Appendices

A Strategy Frequency Estimation Method

The results suggest that strategies are conditionally cooperative, where the conditioning is more on the outcomes of past play than on the realized period 1 game. In this appendix, the analysis will be extended to try to investigate entire strategies. This can be a difficult task as strategies are plans for all possible contingencies whereas the data contains only the contingencies that actually occur. Dal Bó and Fréchette 2011 employ a strategy frequency estimation method (SFEM) in the infinitely repeated prisoner's dilemma that can be used in this setting as well. It is a finite mixture model and the basic idea is that a number of possible strategies are posited, and then maximum likelihood is used to estimate the most likely frequency with which each of these strategies is used by subjects.

The set of possible strategies considered here consists of several of the classic strategies that have been identified in the infinitely repeated prisoner's dilemma as plausible. Then variants of the strategies are added for reasons to be noted momentarily. Table 7 explains the strategies and then the variants.

The way the variants work is to modify the strategies (when applicable). Defect and Suspicious are similar, but differ in that the former ignores period 0 behavior while the latter punishes period 0 defections by one's opponent. Stochastic is called such, because it conditions behavior on the outcome of the stochastic process in the way theory predicts. Also, Defect and Suspicious are mutually exclusive while Stochastic can be added to either the original version or in addition to either of these two variants. In total, this creates a set of 31 strategies.[1]

[1] A few strategies are omitted. The Suspicious and Defect variants are the same for AC. SuspGrim and AD are also observationally the same.

Table 7: Strategies

Strategy	Short-Hand	Explanation
Always Defect	AD	always choose D
Always Cooperate	AC	always choose C
Grim Trigger	Grim	start with C and then continue with C until any player defects after which choose D forever after
Tit-for-Tat	Tft	start with C and then choose the action that the other player chose in the previous period
Trigger 2	T2	start with C and then continue with C until any player defects after which choose D for two periods before returning to C
Tit-for-2 Tats	Tf2t	start with C and then stay with C unless other player chose D in both of the last 2 periods
2 Tits-for-Tat	T2ft	start with C and then stay with C unless other player chose D in either of the last 2 periods

Variant	Prefix	Modification
Defect	D	start with D then start strategy in period 1 ignoring period 0
Suspicious	Susp	start with D rather than C
Stochastic	Stoch	choose D in all periods from 1 on if A is realized in period 1

The reason for the variants Defect and Stochastic is that they are the variants that create the efficient equilibrium strategy detailed in the theory section of this paper. In Treatments AA and BA, this equilibrium strategy is Stochastic Defect Grim Trigger while in Treatments AB and BB, it is Stochastic Grim Trigger. Suspicious is also included, because it is similar to Defect and has been found to be prevalent in previous strategy estimations on the infinitely repeated prisoner's dilemma.

Recall once more that there are many equilibrium strategies. And, importantly, a common theme among these strategies is that the players must defect when A is realized so every (cooperative) equilibrium strategy is Stochastic.

The likelihood function is constructed as follows. Suppose subject i is following strategy s^k. Let cooperate be coded as 1 and defect as 0, and s^k_{mt} be the choice prescribed by s^k in match m and period t. The model is that subject i chooses $y_{imt} = 1$ if $\mathbb{1}_{s^k_{mt}=1} - \mathbb{1}_{s^k_{mt}=0} + \gamma\epsilon_{imt} \geq 0$ in match m and period t where ϵ_{imt} is an error term with variance parametrized by γ. Otherwise subject i chooses $y_{imt} = 0$. The error term is logistic so the probability i chooses strategy s^k given the observed choice y_{imt} is

$$\left(\frac{1}{1+e^{-s^k_{mt}/\gamma}}\right)^{y_{imt}} \left(\frac{1}{1+e^{s^k_{mt}/\gamma}}\right)^{1-y_{imt}}$$

Let p_k be the proportion of subjects that choose strategy s_k (these proportions, in addition to γ, are the parameters that will be estimated). For a set of K strategies indexed by k, the likelihood function is therefore

$$\prod_{i=1}^{I}\sum_{k=1}^{K} p_k \prod_{m=26}^{50}\prod_{t=0}^{T_m}\left(\frac{1}{1+e^{-s^k_{mt}/\gamma}}\right)^{y_{imt}} \left(\frac{1}{1+e^{s^k_{mt}/\gamma}}\right)^{1-y_{imt}}$$

where I is the total number of subjects and T_m is the realized length of match m.

