Flexibility and Cooperation with Imperfect Monitoring

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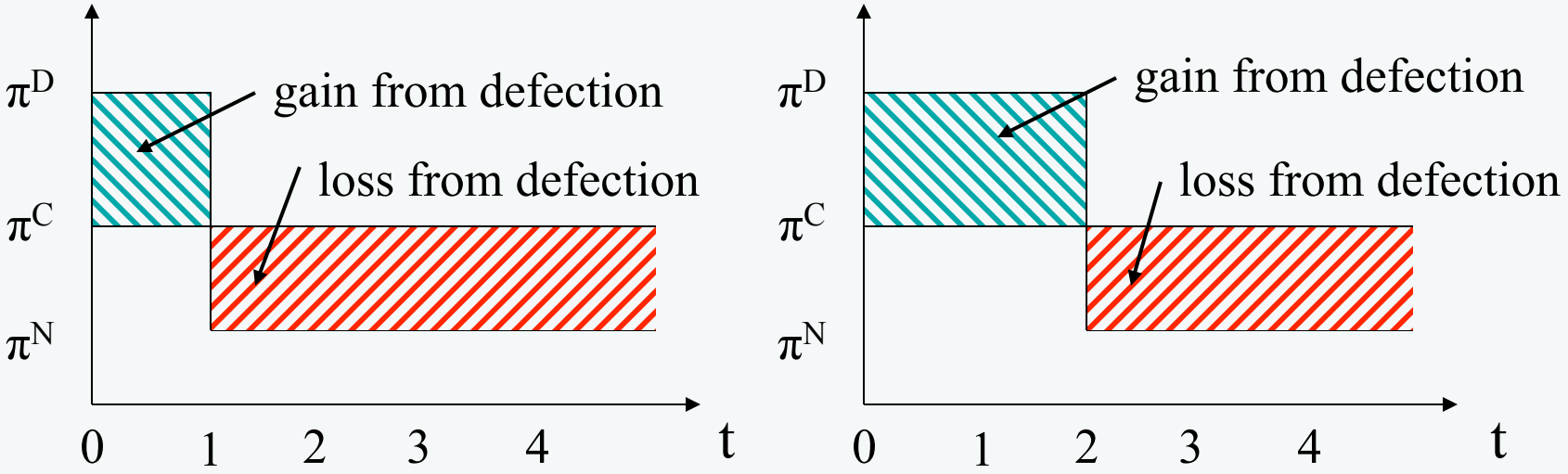
Flexibility

- flexibility = ability to act and react quickly
- regarded as one of the main factors that facilitate cooperation



- strong intuition
- experimental evidence (Axelrod, 1984; Friedman Oprea 2012)

Reflected in Antitrust body of knowledge

- IO/Antitrust handbooks: frequency of interaction (or of orders) facilitates collusion
- see e.g. Tirole (1988, p.240); Church and Ware (2000, p.343); Martin (2001, p.192); Ivaldi et al. (2003); Motta (2004, p.145), Belleflamme and Peitz (2010, p.254)

- Analogous statements in several CA's guidelines
  - OFT's "Predicting Cartels" (2005),
  - DoJ's "Primer",
  - EU "Coordinated Effects" (http://ec.europa.eu/dgs/competition/economist/delamano2.pdf)

Flexibility with Imperfect Monitoring (IM)

- *Abreu, Milgrom and Pearce (ECTA 1991)*
  - with noisy information about opponent's action
  - flexibility also has a negative effect on cooperation
  - players have to react to poor information
- *Sannikov and Skrzypacz (AER 2007)*
  - collusion impossible with high flexibility and IM

Our research questions:

- collusion also impossible with low flexibility…

⇒ flexibility has a non-monotonic effect on collusion!

