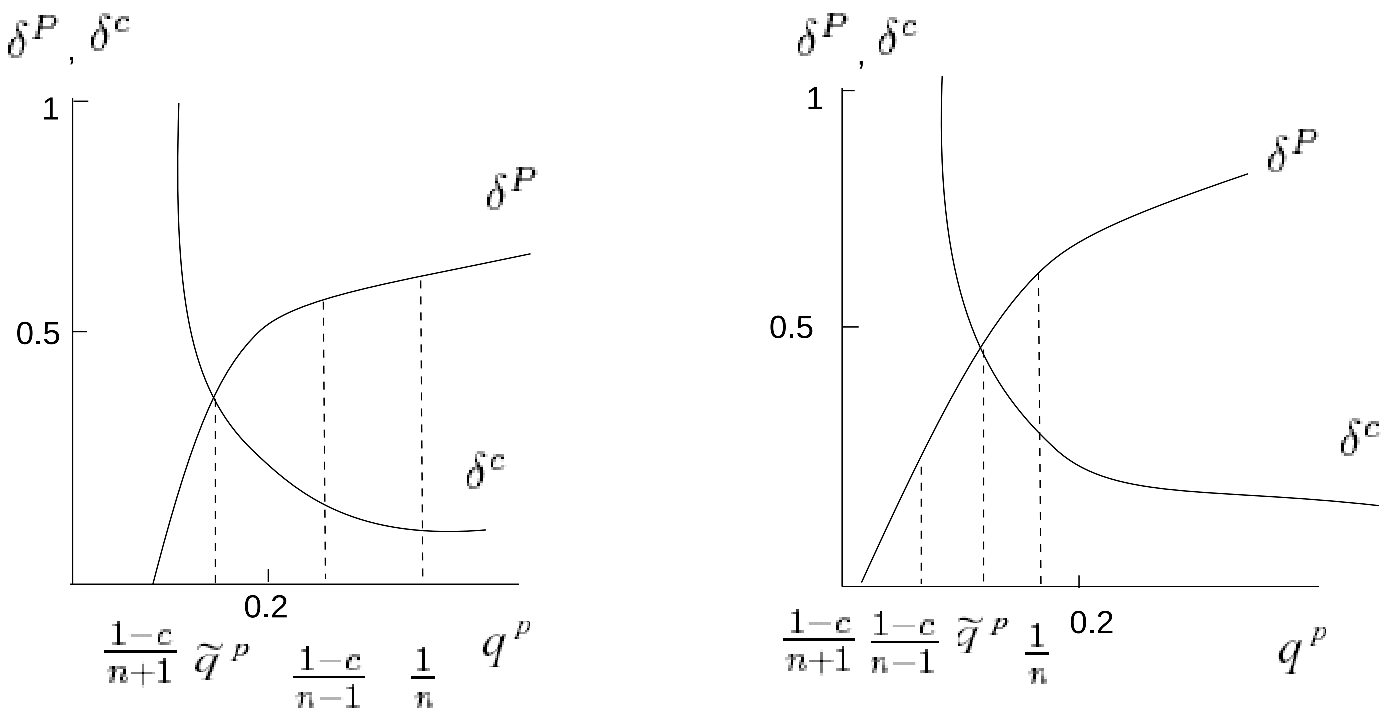


Figure 1a

Figure 1b

Incentive constraints along collusive and punishment paths. Figure drawn for $c = 1/2$ and: (a) $n = 4$; (b) $n = 8$.

Optimal penal codes *(8/9)*

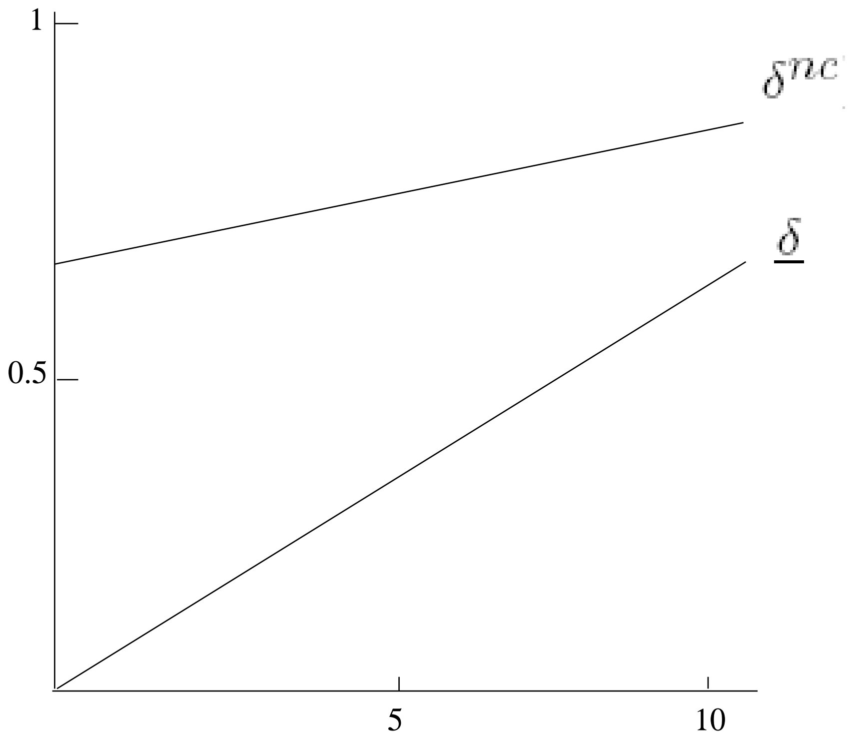
Figure 1a: $\tilde{q}^p = \frac{(3n-1)(1-c)}{2n(n+1)} \equiv \tilde{q}_1^p < \frac{1-c}{n-1}$ (for $n < 3 + 2\sqrt{2} \simeq 5.8$)