Standard deviations are bootstrapped by resampling (with replacement) the data 1000 times. In order to control for session effects, first a number of sessions equal to the total number of sessions for a given treatment are randomly resampled. Then, a number of subjects equal to the number of subjects in the original session are resampled from each resampled session. Then, 25 matches from the last half are resampled for each resampled subject.

The main analysis considers the strategies AD, AC, Grim, and Tft and their variants. Table 8 presents the results of the maximum likelihood estimates with just these 12 strategies for each of the four treatments. The additional strategies will be considered as a robustness check at the end of this section.

Table 8: Strategy Estimates, Last 25 Matches

Strategy	Treatment AA	Treatment AB	Treatment BA	Treatment BB
AD	0.3919***	0.2409***	0.4451***	0.3096***
	(0.0896)	(0.0819)	(0.1025)	(0.1223)
AC	0.0208	0.0655*	0.0185	0.0323
	(0.0270)	(0.0483)	(0.0209)	(0.0295)
Grim	0.0418	0	0.0489	0.2264**
	(0.0379)	(0.0638)	(0.0437)	(0.1089)
DGrim	0.017	0	0	0
	(0.0246)	(0.0123)	(0.0008)	(0.0047)
StochGrim	0	0.0806	0	0.1449*
	(0.0088)	(0.0570)	(0.0131)	(0.0925)
StochDGrim	0.0402	0.0204	0	0.0095
	(0.0625)	(0.0230)	(0.0426)	(0.0140)
Tft	0.1216**	0.352***	0.1142**	0.1161*
	(0.0528)	(0.0732)	(0.0660)	(0.0692)
DTft	0.0209	0.0061	0.0896**	0
	(0.0277)	(0.0249)	(0.0459)	(0.0087)
SuspTft	0.2215***	0.1029*	0.1903***	0.0829
	(0.0685)	(0.0504)	(0.0680)	(0.0568)
StochTft	0	0.0179	0	0.061
	(0.0165)	(0.0262)	(0.0093)	(0.0479)
StochDTft	0.0629	0.0778	0.067	0.0173
	(0.0691)	(0.0580)	(0.0515)	(0.0224)
StochSuspTft	0.0614	0.0359	0.0264	0
Gamma	0.4384***	0.4426***	0.4251***	0.3682***
	(0.0472)	(0.0387)	(0.0390)	(0.0264)
$1/(1+e^{-1/\gamma})$	0.9073	0.9055	0.9131	0.9380
Observations	3722	4518	4128	4634

Bootstrapped standard deviations in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Consider Treatments AA and BA first. There is essentially no evidence for the use of Stochastic Defect Grim Trigger, the efficient equilibrium strategy. Not surprisingly, given the low cooperation rate for period 0 noted in Table 4, the most prominently estimated strategy is the equilibrium strategy AD. However, there are a few cooperative strategies. The only strategy that starts with cooperation with a significant estimate is Tit-for-Tat. There are also some partially cooperative strategies that start with defection and then go to cooperation; Suspicious Tit-for-Tat and, in Treatment BA, Defect Tit-for-Tat. None of these three variant strategies of Tit-for-Tat are Stochastic, and therefore none are equilibrium strategies. Rather, they are conditionally cooperative strategies that condition on past behavior only which further supports Result 4.

