Communication, Renegotiation and the Scope for Collusion

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The Theory of Collusion Success . . .

- Theory has been very successful in describing the form a collusive equilibrium should take.
  - Abreu (1988)
  - Abreu, Pearce, and Stacchetti (1990)
- The theory has been widely applied to anti-trust policy.
  - Motta 2004
  - Coordinated Effects of mergers:
    - Compte, Jenny, and Rey 2002
    - Kühn 2004
    - Kühn 2008

The Standard Collusion Model

The Incentive Condition:

$$(p^c - \varepsilon - c)D(p^c - \varepsilon) - \frac{1}{2}(p^c - c)D(p^c) \leq \delta[\bar{V} - \underline{V}]$$

Benefit from undercutting by one unit

Loss from switching to a worse equilibrium in the future

The Theory of Collusion . . . and Failure

- The theory does not provide a satisfying answer for how players coordinate on a particular collusive equilibrium.
  - Bargaining over equilibrium value set (Harrington 1991; Kühn and Rimler 2006)
  - Cheap talk (Aumann 1990; Farrell 1993; Farrell and Rabin 1996; and Rabin 1994)
    - Communication about contingent strategies crucial
    - Efficiency may not be reached with conflicts of interest
  - Renegotiation (Bernheim and Ray 1989; Farrell and Maskin 1989; Van Damme 1989; Pearce 1987; Abreu, Pearce, and Stacchetti 1993)

- Empirical literature on factors making collusion more likely cannot distinguish between process leading to collusion and conditions that affect the incentive conditions of standard theory.

Unresolved Problems in Collusion Theory

- Explicit vs. Tacit Collusion
- Explicit Collusion:
  - How much does communication matter?
  - Does collusion require specifying contingent strategies?
  - Are feelings of spite or other “fairness” considerations a sufficient enforcement mechanism for collusion?
- Renegotiation:
  - Does it severely limit collusion as theory suggests?

Communication and Collusion

- This paper focuses on the role of communication in fostering collusion.
  - Our goal is *not* to show that allowing communication can increase collusive behavior – this is already known to be true.
  - Our goal is to answer the questions:
    - A) What feature of communication are critical for establishing collusion?
      - Contingent strategies
      - Renegotiation
      - Content analysis
    - B) Is improvement transient or persistent?
    - C) Does the theory of communication in games have predictive power?

Two Stage Bertrand Game

- The underlying game being played by subjects is an infinitely repeated Bertrand duopoly game.
- In the spirit of Abreu, Pearce, and Stacchetti (1990), we collapse the continuation game into a single period game.
  - Conceptually, collusion games are equivalent to a single shot oligopoly game followed by a single shot coordination game.
  - Collusion requires coordination on history contingent strategies.

Period 1

	L	M	H
Player 1 payoffs			
L	$\frac{\pi^L}{2}$	π^L	π^L
M	0	$\frac{\pi^M}{2}$	π^M
H	0	0	$\frac{\pi^H}{2}$

Period 2

	L	M	H
Player 1 *payoffs*			
L	Π^L	$\delta[\pi^L + \Pi^L]$	$\delta[\pi^L + \Pi^L]$
M	$\delta\Pi^L$	Π^M	$\delta[\pi^M + \Pi^L]$
H	$\delta\Pi^L$	$\delta\Pi^L$	Π^H

Two Stage Bertrand Game

- To implement the game, we chose parameters such that collusion at high prices can only be supported using the harshest possible punishment (coordination on low prices) and that coordination at (M,M) is the risk dominant equilibrium in the second period.
  - We set $\pi^L = 78$, $\pi^M = 138$, and $\pi^H = 168$.
  - The discount rate is $\delta = 2/3$.
  - To sharpen the incentives, a fixed cost of 24 was subtracted from all payoffs.

Period 1

	Low	Medium	High
Low	15	54	54
Medium	-24	45	114
High	-24	-24	60

Period 2

	Low	Medium	High
Low	30	56	56
Medium	4	90	96
High	4	4	120

The Two Stage Collusion Game

	L	M	H
L	15,15	54,-24	54,-24
M	-24,54	45,45	114,-24
H	-24,54	-24,114	60,60

Period 1

The Two Stage Collusion Game

Period 2

30, 30	56, 4	56, 4
4, 56	90, 90	96, 4
4, 56	4, 96	120,120

The Risk Dominant Outcome

The Two Stage Collusion Game

	L	M	H
L	15,15	54,-24	54,-24
M	-24,54	45,45	114,-24
H	-24,54	-24,114	60,60

30, 30	56, 4	56, 4
4, 56	90, 90	96, 4
4, 56	4, 96	120,120

Experimental Design

- Subjects in all sessions play twenty rounds of the TSBG.
  - First ten rounds have no communication.
  - Communication is introduced for the second half of the experiment. The form of communication is a treatment variable.
- Subjects are in large sessions (at least twenty subjects) and random rematching is used to reduce repeated game effects between rounds.
- All subjects were undergraduates at CWRU. Sessions took 75 – 105 minutes – sessions with more communication took longer. All sessions were run using CWRU's mobile lab. Software is programmed in z-tree (Fischbacher, 2007).
- The conversion rate was 130 ECU/$. There was a show-up fee of $6. Subjects are paid for all rounds. Average pay was slightly below $20/subject.

Experimental Design

Table of Treatments

	N Treatment	P1 Treatment			PChat Treatment	RChat Treatment
Number of Sessions	3	3			3	3
Number of Subjects	64	68			64	76
First Period Messages		✓				
Second Period Messages						
Contingent Messages						
First Period Chat					✓	✓
Second Period Chat						✓

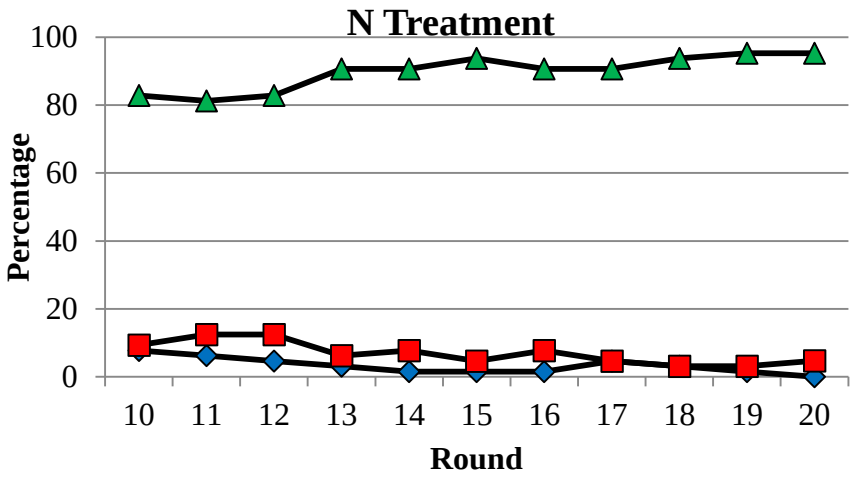
Non-contingent Message Treatment

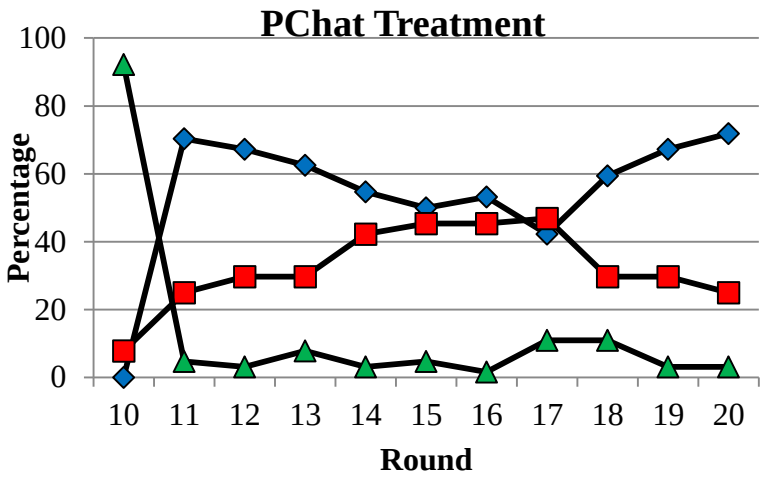
- Fixed Messages – each subject sends a single message simultaneously. Very limited message space is available. Subject have option of send no message or a partial message.
  - First period message
    - "I think we should choose the following in Period 1"
    - Specify my choice and other's choice