Figure 1b $\tilde{q}^p = \frac{(1+\sqrt{n})^2(1-c)}{4n\sqrt{n}} \equiv \tilde{q}_2^p > \frac{1-c}{n-1}$ (for $n > 3 + 2\sqrt{2}$)

Therefore:

$$\underline{\delta} = \frac{(n+1)^2}{16n}, \text{ for } n < 3 + 2\sqrt{2}$$
$$\frac{(n-1)^2}{(n+1)^2}, \text{ for } n \geq 3 + 2\sqrt{2}.$$

Optimal penal codes *(9/9)*



Conditions for collusion: Nash reversal (δ^{nc}) vs. two-phase ($\underline{\delta}$) punishment strategies

Firms might do better than Nash reversal without $V^p = 0$.

Timing (infinite horizon game):

$t = 0$: AA can commit to LP with reduced fines. $0 \leq R \leq F$.
All firms know R, prob. α AA opens investigation, prob. p it proves collusion. (R to any firm cooperating even after investigation opens.)

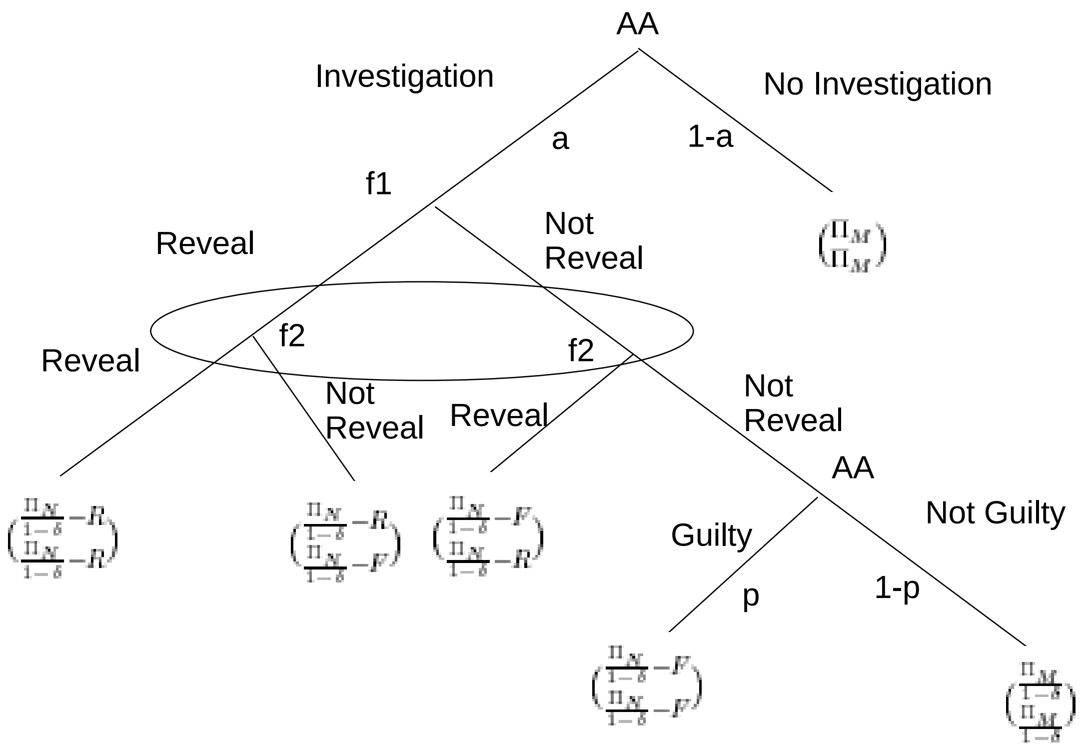
$t = 1$: The n firms collude or deviate and realize per-period Π_M or Π_D. Grim strategies (forever Π_N after deviation). AA never investigates if firms do not collude.

$t = 2$: See Figure.

For any $t > 2$, if no investigation before, as in $t = 2$.

Focus on $\delta \geq (\Pi_D - \Pi_M)/(\Pi_D - \Pi_N)$: if no antitrust, collusion.

