The Role of Information and Monitoring on Collusion

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# Motivation

- Stylized IO facts on factors affecting collusion: 1.
	- **Monitoring** of cartel members (Stigler)
	- **Demand information** (Tirole)
- Well-known theories inform our design:  $\overline{2}$ .
	- Green and Porter (1984), GP
	- Finite price wars triggered by low demand  $\rightarrow$
	- Collusion more stable when demand is high  $\rightarrow$
	- Rotemberg and Saloner (1986), RS
		- Price wars observed in high demand  $\rightarrow$
		- Collusion more stable during low demand  $\rightarrow$

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# **Theory: Assumptions**

- Homogenous products  $\overline{\phantom{0}}$
- **Cournot competition**  $\left\langle \right\rangle$
- Symmetric firms and constant MC  $\left\langle \right\rangle$
- Infinitely repeated game  $\overline{\phantom{a}}$
- $\left\langle \right\rangle$ **Stochastic (uncertain) demand** 
	- RS: f,
		- ⋋ Uncertain future demand, except for t+1 (tomorrow),
		- ⋋ **Perfect monitoring and perfect information on "(t+1)"**
		- $GP:$

f,

- Uncertainty for all future (and past) demand schedules ⋋
- $\rightarrow$ **Imperfect monitoring and imperfect information**

# Theory: RS Equilibrium

- Demand is stochastic but we all know that tomorrow is  $\mathcal{P}$ "Christmas"
- For a large enough demand shock:  $\sum$

D	C	$\bigcup_{high}$	$\bigcup_{i}$	$\bigcup_{i}$	$\bigcup_{i}$	$\bigcup_{i}$	$\bigcup_{i}$
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Collusion is more feasible in "bad times"  $\overline{\Sigma}$ 

$$
\begin{array}{ccc}\nD & C & \longrightarrow & E & F & F \\
\hline\nlow & 1 & 1\n\end{array}
$$

- Grim-trigger strategy is assumed (but not necessary)  $\sum_{i=1}^{n}$
- Other equilibria, e.g. always defect  $\sum_{i=1}^{n}$



#### **Experimental Design**

- Two Quantity choices (L, H), prisoner's dilemma  $\sum_{i=1}^{n}$
- 3 Demand states (three payoff matrices):  $\overline{\mathbf{y}}$ 
	- f, *high* (20%) - *h*
	- f, *medium (60%) - m*
	- f, *low l*
- 30 rounds, then game ends with 25% probability  $\sum$
- 3 treatments:  $\sum$ 
	- FI: demand information + perfect monitoring (RS) f,
	- M: perfect monitoring f,
	- IM: imperfect monitoring (GP) f,





 $1.00$  ,  $1.00^\circ$ 

Neci<br>Choice is<br>"B"  $3.50, 0.60$   $^{-1}$ 





# **Experimental Design**

- 464 subjects, 15,000 + obs
- Extensive training: instructions, practice  $\overline{\phantom{a}}$ questions, quiz, messages
- Several parameterizations (P1, P2, P3):  $\sum$ RS:
	- Incentive to collude in *medium* and low demand  $(P1)$
	- Incentive to collude in all demand states (P2)
	- GP: not feasible  $(P1)$ ; punishment length,  $N^*=3$ , periods (P2)
- Robustness checks: control for risk aversion  $\sum$ (P3), different demand draws (P2b)

#### **Results (Parameterization 2)**



#### Results: Information and Monitoring



*L*  $\cdot$  *\* Both* players chose *L* 

#### **Results FI Treatment (RS theory)**



# Results: RS (FI treatment)



#### Results: RS (FI treatment)

- Does RS strategy explain data better than other strategies? Š.
	- **Random strategy** Š.
	- *s* "Tit-for-Tat" strategy
	- Finite punishment strategies (after defection) Š.
	- Grim strategy (after defection) Š.
- 1. Indicator variable determines the "theoretical" state (coop=1 or dev=0) for each strategy (an "automaton")
- 2. Probit model of actual choice (coop=1,  $dev=0$ ) on "theoretical" state
- 3. Likelihood-ratio tests wrt random strategy



#### Results: RS (FI treatment)

- Strategies implied by RS equilibrium seem  $\sum_{i=1}^{n}$ supported by data
- Grim strategy appears to explain data best  $\sum_{i=1}^{n}$ 
	- Important: grim strategy is assumed by RS to f, derive their predictions
- $\overline{\mathbf{y}}$ These are tests on *individual* choices
- $\sum_{i=1}^{n}$ Test on *outcomes:* 
	- Parm. 1: 54% (RS), 51% (always collude), 29% f, (always defect), 21% (H,L or L,H)
	- *71% (always collude)*f, (always defect), 12% (H,L or L,H)



#### Results: GP (IM treatment)

- Cooperation is lower during price war periods predicted by GP (especially for infinite price wars)
- How does GP do against other individual (complex)  $S_{\cdot}$ strategies?
- Random strategy, and "threshold" strategies based on Š. noisy signal (price)
	- 1. One threshold:
		- Deviation triggered by low price; reversion to collusion Š. after fixed periods or never (grim strategy)
	- 2. Two thresholds:
		- Deviation triggered by a low price; reversion to collusion Š. after a high price

#### Random *GPN*One-Threshold, N=punishment period

Two-Thresholds

#### Results: GP (IM treatment)

- Random strategy can be rejected in favor of  $\sum_{i=1}^{n}$ **GP** equilibrium
- Grim strategy appears to explain data best  $\sum$
- There are trigger strategies, but different than  $\sum_{i=1}^{n}$ predicted by GP
	- Longer duration, or duration determined by signal f,
	- Not necessarily triggered by the predicted signals f,
- $\sum_{i=1}^{n}$ Test on *outcomes:* 
	- Parm. 1: 72% (GP), 50% (GP3), 37% (always f, defect)
	- Parm. 2: 62% (GP), 51% (GP3), 33.6% (always f, defect)

# Conclusion

- Monitoring appears to matter the most in this  $\sum_{i=1}^{n}$ setting
- Less information may increase collusion  $\sum_{i=1}^{n}$

# Robustness and Caveats

- **Risk aversion**  $\overline{\phantom{0}}$ 
	- **Controlled for**
- Students as subjects  $\overline{\sum}$ 
	- Dyer, Kagel, Levin, 1989; Potters van Winden, 2000; Davis and Holt, 1993; Ball and Cech, 1996
- Infinitely repeated game  $\sum_{i=1}^{n}$

#### **Parameterization 2**

**High Demand (h)** 

#### **Imperfect Public Monitoring**