- **Is the negative effect of flexibility with imperfect monitoring behaviorally relevant?**
- **Can we really observe a non-monotonic effect of flexibility?**

Experimental design

- Based on Sannikov and Skrzypacz (AER 2007)
- Stage game is a 2x2, 2-player Cournot game
  - $q_i \in \{3, 4\}$
  - $P(Q) = 12 - Q,$ $\quad Q = q_1 + q_2$
  - $\pi_i = P(Q)q_i - 16$

		q_2	
	Profits	3 units	4 units
q_1	3 units	2, 2	-1, 4
	4 units	4, -1	0, 0

Experimental design

- Imperfect monitoring
  - At the end of a period, players only observe market price, which is a noisy signal of total quantity
  - $P(Q_t) = 12 - Q_t + \varepsilon_t$,

    $\varepsilon_t \sim N(0,\sigma^2)$, $\sigma = 1.3$, i.i.d. across periods
- Flexibility
  - Players can change quantity every Δ periods
  - Three treatments: $\Delta = 1$, $\Delta = 2$, $\Delta = 3$
  - Two effects of Δ
    - players can react (punish) only after Δ periods
    - players have Δ independent signals about other's action before they can react

Experimental design

- Repeated game
  - Model: infinitely repeated game with discount rate $\delta = e^{-r\Delta}$
  - Experiment: indefinitely repeated game with continuation probability $\delta = e^{-r\Delta}$
    - After Δ periods,
      - with probability δ the game continues for at least another Δ periods
      - with probability $1-\delta$ the game ends.
  - with r=0.10:
    - δ = 0.90, 0.82, 0.74 for Δ = 1, 2, 3, resp.

Experimental design

- Theoretical predictions
  - cutoff strategies to sustain cooperation
    - play q=3 as long as $P \geq P`$
    - play q=4 as soon as $P < P`$
  - **$\Delta = 2$**: cooperation **is an equilibrium**
    - with $P` \approx 5$
  - **$\Delta = 1$**: cooperation is **not an equilibrium**
    - effect of q=3 on Prob(P ≥ P`) is too low
  - **$\Delta = 3$**: cooperation is **not an equilibrium**
    - δ too low; future is not important enough