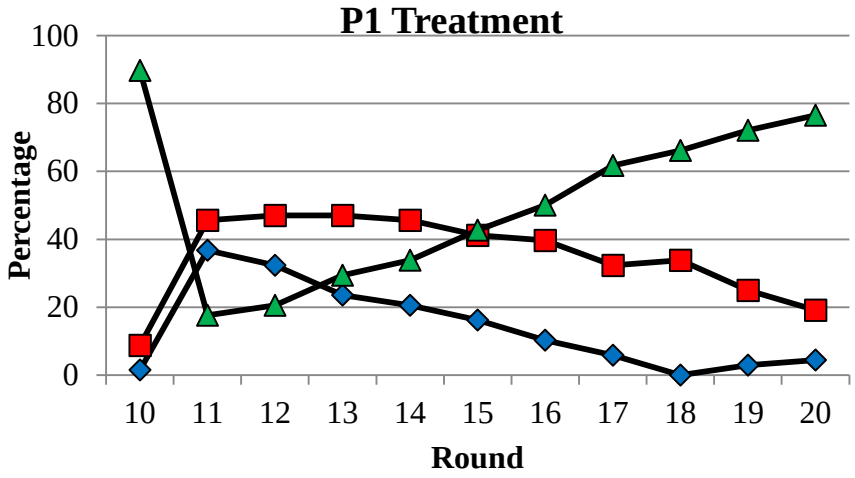
Chat

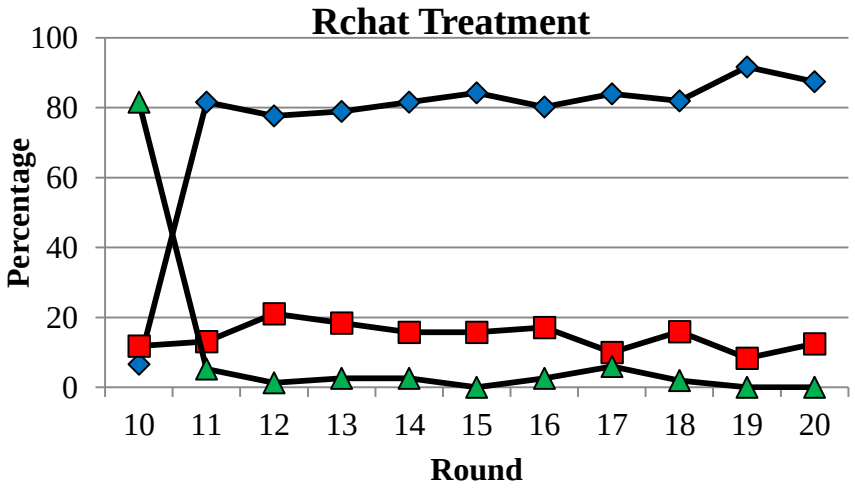
- Using latest version of z-tree (Fischbacher, 2007), we allow unstructured chat prior to the first and/or second periods.
  - Subjects are only instructed to not identify themselves and to avoid offensive language.
  - Subjects were allowed 75 seconds to chat. They were instructed to "sign off" when making a decision.

Treatment Effects: Period 1









Model 1			Model 2		
Variable	Parameter Estimate	Standard Error	Variable	Parameter Estimate	Standard Error
Rounds 13 – 14 (β_2)	-0.477***	0.125	N, Difference Rds 13-14 vs. Rds 11-12	-0.477***	0.125
Rounds 15 – 16 (β_3)	-0.606***	0.204	N, Difference Rds 15-16 vs. Rds 13-14	-0.129	0.211
Rounds 17 – 18 (β_4)	-0.495***	0.191	N, Difference Rds 17-18 vs. Rds 15-16	0.110	0.237
Rounds 19 – 20 (β_5)	-0.904***	0.205	N, Difference Rds 19-20 vs. Rds 17-18	-0.409	0.262
Rds 11 – 12, Difference P1 vs. N (γ_1)	1.856***	0.187	P1 Treatment	1.856***	0.187
Rds 13 – 14, Difference P1 vs. N (γ_2)	1.935***	0.202	P1, Difference Rds 13-14 vs. Rds 11-12	-0.398***	0.101
Rds 15 – 16, Difference P1 vs. N (γ_3)	1.682***	0.220	P1, Difference Rds 15-16 vs. Rds 13-14	-0.382***	0.120
Rds 17 – 18, Difference P1 vs. N (γ_4)	1.052***	0.245	P1, Difference Rds 17-18 vs. Rds 15-16	-0.519***	0.112
Rds 19 – 20, Difference P1 vs. N (γ_5)	1.220***	0.242	P1, Difference Rds 19-20 vs. Rds 17-18	-0.241**	0.111
Rds 11 – 12, Difference PChat vs. P1 (η_1)	0.933***	0.176	PChat Treatment	2.789***	0.205
Rds 13 – 14, Difference PChat vs. P1 (η_2)	1.071***	0.174	PChat, Difference Rds 13-14 vs. Rds 11-12	-0.260**	0.122
Rds 15 – 16, Difference PChat vs. P1 (η_3)	1.357***	0.172	PChat, Difference Rds 15-16 vs. Rds 13-14	-0.097	0.112
Rds 17 – 18, Difference PChat vs. P1 (η_4)	1.731***	0.184	PChat, Difference Rds 17-18 vs. Rds 15-16	-0.144	0.125
Rds 19 – 20, Difference PChat vs. P1 (η_5)	2.498***	0.182	PChat, Difference Rds 19-20 vs. Rds 17-18	0.526***	0.128
Rds 11 – 12, Difference RChat vs. PChat	0.264	0.205	RChat Treatment	3.053***	0.226
Rds 13 – 14, Difference RChat vs. PChat	0.569***	0.199	RChat, Difference Rds 13-14 vs. 11-12	0.045	0.167
Rds 15 – 16, Difference RChat vs. PChat	0.761***	0.197	RChat, Difference Rds 15-16 vs. 13-14	0.095	0.113
Rds 17 – 18, Difference RChat vs. PChat	0.931***	0.229	RChat, Difference Rds 17-18 vs. 15-16	0.025	0.192
Rds 19 – 20, Difference RChat vs. PChat	0.734***	0.278	RChat, Difference Rds 19-20 vs. Rds 17-	0.329	0.257
Average Period 1 Price (Rds 1 – 10)	0.882***	0.196	Average Period 1 Price (Rds 1 – 10)	0.882***	0.196
Average Period 2 Price (Rds 1 – 10)	0.105	0.114	Average Period 2 Price (Rds 1 – 10)	0.105	0.114

Results: Chat

- Allowing first period chat leads to dramatically higher levels of collusion. There is no deterioration in collusion with experience.
  - There is a dip in the middle periods.
  - Coordination slightly improves in the second period.
- Adding second period chat substantially improves collusion. Collusion slightly improves with experience.
  - This directly contradicts the relevant theory of renegotiation.
  - There is also improvement in second period coordination with second period chat.