Now consider Treatments AB and BB. For these treatments, the efficient equilibrium strategy is Stochastic Grim Trigger, and while there is some mild evidence for this strategy in Treatment BB there is little evidence for it in Treatment AB. As for the previous two treatments, there is far more evidence for just conditionally cooperative strategies that condition on past behavior but are not equilibria. In this case, Grim Trigger in Treatment BB, Tit-for-Tat in both treatments (particularly in Treatment AB), and Suspicious Tit-for-Tat in Treatment AB. Finally, the implied error $1 - 1/(1 + e^{-1/\gamma})$ is less than .1 for each of the four treatments indicating that the set of strategies provides a reasonable fit to capture behavior.

For robustness, Table 9 presents the maximum likelihood estimation with all 31 strategies. There seems to be some small evidence for Tit-for-2-Tats in Treatment AB (another non-equilibrium strategy), but otherwise the results look very similar.

Result 5. *Many subjects choose to always defect. Those that choose cooperative strategies, choose non-equilibrium strategies that condition on previous cooperative outcomes but not on the realization of the period 1 game.*

Table 9: Augmented Strategy Estimates: Last 25 Matches

Strategy	Treatment AA	Treatment AB	Treatment BA	Treatment BB
AD	0.4017***	0.2396***	0.3892***	0.2890***
	(0.0947)	(0.0808)	(0.1087)	(0.1208)
AC	0.0208	0.0169	0	0.0161
	(0.0239)	(0.0271)	(0.0091)	(0.0237)
DAC	0	0	0	0
	(0.0390)	(0.0020)	(0.0136)	(0.0000)
StochAC	0	0.019	0	0
	(0.0018)	(0.0074)	(0.0029)	(0.0024)
StochDAC	0	0	0	0
	-	-	-	-
Grim	0.0421	0	0.0501	0.2328**
	(0.0373)	(0.0627)	(0.0486)	(0.1121)
DGrim	0.0173	0	0	0
	(0.0237)	(0.0090)	(0.0000)	(0.0044)
StochGrim	0	0.0833	0	0.1441*
	(0.00049)	(0.0541)	(0.0111)	(0.0886)
StochDGrim	0.0177	0	0	0.0122
	(0.0404)	(0.0125)	(0.0282)	(0.0123)
Tft	0.1005**	0.2708***	0.0989**	0.0934
	(0.0437)	(0.0677)	(0.0585)	(0.0645)
DTft	0.0209	0.0096	0.0192	0
	(0.0220)	(0.0222)	(0.0282)	(0.0061)
SuspTft	0.1971***	0.0761	0.1859***	0.0638
	(0.0721)	(0.0457)	(0.0642)	(0.0451)
StochTft	0	0	0	0.0618
	(0.0175)	(0.0074)	(0.0032)	(0.0494)
StochDTft	0	0.0304	0	0
	(0.0195)	(0.0315)	(0.0123)	(0.0075)
StochSuspTft	0.036	0.0367	0	0
	(0.0415)	(0.0312)	(0.0212)	(0.0153)
T2	0	0	0	0
	(0.0006)	(0.0050)	(0.0000)	(0.0007)