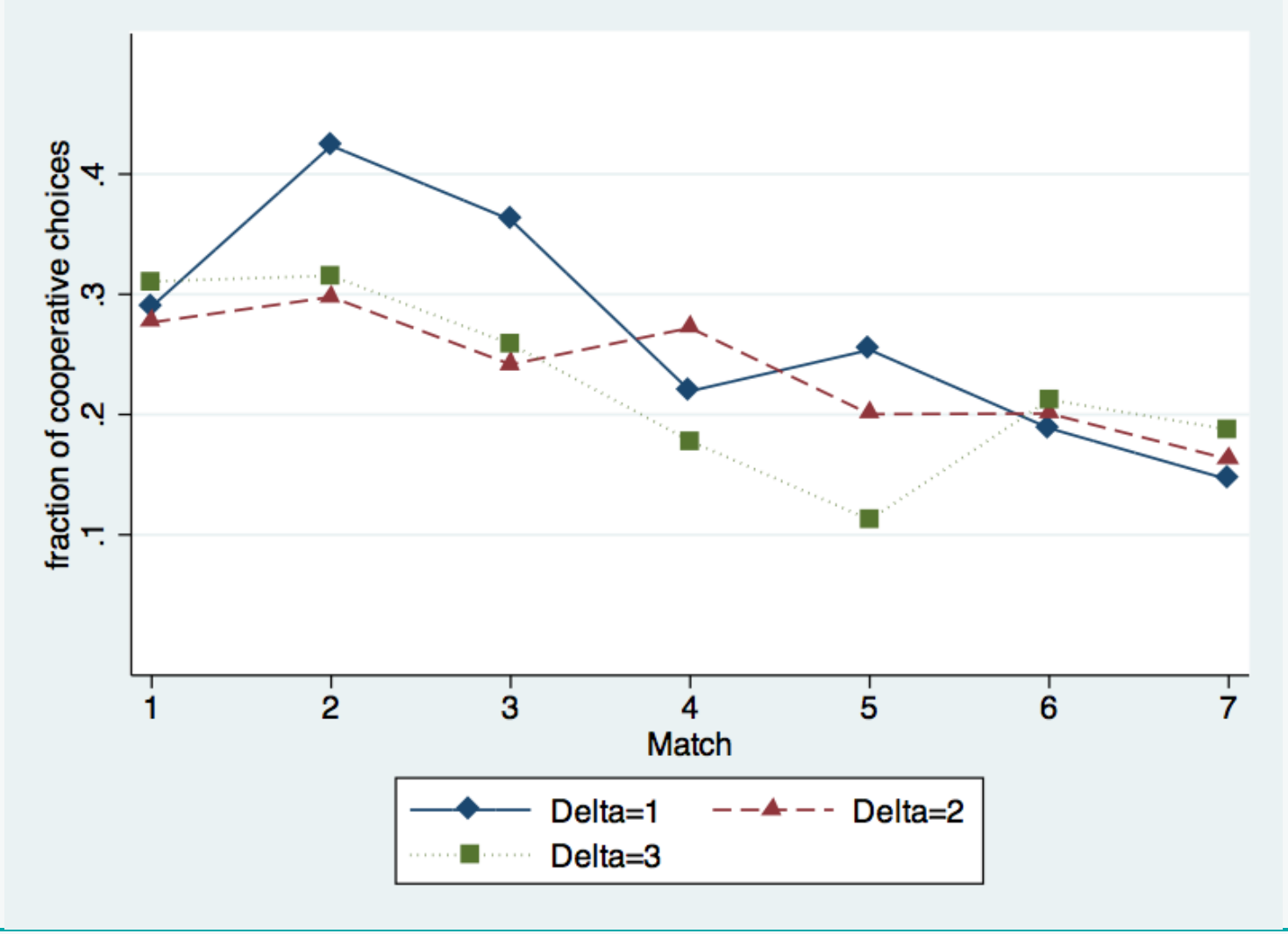
Experiments on imperfect monitoring

- Aoyagi and Frechette (JET 2009)
  - vary the variance of the noisy signal
- Fudenberg, Rand, Dreber (AER, 2012)
  - vary the gains of cooperation
- We vary flexibility
  - consider the case of “frequent actions”