Content Analysis

- All messages were coded for content.
  - David and I separately developed coding schemes for a test sample of messages.
  - We then reconciled our separate coding schemes into a single unified set of codes.
  - Two RAs were independently trained and independently coded all messages.
  - The coding is binary. Coders were free to choose as many or few codes as they desired. Coders were not told anything about our hypotheses for the data.
  - The cross-coder correlations for major categories (with one exception) are pretty good – always at least .5 and usually around .7 or .8. Cross-coder correlations around .6 for major categories are what we've typically seen in earlier studies.
- Data reported below is based on whether the category was coded by either coder during a conversation.

What is Important in Chat?

1 if we both choose c for the first one we both get ecu
2 Yea
1 F for period 2
2 and then we both can choose f for the second one
2 yeah
1 making my decision
2 and don't backstab

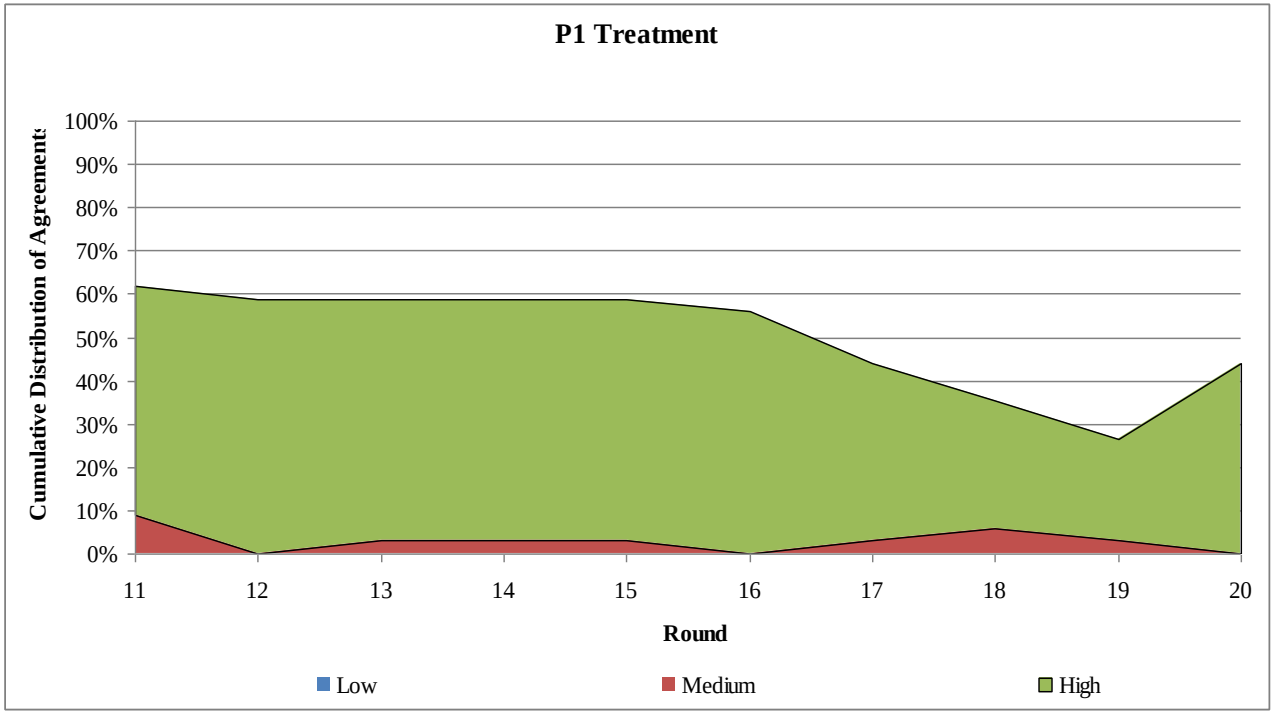
1 hey
2 if we both choose c and then f we get a dollar for the round
1 so i just got skrewed, awesome
2 haha
1 don't screw me tho
2 i wont u
1 lol yep c's anf f's sounds goood
2 sending mine
1 ciao!

1 ^*%&(*^)&(*^(%&
2 im starting to hate people lol
1 ya i know the feeling
2 do you?
1 there are some real jerks out there
2 bcs so did the last person who skrewed me lol
1 haha
2 so whats the plan?
1 c then f?
2 yea. if you but b tho i'm putting D for the nxt one.. lol.
1 why would you do that?
2 C and F... yes...
1 why would you put anything other than F for the last one?
this game isn't dependant on how bad other poeple do
you are giving up money just to spite someone you will never know
2 if you skrew me on the 1st one im skrewing you bak no matter what
thats why lol
1 that doesn't make any sense
2 lol so you are planning on putting be
*B
1 of course
2 alright
1 ... lol....
2 dont be stupid
bcs
i will. put . D
1 since i know you are going ot screw me on the second one
i'll put c then f
no point in doing anything else
might as well get 180
2 i'm choosing
1 right .