Strategy	Treatment AA	Treatment AB	Treatment BA	Treatment BB
DT2	0	0	0.0184	0
	(0.0050)	(0.0039)	(0.0162)	(0.0005)
StochT2	0	0	0	0
	(0.0021)	(0.0010)	(0.0008)	(0.0182)
StochDT2	0	0	0	0
	(0.0000)	(0.00015)	(0.0063)	(0.0022)
Tf2t	0.0208	0.1058**	0.0185	0.0324
	(0.0302)	(0.0571)	(0.0261)	(0.0293)
DTf2t	0	0	0.0150	0
	(0.0154)	(0.0092)	(0.0183)	(0.0034)
SuspTf2t	0.0192	0	0.0394	0
	(0.0209)	(0.0142)	(0.0313)	(0.0034)
StochTf2t	0	0.0335	0.0114	0
	(0.0117)	(0.0360)	(0.0115)	(0.0043)
StochDTf2t	0.1060	0.0128	0.0330	0.0161
	(0.0694)	(0.0193)	(0.0381)	(0.0198)
StochSuspTf2t	0	0.0399	0.0350	0
	(0.0236)	(0.0335)	(0.0408)	(0.0077)
T2ft	0	0.0055	0	0
	(0.0128)	(0.0409)	(0.0176)	(0.0259)
DT2ft	0	0	0	0
	(0.0053)	(0.0010)	(0.0045)	(0.0003)
SuspT2ft	0	0.0207	0.0180	0
	(0.0183)	(0.0256)	(0.0322)	(0.0239)
StochT2ft	0	0	0	0
	(0.0061)	(0.0139)	(0.0072)	(0.0329)
StochDT2ft	0	0	0	0
	(0.0090)	(0.0039)	(0.0041)	(0.0030)
StochSuspT2ft	0	0.0185	0.0679	0.0382
	(0.0390)	(0.0240)	(0.0542)	(0.0251)
Gamma	0.4263***	0.4238***	0.4142***	0.3590***
	(0.0439)	(0.0339)	(0.0372)	(0.0236)
$1/(1+e^{-1/\gamma})$	0.9126	0.9137	0.9179	0.9419
Observations	3722	4518	4128	4634

Bootstrapped standard deviation in parentheses (StochDAC omitted from maximization)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Robustness Checks for Results

Table 10: Determinants of Period 0 Cooperation

	Matches					
	All	2-10	11-20	21-30	31-40	41-50
match1coop	0.987***	1.172***	0.916***	0.841***	0.869***	1.008***
	(0.122)	(0.114)	(0.157)	(0.133)	(0.137)	(0.151)
period0A	-0.0150	-0.111	-0.0344	0.105	-0.0300	-0.00804
	(0.195)	(0.165)	(0.187)	(0.219)	(0.235)	(0.222)
period1A	-0.541***	-0.151	-0.599***	-0.491**	-0.773***	-0.759***
	(0.184)	(0.165)	(0.186)	(0.218)	(0.233)	(0.191)
lastothercoop	0.621***	0.693***	0.615***	0.630***	0.626***	0.543***
	(0.133)	(0.0985)	(0.120)	(0.160)	(0.204)	(0.174)
lastmatchper	0.0118**	0.0465	0.0305	0.00205	0.0281***	-0.00714
	(0.00601)	(0.0317)	(0.0207)	(0.00988)	(0.0108)	(0.0203)
lastperiod1A	0.00388	0.0398	0.106	0.0216	0.0137	0.00454
	(0.0515)	(0.134)	(0.121)	(0.0926)	(0.110)	(0.0552)
lastperiod1B	0.0536	0.161	-0.0632	0.163	0.0286	0.113
	(0.0427)	(0.0994)	(0.117)	(0.112)	(0.130)	(0.0794)
Constant	-0.902***	-1.331***	-0.872***	-0.880***	-0.782***	-0.863***
	(0.223)	(0.212)	(0.225)	(0.269)	(0.294)	(0.231)
Observations	11200	2016	2240	2240	2240	2240

Dependent variable 1 if cooperate

Standard errors clustered at session level in parentheses

* if $p < 0.1$, ** if $p < 0.05$, *** if $p < 0.01$

Table 11: Cooperation Rates for Periods $t \geq 1$, Last 25 Matches

Treatment	Period 1	Period 0 Outcome				
	Game	All	(C, C)	(C, D)	(D, C)	(D, D)
AA	A	.16	.84	.38	.33	.03
	B	.32	.88	.48	.30	.14
AB	A	.29	.92	.35	.33	.03
	B	.42	.98	.44	.35	.05
BA	A	.18	.93	.28	.36	.05
	B	.28	.95	.43	.37	.11
BB	A	.18	.77	.28	.13	.02
	B	.46	.95	.27	.21	.05

C Instructions

Welcome. This is an experiment in decision making. Various research foundations and institutions have provided funding for this experiment and you will have the opportunity to make a considerable amount of money which will be paid to you at the end. Make sure you pay close attention to the instructions because the choices you make will influence the amount of money you will take home with you today. Please ask questions if any instructions are unclear.

