The Role of Information and Monitoring on Collusion

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## Motivation

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

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## Theory: Assumptions

- Homogenous products
- Cournot competition
- Symmetric firms and constant MC
- Infinitely repeated game
- Stochastic (uncertain) demand
  - RS:
    - > Uncertain future demand, *except* for t+1 (tomorrow),
    - Perfect monitoring and perfect information on "(t+1)"
    - GP:
      - > Uncertainty for all future (and past) demand schedules
      - > Imperfect monitoring and imperfect information

### Theory: RS Equilibrium

- Demand is stochastic but we all know that tomorrow is "Christmas"
- > For a large enough demand shock:

$$\begin{array}{ccc} D & C \\ high & high \end{array} \quad \frac{1}{1} \quad E\left(\begin{array}{cc} C & NE \\ i & i \end{array}\right)$$

Collusion is more feasible in "bad times"

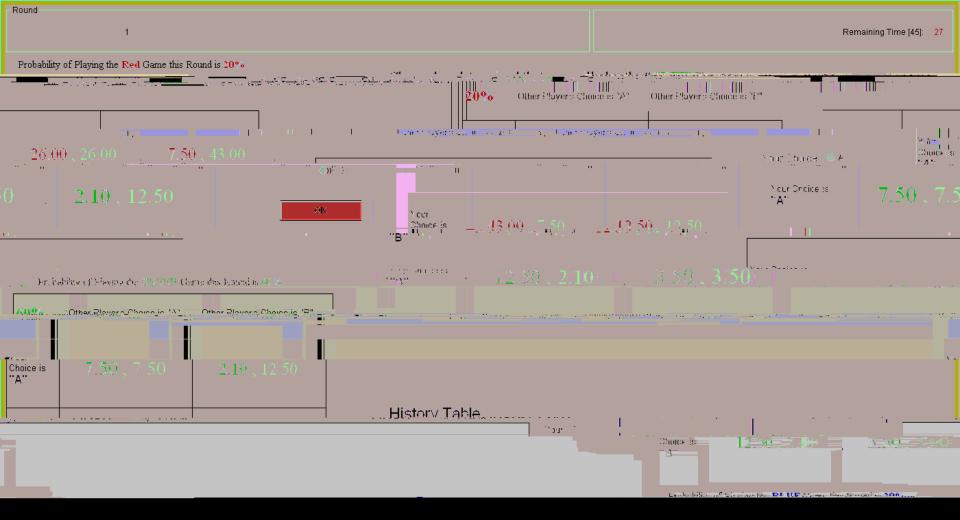
$$\begin{array}{ccc} D & C \\ low & low \end{array} \quad \frac{1}{1} \quad E\left(\begin{array}{ccc} C & NE \\ i & i \end{array}\right)$$

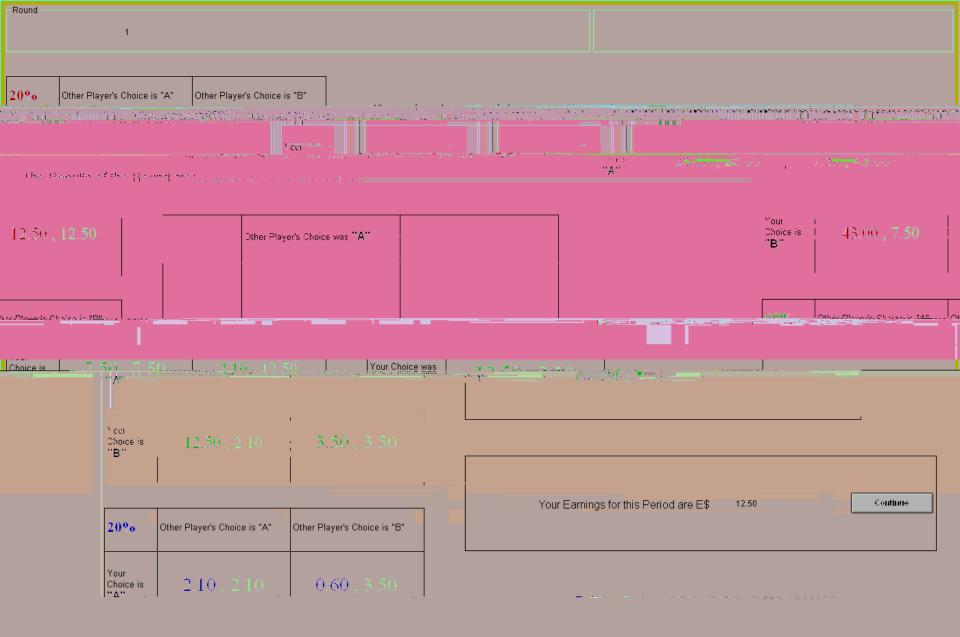
- Grim-trigger strategy is assumed (but not necessary)
- > Other equilibria, e.g. always defect