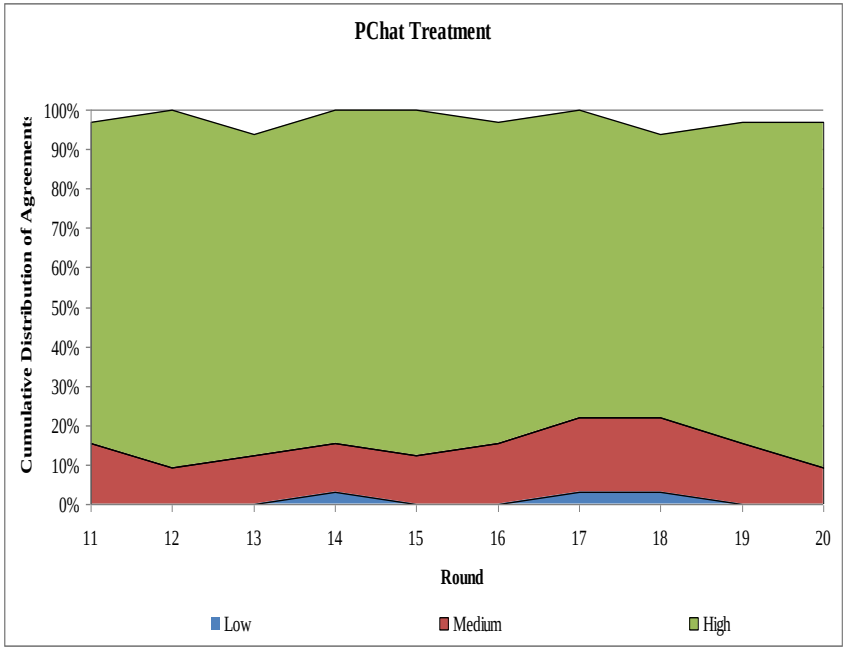
Most Common Period 1 Codes

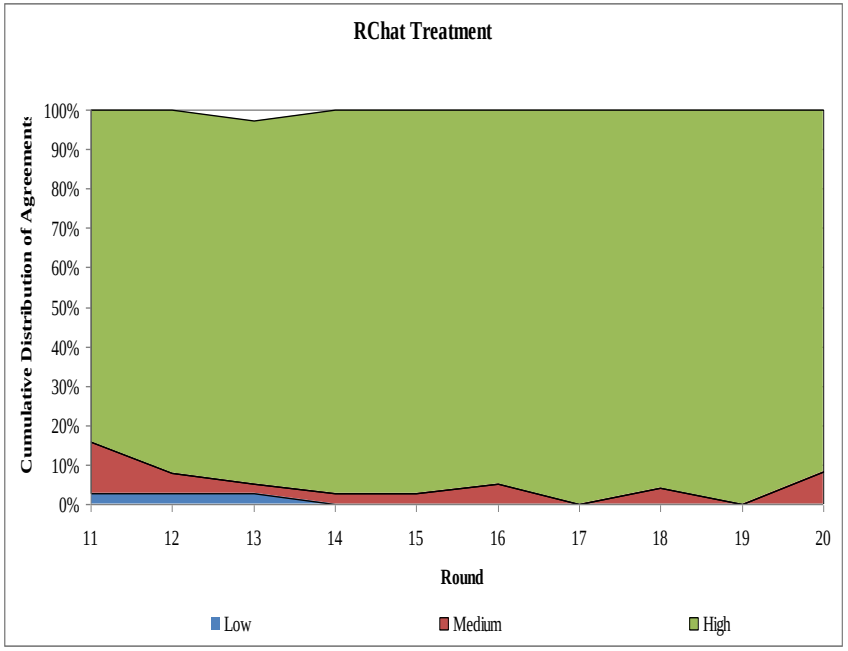
Message Description	Proportion Observed Pchat	Proportion Observed RChat
Period 1 Proposal: Both Play Medium	0.211	0.081
Period 1 Proposal: Both Play High	0.889	0.975
Period 2 Proposal: Both Play High	0.936	0.541
Disagreement with Most Recent Proposal	0.109	0.040
Agreement with Most Recent Proposal	0.794	0.791
Explicit Threat to Punish Cheating with Low in Period 2	0.141	0.017
Agreement with Proposed Punishment (All Punishments)	0.108	0.023
Request for Proposals	0.077	0.118
Appeal to Joint Payoffs	0.297	0.157
Specific Reference to Payoff Table	0.169	0.096
Indicate You Should be Trusted (Promises)	0.111	0.086
Expression of Distrust	0.111	0.036
Self-Report Having Been Cheated in Earlier Rounds	0.169	0.108