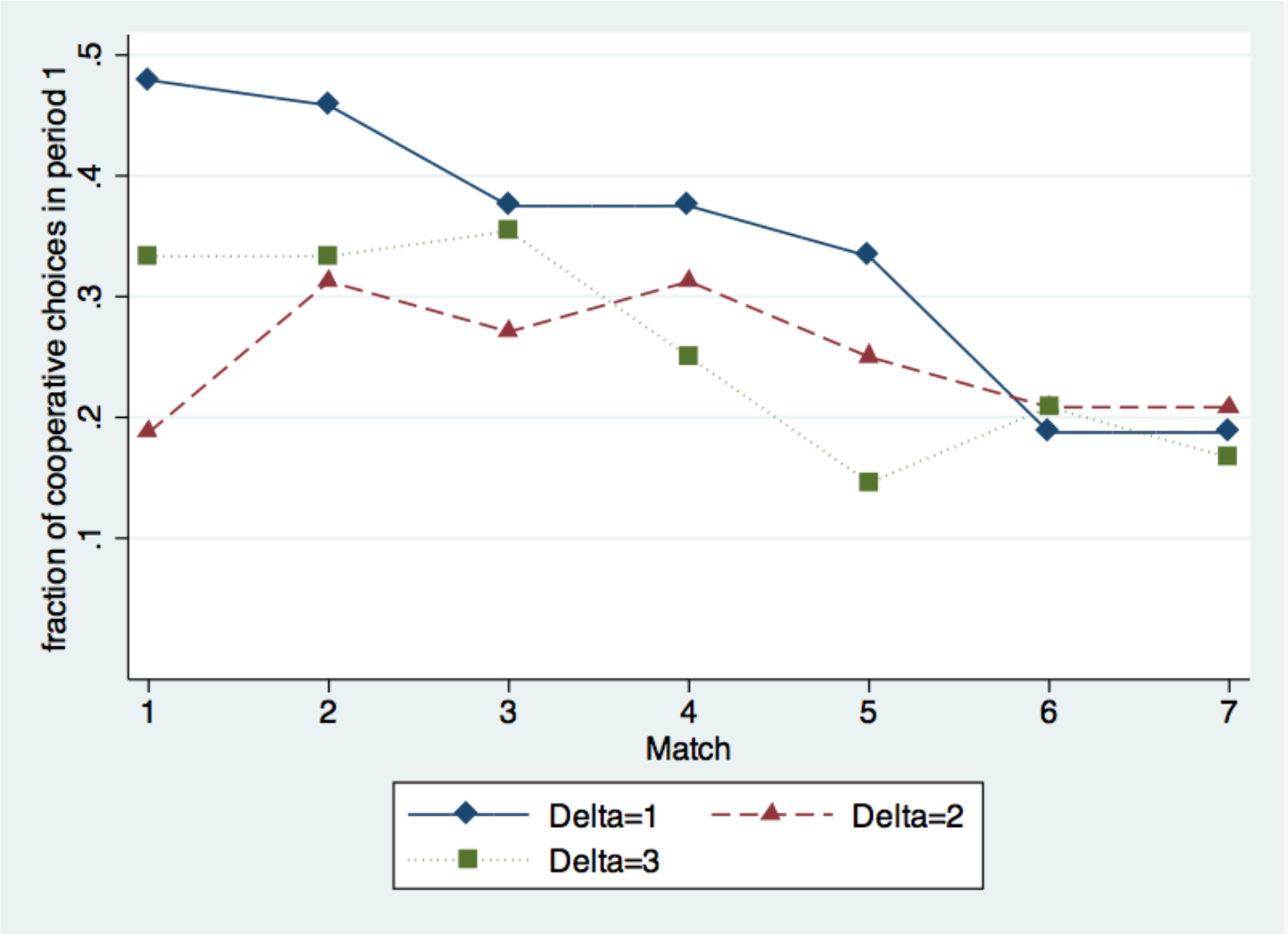
Experimental procedure

- CentERlab Tilburg, zTree
- 3 sessions per treatment
- 16 subjects per session (144 subjects in total)
- 2 matching groups of 8 subjects per session
- each subject plays 7 indefinitely repeated games
- sessions lasted about 2 hours
- average earnings €18.90 (min €10, max €38)

Cooperation rate (all periods)



Cooperation rate (1st period)



Coordination problem?

- In treatment Delta=2,
  - non-cooperation is also an equilibrium
  - there are many (partially) cooperative equilibria.