The Choice Problems

In this experiment you will be engaging in two Choice Problems. You will engage in each Choice Problem with one other participant, which we will call your partner. Each Choice Problem consists of both you and your partner choosing between two options, which we label A and B. Thus there are four possible outcomes; you choose A and your partner chooses A, you choose A and your partner chooses B, you choose B and your partner chooses A, and you choose B and your partner chooses B. Each of these four outcomes results in a payoff for both you and your partner. The following two tables show these payoffs.

Choice Problem 1 is given by the following table.

Your Choice	Partner's Choice	Your Payoff	Partner's Payoff
A	A	15	15
A	B	8	45
B	A	45	8
B	B	12	12

Choice Problem 2 is given by the following table.

Your Choice	Partner's Choice	Your Payoff	Partner's Payoff
A	A	65	65
A	B	8	95
B	A	95	8
B	B	12	12

To illustrate, if you and your partner are engaging in Choice Problem 1 and you choose A while your partner chooses B then you will get 8 and your partner will get 45. Or if you and your partner are engaging in Choice Problem 2 and you choose B while your partner chooses A then you will get 95 while your partner will get 8.

Matches and Rounds

The experiment consists of 50 Matches. At the beginning of each Match you will be randomly paired with another participant from the room and engage in a randomly determined number of Rounds, each of which is one of the two Choice Problems above, with this participant as your partner.

Each of the 50 Matches proceeds as follows. In Round 1 of each Match you and your partner engage in Choice Problem 1. When Round 1 is over, the computer will randomly determine whether the Match will continue to Round 2 or end. The computer is programmed to select to continue with 2/3 chance and to end with the remaining 1/3 chance. This is true for all further rounds as well. That is, at the end of each Round, the Match continues with probability 2/3 and ends with probability 1/3.

If the Match continues at the end of Round 1, the Round 2 Choice Problem is selected randomly by the computer. The computer is programmed to select Choice Problem 1 with 3/4 chance and Choice Problem 2 with the remaining 1/4 chance. If the Match continues again, the Round 3 Choice Problem is the problem selected randomly by the computer for Round 2. In fact, as long as the Match continues, all subsequent Rounds; fourth, fifth, sixth, etc. will be the Choice Problem determined for Round 2. For example, if the Match lasts 4 Rounds, you and your partner will either engage in Choice Problem 1 four times or Choice Problem 1 once followed by Choice Problem 2 three times.

Thus there are two important things to remember when a new Match starts. First, you get a new partner. Second, you return to Choice Problem 1 and (if the new Match continues to Round 2) you will have a randomly determined Choice Problem in Round 2 that will remain the Choice Problem for all further Rounds of the new Match.

Your Screen

Your screen is laid out as follows. In the upper left corner you will see which of the 50 Matches you are currently in. At the top in the middle you will see what Round you are in and which of the two Choice Problems you are engaging in for this Round. Below this you will have the table (from above)for this Choice Problem to remind you what payoffs each outcome produces. Below the table is the box where you make your Choice, A or B, for this Round by clicking on the corresponding button.

You can also see the outcomes and payoffs of all past Choice Problems you have engaged in. On the left side of your screen, the previous Rounds of the current Match are displayed. On the right side of your screen you can enter the Match number (then click Check) of any previous Match to see the outcomes and payoffs for that Match. The last row of each display presents cumulative payoffs. In other words, this row sums up the column for your payoff and the column for your partner's payoff.

A second screen will show up after each Round as well. It will tell you the outcome for that Round and whether the Match will continue or end. Also, if you just finished Round 1 of a Match and the Match is continuing it will tell which of the two Choice Problems the computer has selected and thus you will engage in for the rest of the Match.

Payoffs

We will add up all of your payoffs over the course of the experiment. These payoffs are denominated in points and will be converted into dollars at the rate of .5 cents per point. That is, for each 200 points you earn, you get one dollar. In addition to earnings in the experiment you will get 5 dollars just for participating.