Agreements for Period 1 Play: P1 Treatment



Agreements on Period 1 Play





Cheating

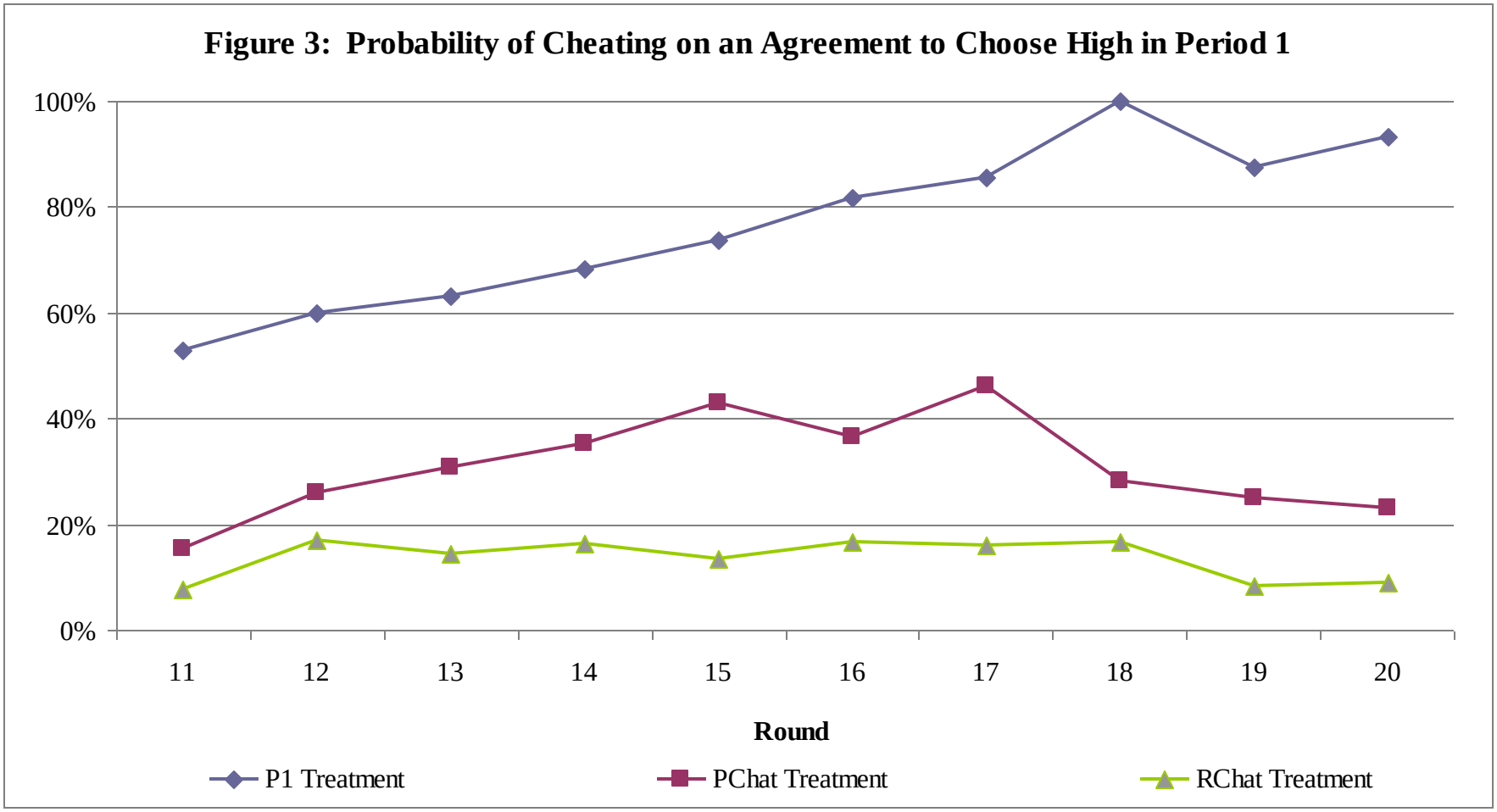
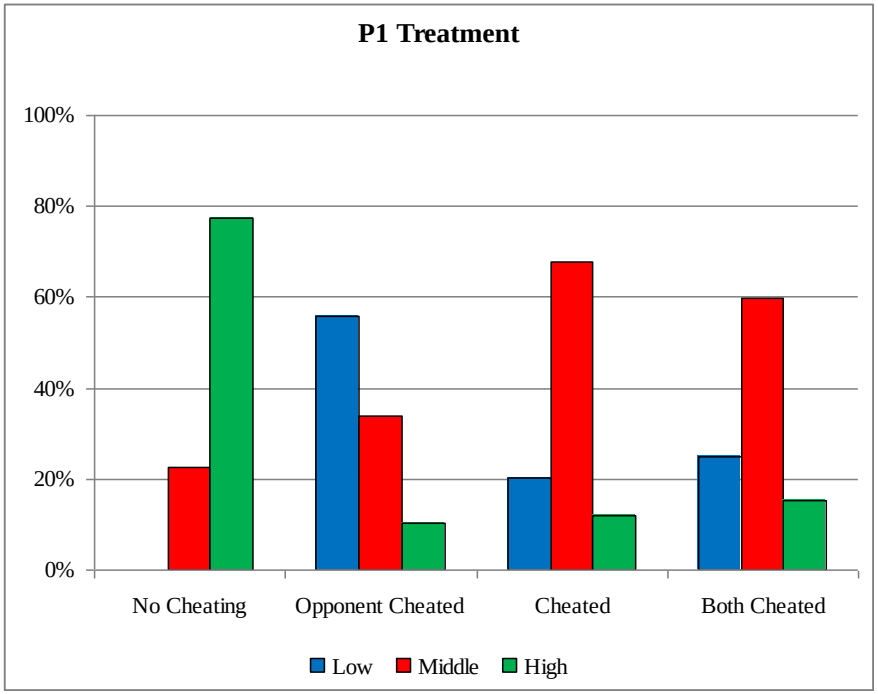
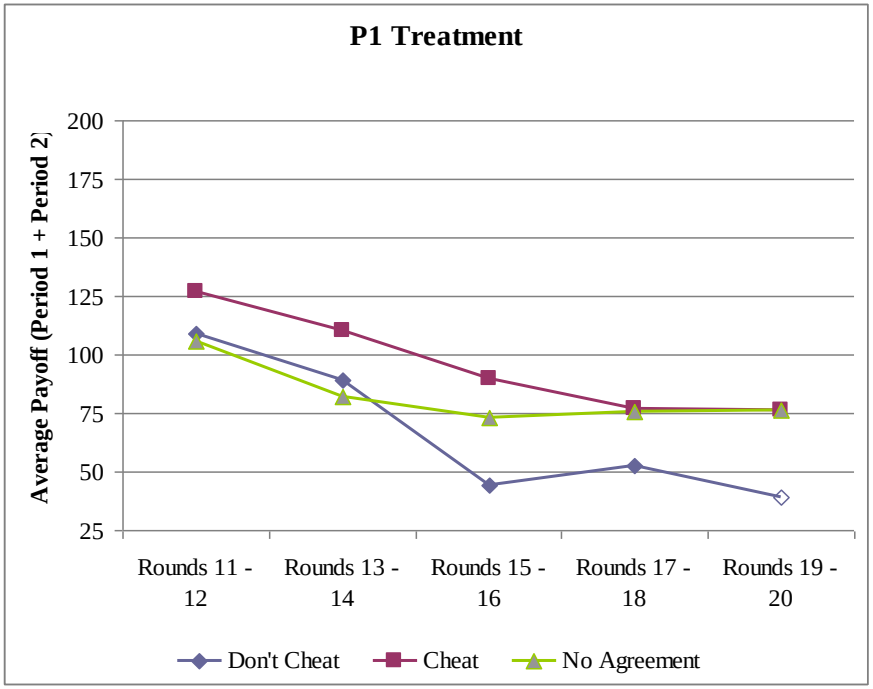
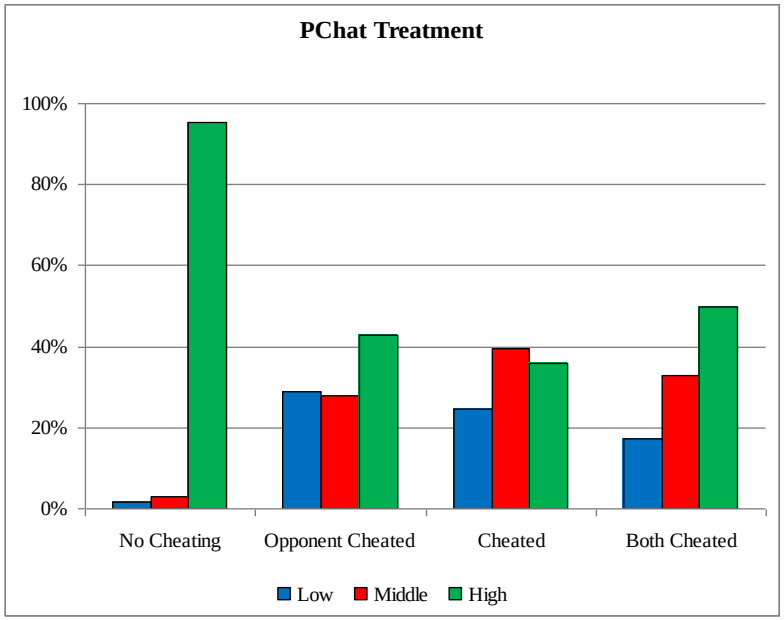


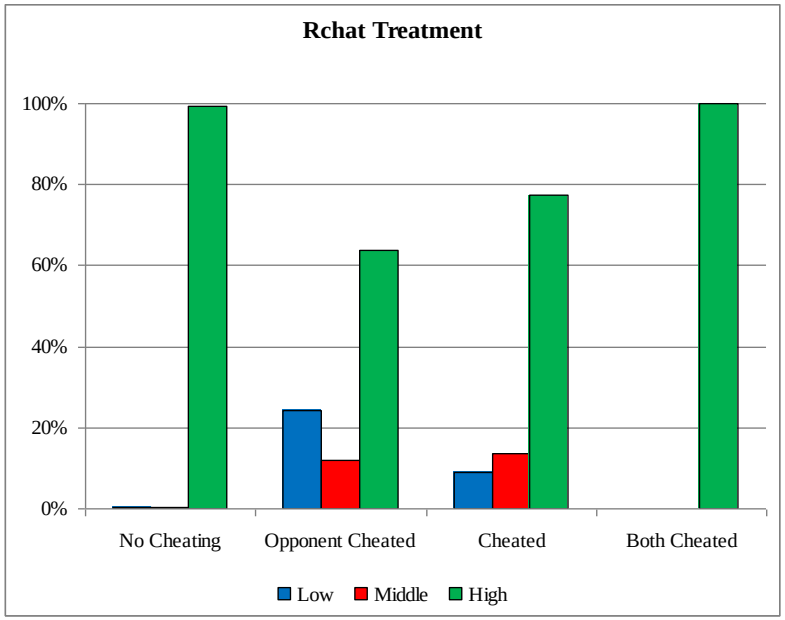
Figure 3: Probability of Cheating on an Agreement to Choose High in Period 1
100%
80%
60%
40%
20%
0%
11
12
13
14
15
16
17
18
19
20
Round
P1 Treatment
PChat Treatment
RChat Treatment