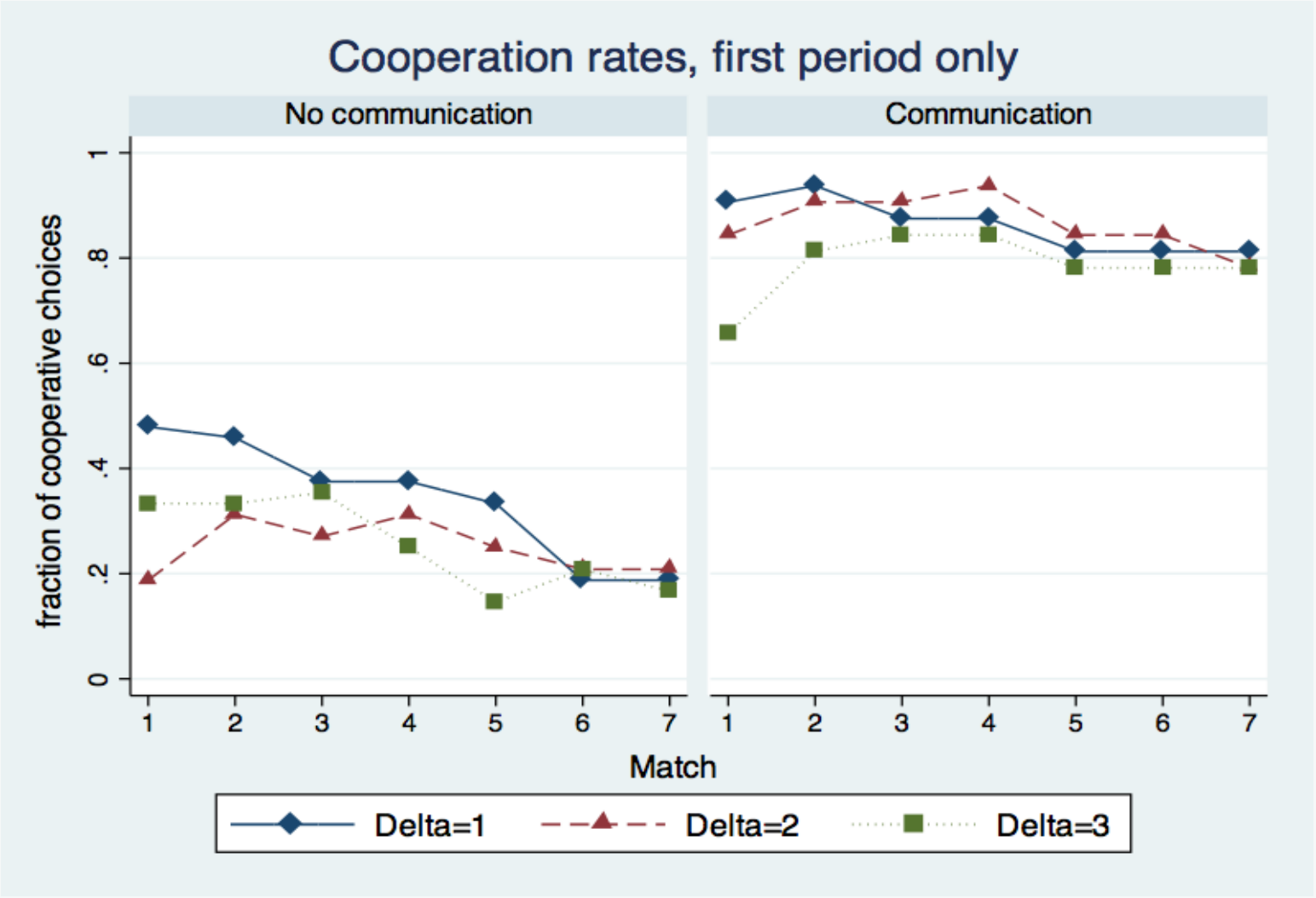
- Question:
  - Is the “failure” of the predicted treatment effect, due to coordination problems in Delta=2?
  - Perhaps communication can foster cooperation, in case it is an equilibrium (Cooper and Kuhn, 2011)