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### **Experimental Design**

- Two Quantity choices (L, H), prisoner's dilemma
- 3 Demand states (three payoff matrices):
  - high (20%) h
  - *medium* (60%) *m*
  - low (20%) 1
- > 30 rounds, then game ends with 25% probability
- > 3 treatments:
  - FI: demand information + perfect monitoring (RS)
  - M: perfect monitoring
  - IM: imperfect monitoring (GP)





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Net Choice is 1 3.50 , 0.60 1 "B"

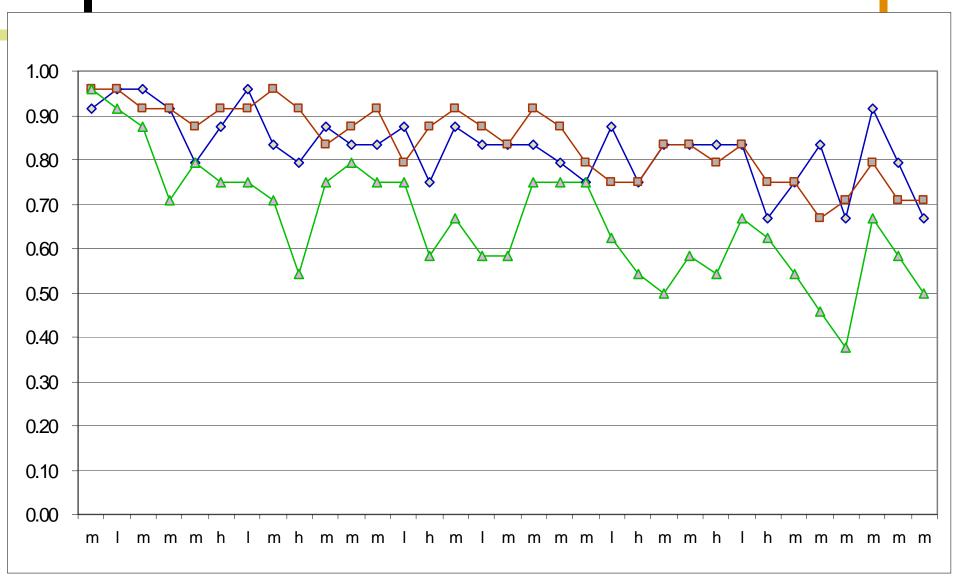




## Experimental Design

- 464 subjects, 15,000 + obs
- Extensive training: instructions, practice questions, quiz, messages
- Several parameterizations (P1, P2, P3):
  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 (P3), different demand draws (P2b)