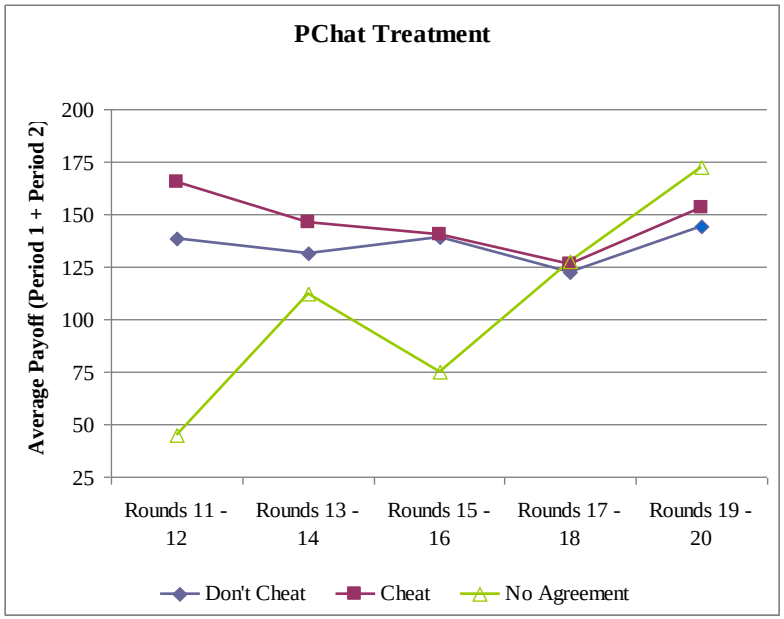
Contingent Behavior

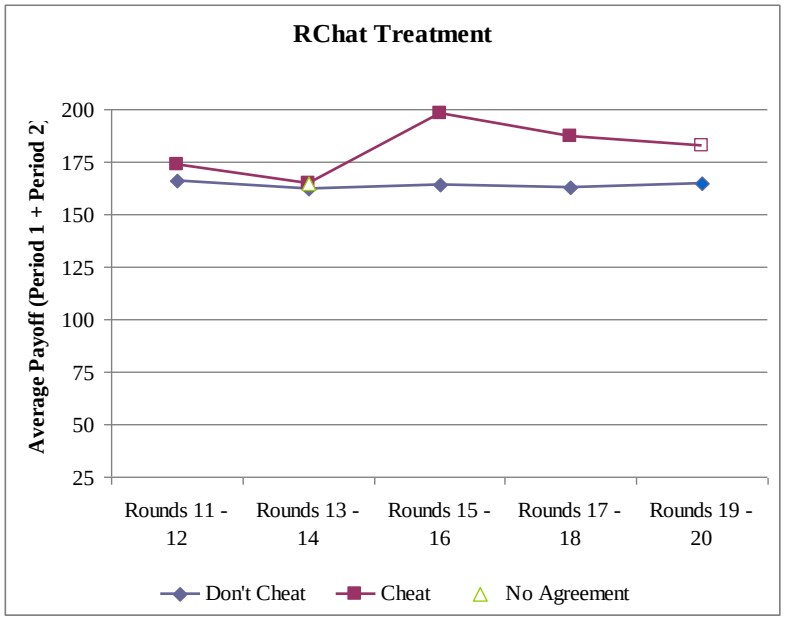




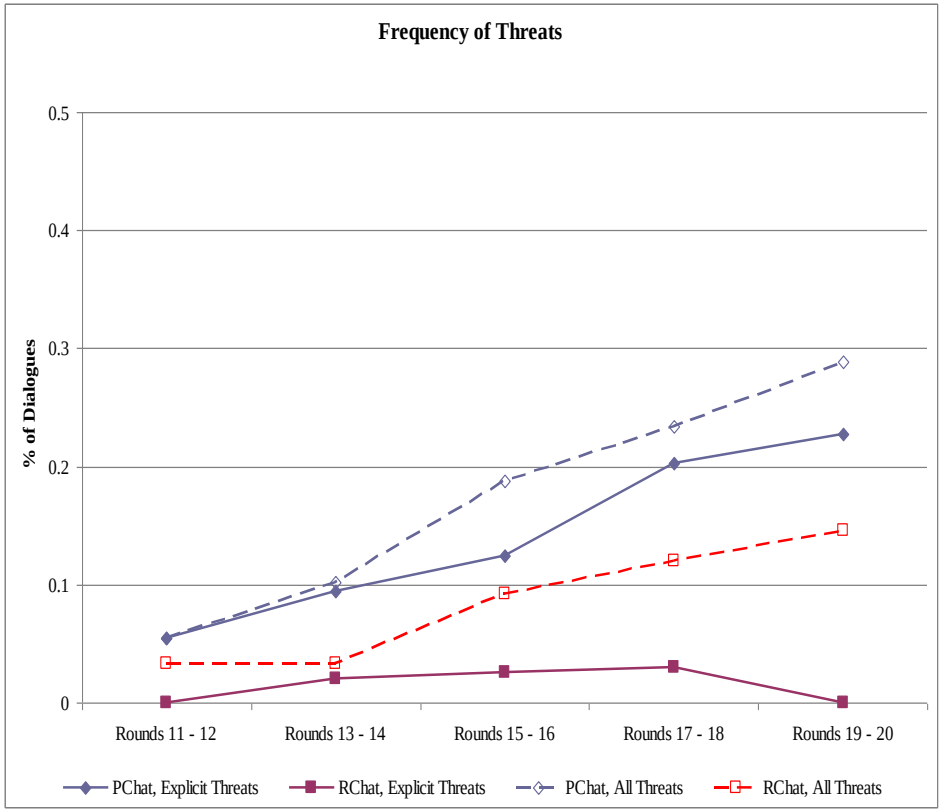

PChat Treatment
100%
80%
60%
40%
20%
0%
No Cheating
Opponent Cheated
Cheated
Both Cheated
Low
Middle
High

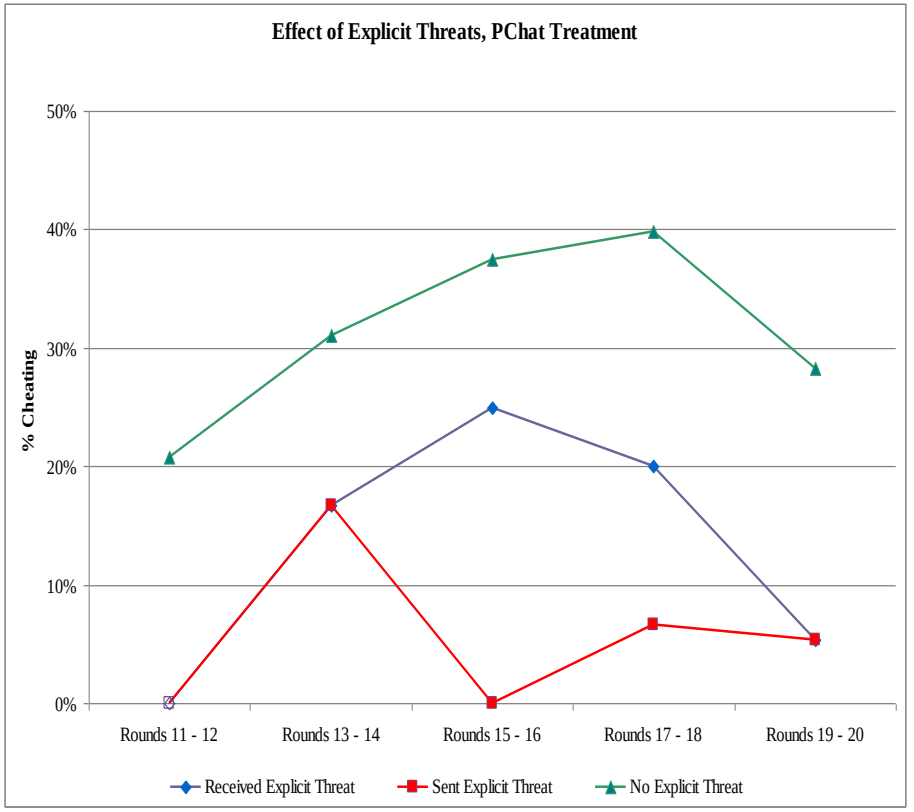

Rchat Treatment
100%
80%
60%
40%
20%
0%
No Cheating
Opponent Cheated
Cheated
Both Cheated
Low
Middle
High