Allow for communication

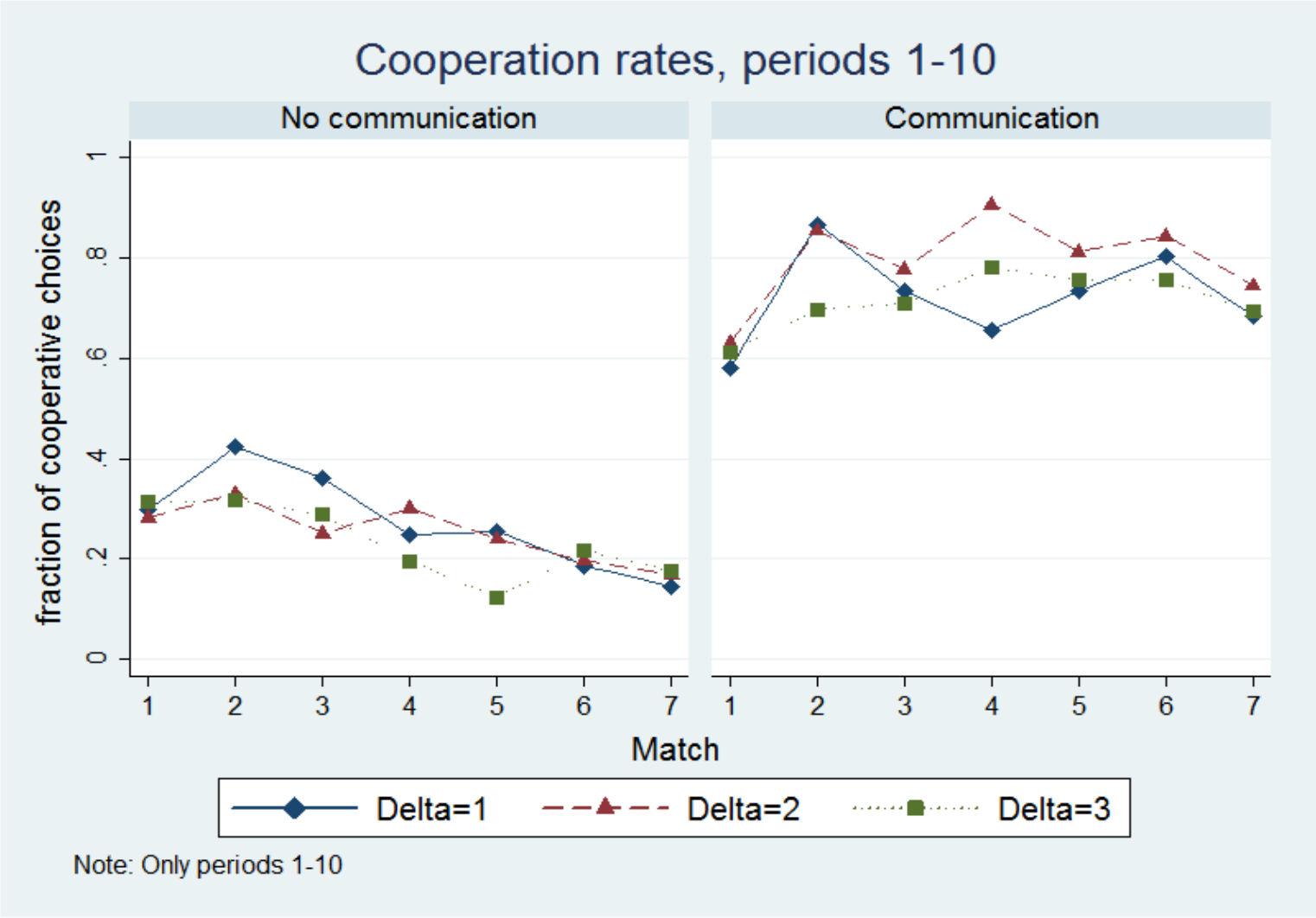
- 6 additional sessions
  - 2 sessions per Delta treatment
  - with the exact same design as before

- At the beginning of each repeated game
  - a chat window opens
  - paired subjects can send messages to each other
  - for 2 minutes
  - in free form (in English, anonymous, not offensive)

Impact of communication



Impact of communication



Impact of communication

- Strong effect of communication on cooperation
  - in all treatments

- Communication does not merely alleviate coordination problem (Δ=2), but also seems to enable subjects to circumvent the forces that erode cooperation:
  - Δ=1: not react to noisy signals too quickly
  - Δ=3: resist temptation to defect

- Question:
  - Is this reflected in the chats?