Leniency programmes (simp. Motta-Polo) *(2/8)*



Game tree, at $t = 2$.

Solution

$t = 2:$ "revelation game" if investigation opened:

$firm\ 1$ \ $firm\ 2$	Reveal	Not Reveal
Reveal	$\frac{\Pi_N}{1-\delta} - R, \frac{\Pi_N}{1-\delta} - R$	$\frac{\Pi_N}{1-\delta} - R, \frac{\Pi_N}{1-\delta} - F$
Not Reveal	$\frac{\Pi_N}{1-\delta} - F, \frac{\Pi_N}{1-\delta} - R$	$p(\frac{\Pi_N}{1-\delta} - F) + (1-p)\frac{\Pi_M}{1-\delta}$, $p(\frac{\Pi_N}{1-\delta} - F) + (1-p)\frac{\Pi_M}{1-\delta}$

(Reveal,.., Reveal) always a Nash equilibrium.

(Not reveal,.., Not reveal), is NE: (1) if $pF < R$, always; (2) if $pF \geq R$ and:

$$p \leq \frac{\Pi_M - \Pi_N + R(1-\delta)}{\Pi_M - \Pi_N + F(1-\delta)} = \tilde{p}(\delta, R, F). \tag{5}$$

If (NR,.., NR) NE exists, selected (Pareto-dominance, risk dominance).

$\rightarrow$ Firms reveal information only if $p > \tilde{p}$.

(a) If no LP, $R = F$ and $\tilde{p} = 1$: firms never collaborate.

(b) To induce revelation the best is $R = 0$.

$t = 1$: collude or deviate?

(1) Collude and reveal: $p > \tilde{p}$: $V_{CR} \geq V_D$, if:

$$\alpha \leq \frac{\Pi_M - \Pi_D + \delta(\Pi_D - \Pi_N)}{\delta(\Pi_D - \Pi_N + R)} = \alpha_{CR}(\delta, R).$$

(2) Collude and not reveal: $p \leq \tilde{p}$. $V_{CNR} \geq V_D$ if:

$$\alpha \leq \frac{(1-\delta)[\Pi_M - \Pi_D + \delta(\Pi_D - \Pi_N)]}{\delta[pF(1-\delta) + p(\Pi_M - \Pi_N) + \Pi_D(1-\delta) - \Pi_M + \delta\Pi_N]} = \alpha_{CNR}(\delta, p, F),$$

if $p\,[F(1-\delta) + \Pi_M - \Pi_N] > \Pi_M - \Pi_D + \delta(\Pi_D - \Pi_N)$;

always otherwise.

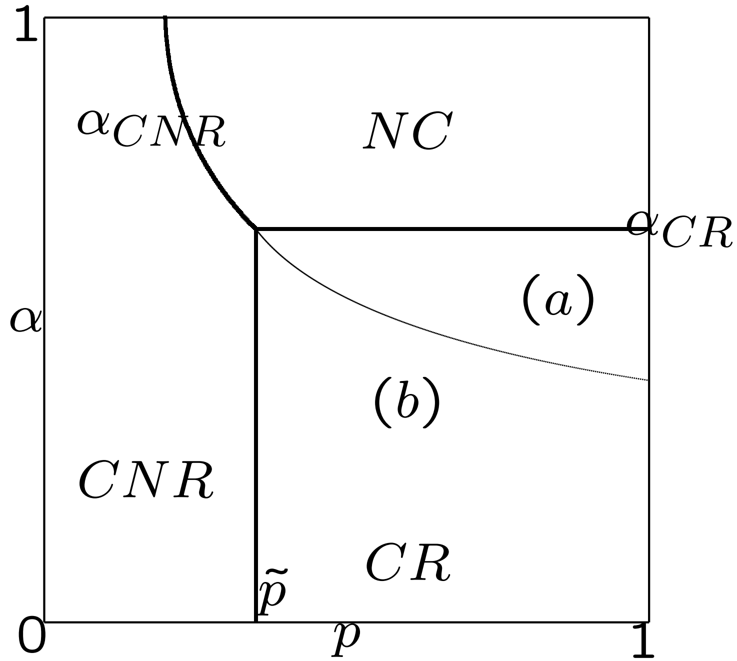


Figure: note areas (a) and (b).

Implementing the optimal policy

LP not unambiguously optimal: ex-ante deterrence vs. ex-post desistence.

Motta-Polo: LP to be used if AA has limited resources.

Intuitions:

1) NC>CR>CNR.

2) If high budget, high (p, α) and full deterrence by F, (LP might end up in (a)).

3)if lower budget, no (NC): better (CR) by $R = 0$ than (CNR).

Fine reductions only before the inquiry is opened

Same game, but at $t = 2$, reveal or not before α realises.

LP ineffective: no equilibrium “collude and reveal.”

(No new info after decision of collusion and before moment they are asked to cooperate with AA).

Prepared with SEVISLIDES

Competition Policy - Spring 2005

Collusion II

Antonio Cabrales & Massimo Motta

April 22, 2005