PChat Treatment
Average Payoff (Period 1 + Period 2)
200
175
150
125
100
75
50
25
Rounds 11 - 12
Rounds 13 - 14
Rounds 15 - 16
Rounds 17 - 18
Rounds 19 - 20
Don't Cheat
Cheat
No Agreement

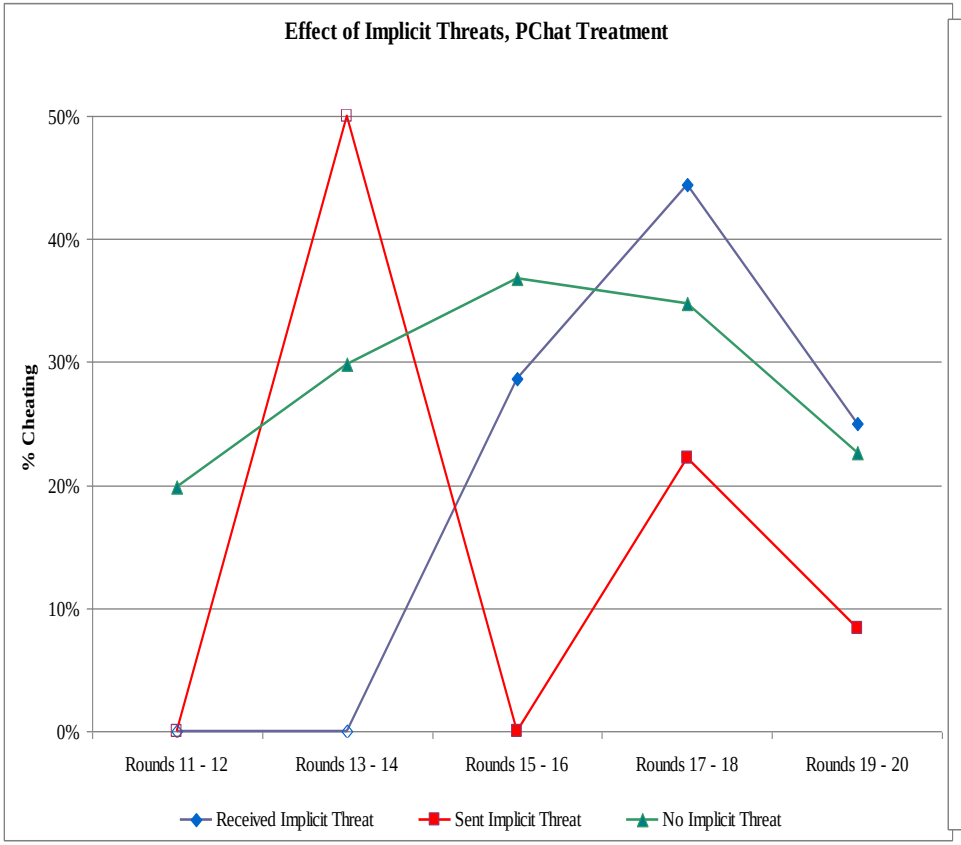

RChat Treatment
Average Payoff (Period 1 + Period 2)
200
175
150
125
100
75
50
25
Rounds 11 - 12
Rounds 13 - 14
Rounds 15 - 16
Rounds 17 - 18
Rounds 19 - 20
Don't Cheat
Cheat
No Agreement