Communication data

- 6 sessions x 7 matches x 8 pairs = 336 chats
  - 13 lines on average
- Coding

  message types (Cooper & Kuhn, 2012, Fonseca & Normann, 2012)
  - Courtesy and Small talk (2 categories)
  - Coordination and Agreement (5 cat.),
  - Trust and Distrust (4 cat.)
  - Strategies (promise, threat, leniency) (7 cat.),
  - Experience (10 cat.)
- PRELIMINARY ! (only one coder yet)

Frequency of messages by treatment

Average Frequency	$\Delta = 1$	$\Delta = 2$	$\Delta = 3$	significant differences
Greetings	0.77	0.89	0.87	1<2
Agreement	**0.59**	**0.68**	**0.80**	**1<3**, (2<3)
Appeal to trustworthiness	0.04	0.10	0.13	.
Promise	0.19	0.17	0.16	.
Threat	0.11	0.09	0.09	.
Leniency	**0.21**	**0.10**	**0.05**	**1>3**
Agree to strategy	0.24	0.06	0.05	1>2,1>3
Mention shocks	0.18	0.13	0.07	.
Good experience	0.14	0.27	0.11	2>3
Bad experience	0.07	0.14	0.03	2>3

notes: only messages which occur at rate of at least 0.10 in one treatment; averages and tests use four matching groups as observations

Relation between messages and collusion

marginal effects (stand dev)	Δ=1	Δ=2	Δ=3
Match	-.05 (.03)	-.05 (.01)***	-.04 (.01)***
Greetings	-.07 (.10)	-.09 (.24)	-.24 (.08)***
Agreement	38 (.14)***	.46 (.12)***	.70 (.07)***
Appeal to trustworthiness	-.43 (.45)	-.001 (.11)	.03 (.05)
Promise	.09 (.07)	.03 (.13)	.19 (.13)
Threat	.11 (.10)	.09 (.12)	.25 (.15)
Leniency	.26 (.03)***	.11 (.10)	.14 (.23)
Agree to strategy	-.05 (.06)	.14 (.13)	-.29 (.40)
Mention shocks	.08 (.05)	-.08 (.07)	.23 (.17)
Good experience	-.01 (.15)	.24 (.13)*	.09 (.18)
Bad experience	.08 (.07)	.01 (.02)	.05 (.18)
# obs.	111	112	111

notes: collusion=1 if, in period 1, both players play q=3; message codes by chat; logit regressions; standard errors clustered by Matching Group.

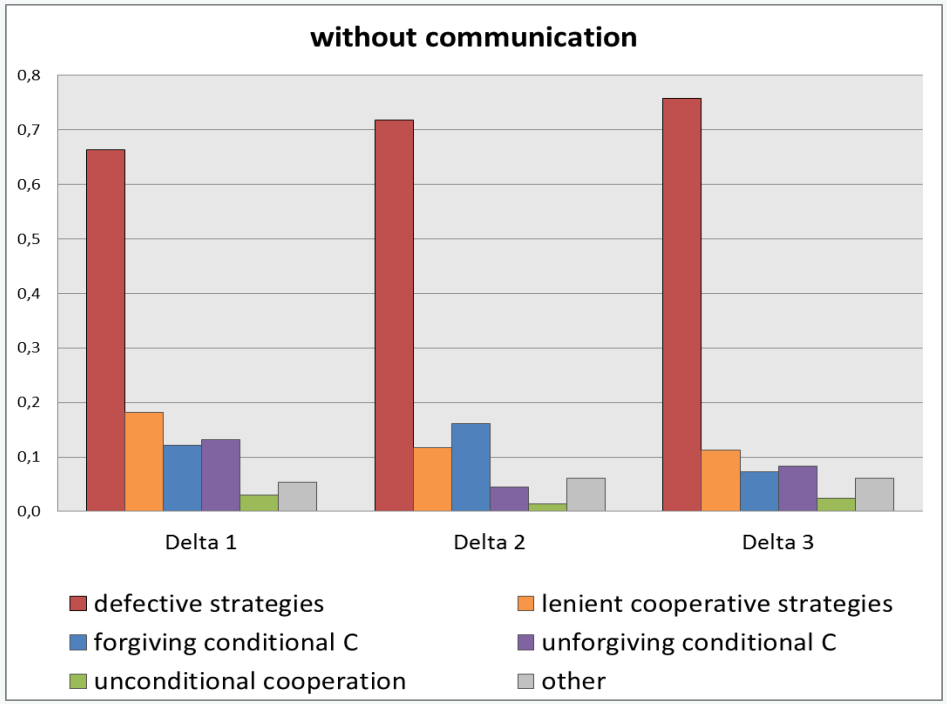
What type of strategies did subjects use?