### Results (Parameterization 2)

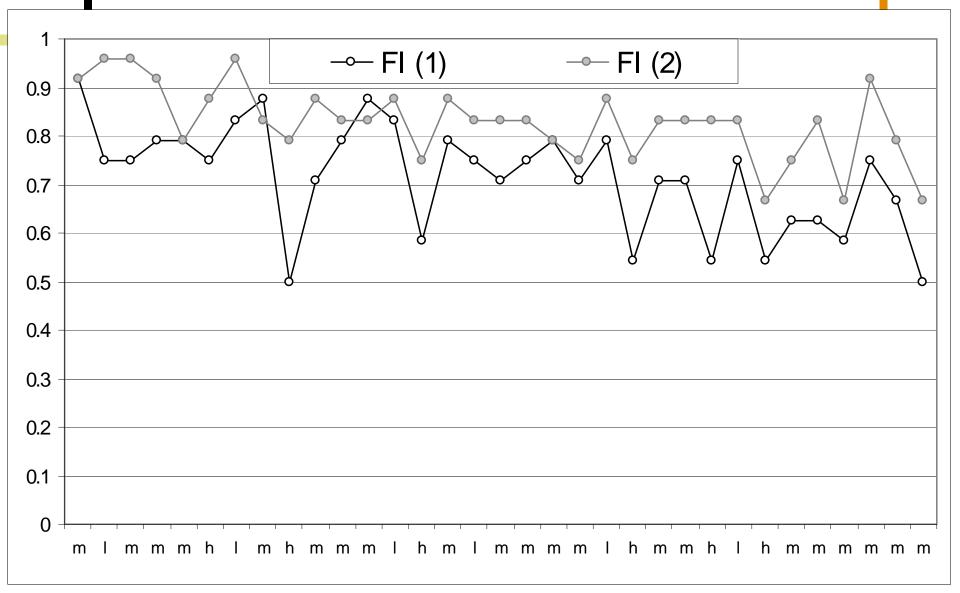


## Results: Information and Monitoring

Treatment	Parameterization	Frequency of	Frequency of	
Treatment	Farameterization	Cooperation*	Collusion**	
	1	0.72 (0.45)	0.51 (0.50)	
Full Information	2	0.83 (0.38)	0.71 (0.46)	
	1	0.76 (0.42)	0.59 (0.49)	
Monitoring	2	0.84 (0.37)	0.71 (0.46)	
	1	0.63 (0.48)	0.31 (0.46)	
Imperfect Monitoring	2	0.66 (0.47)	0.41 (0.49)	

\*Either player chooses *L*. \*\* *Both* players chose *L*.

### Results FI Treatment (RS theory)



## Results: RS (FI treatment)

Demand State	р	Freq.	Freq.	
Demand State	Р	Coop.*	Collusion**	
High(h)	1	0.58 (0.49)	0.43 (0.50)	
High (h)	2	0.80 (0.40)	0.67 (0.47)	
	1	0.78 (0.42)	0.56 (0.50)	
Medium (m)	2	0.85 (0.36)	0.73 (0.44)	
	1	0.79 (0.41)	0.59 (0.49)	
Low ( <i>l</i> )	2	0.90 (0.30)	0.77 (0.42)	

#### Results: RS (FI treatment)

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

Parameter	Random	RS	tt	P-2	P-3	<b>P-6</b>	Р-
	-0.80* * *	-0.66	-0.97*	-0.93* *	-0.85* *	-0.86* *	-0.69*
	(0.43)	(0.46)	(0.36)	(0.39)	(0.39)	(0.35)	(0.16)
1		0.92*					
		(0.14)					
2			0.56*				
			(0.12)				
3				0.37*	0.23* *	0.53*	2.39*
				(0.11)	(0.12)	(0.14)	(0.24)

### Results: RS (FI treatment)

- Strategies implied by RS equilibrium seem supported by data
- Grim strategy appears to explain data best
  - Important: grim strategy is assumed by RS to derive their predictions
- These are tests on *individual* choices
- Test on *outcomes:* 
  - Parm. 1: **54% (RS)**, 51% (always collude), 29% (always defect), 21% (H,L or L,H)
  - Parm. 2: 71% (always collude), 65% (RS), 17%
    (always defect), 12% (H,L or L,H)

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### Results: GP (IM treatment)

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



### Results: GP (IM treatment)

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

# Conclusion

- Monitoring appears to matter the most in this setting
- > Less information may increase collusion

## **Robustness and Caveats**

- Risk aversion
  - Controlled for
- Students as subjects
  - Dyer, Kagel, Levin, 1989; Potters van Winden, 2000; Davis and Holt, 1993; Ball and Cech, 1996
- Infinitely repeated game

#### Parameterization 2

High Demand (h

#### Imperfect Public Monitoring

•			High Demand		
			Player 2		
			L H		
	er 1	L	p <sub>4</sub>	p <sub>3</sub>	
	Player 1	Н	$P_3$	p <sub>2</sub>	

		Medium Demand		
		Player 2		
		L H		
Player 1	L	p <sub>3</sub>	p <sub>2</sub>	
Ыay	Н	p <sub>2</sub>	p <sub>1</sub>	

		High Demand		
		Player 2		
		L	Н	
Player 1	L	p <sub>2</sub>	p <sub>1</sub>	
Play	Н	p <sub>1</sub>	p <sub>0</sub>	