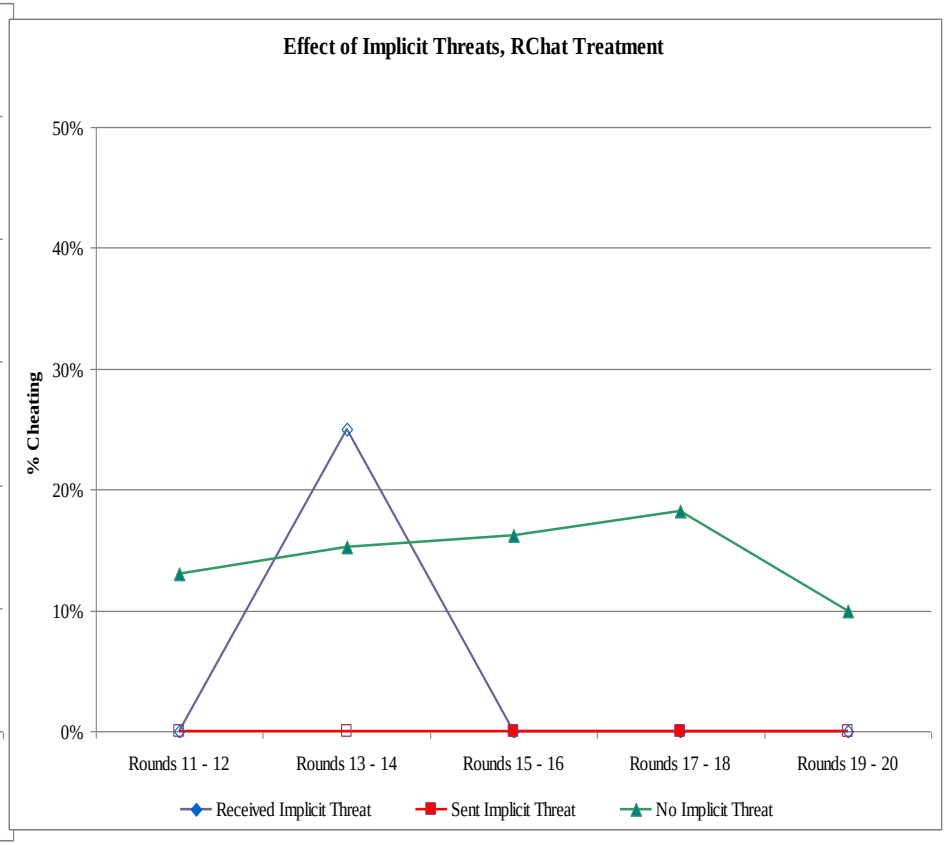
The Role of Threats 1



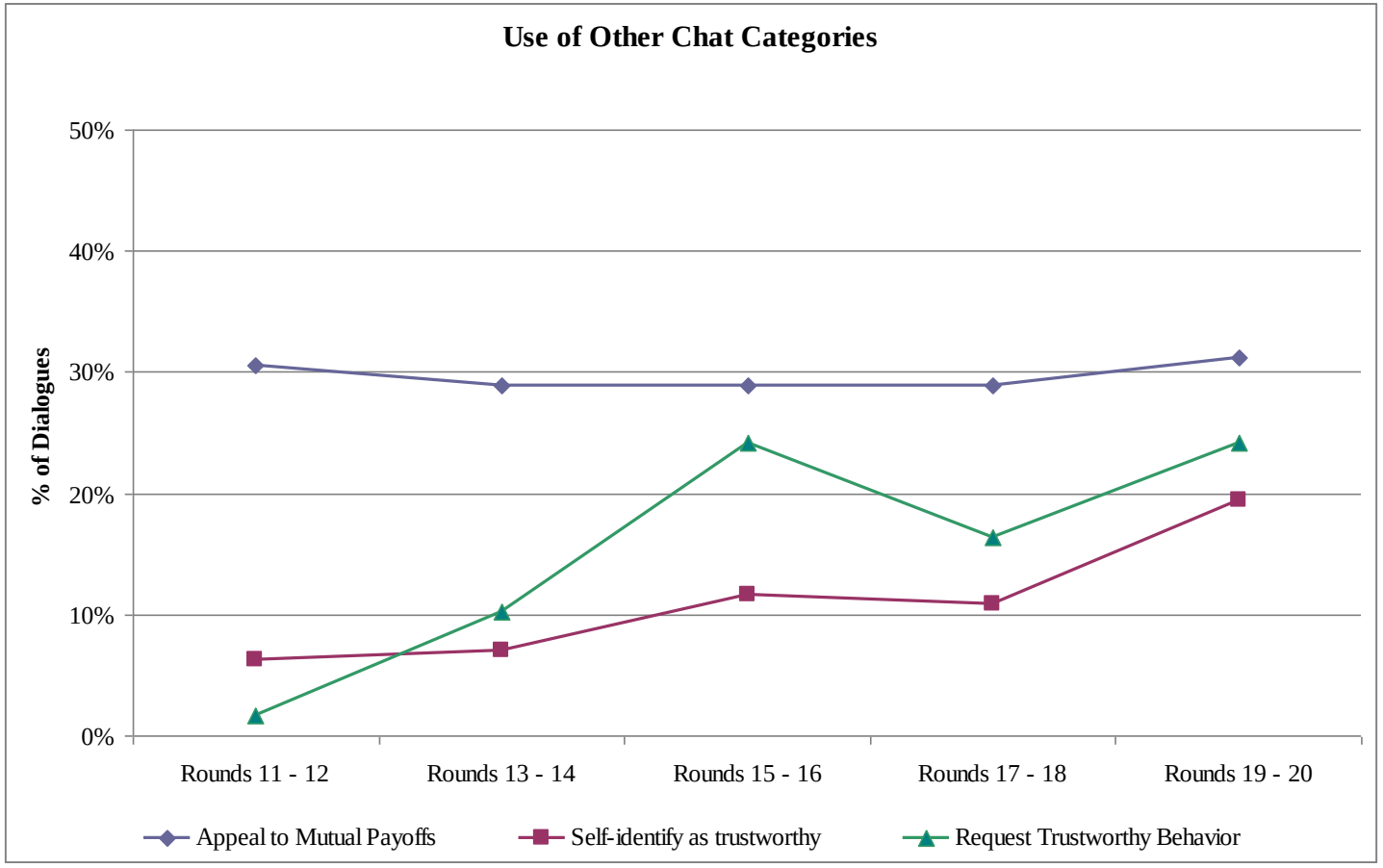


The Role of Threats 2





Other Chat Categories



The Effect of Chat Categories

	Model 1	Model 2	Model 3
Data Set	PChat	PChat	RChat
Number of Observations/Subjects	626/64	626/64	602/76
RECEIVED: Implicit Threat	.427 (.417)	.482 (426)	-1.227** (.472)
Explicit Threat	-.750** (.297)	-.796** (.314)	.365 (.772)
Request for Proposals			.453 (.285)
Appeal to Mutual Payoffs	-.263 (.176)	-.312 (.192)	-.011 (.314)
Specific Reference to Payoff Table	-.061 (.245)	-.136 (.268)	
Indicate You Should be Trusted	-.267 (.289)	-.149 (.296)	
Expresion of Distrust	-.110 (.265)	.180 (.284)	
Appeal for Trustworthy Behavior	.138 (.243)	.347 (.256)	
Self-Report Being Cheated Earlier	-.323 (.236)	-.170 (.230)	.163 (.264)
SENT: Implicit Threat		-.379 (.473)	No Cheating
Explicit Threat		-1.217*** (.375)	No Cheating
Request for Proposals			.226 (.309)
Appeal to Mutual Payoffs		-.238 (.237)	-.180 (.337)
Specific Reference to Payoff Table		.252 (.287)	
Indicate You Should be Trusted		-.567** (.248)	
Expression of Distrust		.310 (.385)	
Appeal for Trustworthy Behavior		-.463 (.388)	
Self-Report Being Cheated Earlier		-.258 (.241)	-.500* (.303)
Log Likelihood	-345.13	-328.50	-231.37

Pre-Play Chat: Explaining the U

- Subjects infrequently have the idea to state contingent threats (in rounds 11-15 only 5% are coded for this category)
- Subjects tend to need a lot of explanation
- When subjects use this category, they are very successful in establishing collusion
- Subjects who use contingent threats tend to use them again (63% vs 3% of those who have not used them)
- Subjects who experience a contingent threat are much more likely to use it relative to those who have not (10% vs. 2%)

Is punishment credible?

- Our analysis does not really show that punishment is an credible in the sense of subgame perfection: Is the threat mutual?
- Do subjects just react to the threat, or do they understand that there is selection of the continuation equilibrium contingent on history
- Tantalizing Factoid: 7 proposers of a contingent strategy deviate in period 1. The receivers all respond with L in period 2.

Renegotiation Success with Chat

- There is some period 2 contingent behavior:
  - 99.8% chose “H” after choices agreed in period 1
  - 71.9% chose “H” after choices disagreed in period 1
  - Much less contigent play than in PChat (90% vs. 40%)
  - Renegotiation has the expected period 2 effect in limiting punishments
- Why is there more collusion in period 1?

The content of Renegotiation Messages

Message Description	Proportion Observed	Proportion Observed		Group Cooperation (Per. 2/Per. 1 No-Coop)	
		P. 1 Cooperation	P. 1 Non-cooperation	Not Observed	Observed
Positive Feedback Following Cooperation	0.204	0.283	---	---	---
Apology for Cheating	0.111	---	0.372	0.803	0.842
Rationalizing Cheating	0.103	---	0.339	0.844	0.784
Admonition for Cheating	0.119	---	0.394	0.953	0.697
Proposed Period 2 Cooperation (Both "High")	0.902	0.901	0.906	0.500	0.846
Agreement to Proposal	0.626	0.675	0.511	0.529	0.938
Appeal to Joint Payoffs	0.094	0.017	0.278	0.790	0.856

The Power of Verbal Punishment

Table 10
Effect of Punishment on Next Round's Period 1 Cooperation

	Opponent Admonished	Opponent Didn't Admonish
Opponent Used "High"	81%	59%
Opponent Didn't Use "High"	91%	74%

- Admonishment has stronger impact than monetary punishment on future cooperation
- Admonishment and market punishments are complements
- Socially generated payoffs are powerful incentives to maintain collusive outcomes and are facilitated by Renegotiation

What does this mean for the relevance of collusion theory?

- Are the results on pre-play communication irrelevant for the real world? No:
  - Avoiding social punishments in renegotiation by refusing to listen
  - Changing the social context: praise for cheating from those who benefit
- But the social context matters for how easy collusion is and how it can be sustained

Conclusions

- For unrestricted pre-play communication specifying contingent threats is the most effective tool for collusion
- Contingent threats are learnt by individuals
- However, there are other mechanisms that can facilitate low level collusion (and may be identified with tacit collusion).
- Renegotiation may be a powerful tool for collusion because it creates scope for non-monetary punishments.
- This makes it interesting to studying variations in social incentives that may impact the scope for collusion