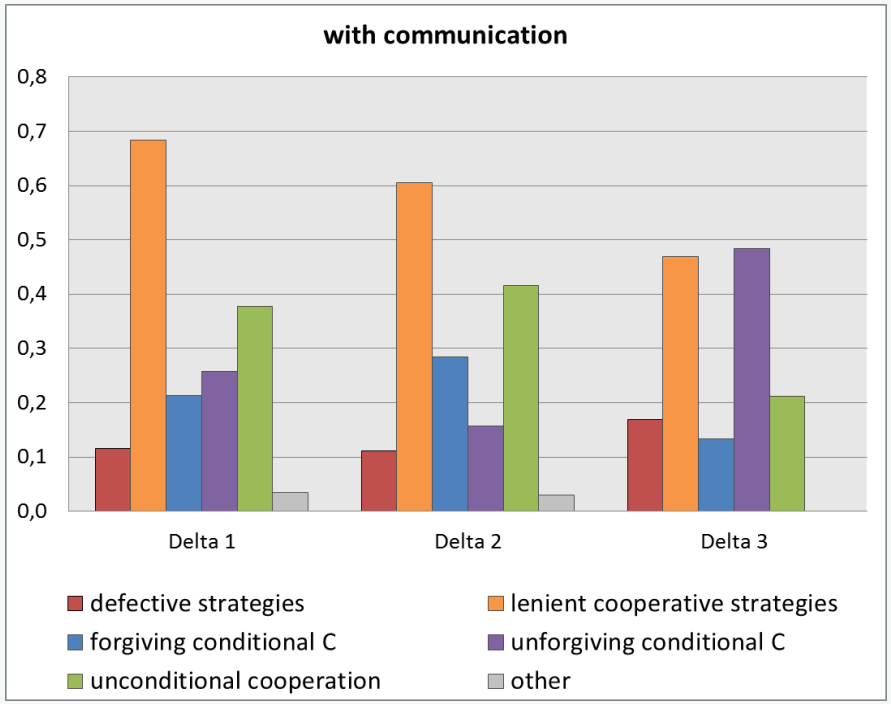
- estimate frequency of strategies (Dal Bo, Frechette, 2011)
- 20 strategies:

  always coop, always defect; unforgiving conditional: grim trigger, lenient-grim, tit-for-tat, tit-for-2tats, 2tits-for-tat, suspicious tit-for-tat,... (Fudenberg, Rand, Dreber, 2012)

  - conditional vs unconditional
  - lenient vs strict (how fast to react)
  - forgiving vs unforgiving (whether to go back to coop)

What type of strategies did subjects use?





- without communication, always defect most prevalent
- with communication, Leniency particularly frequent in Delta1, Forgiveness in Delta2, Unforgiveness in Delta3.

Conclusion

- Common wisdom that flexibility facilitates cooperation is not robust to imperfect monitoring.
- Evidence for non-monotonic effect is weak
  - Without communication:
    - 'too little' collusion with intermediate flexibility
  - With communication:
    - 'too much' collusion with low and high flexibility
- Message content reflects behavioral relevance of the two main forces that may impede collusion:
  - reaction to noisy information with high flexibility
  - temptation to defect with low flexibility

Thanks for your attention.