

# The Evolution of Cooperation: The Role of Costly Strategy Adjustments

## Online Appendix

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### A Quiz

The quiz consisted of ten questions displayed on the screen after the instructions were completed. There were three different types of questions:

1. Given the current rule set, what action will be played next? (Four questions: #1, #4, #7 and #10.)
2. Given the current rule set, what payoffs will be received in the next period if the other subject chooses a given action? (Three questions: #2, #5 and #8.)
3. Modify the rule set so that it plays a given action. (Three questions: #3 add rule, #6 delete rule, #9 switch rule.)

The full screenshot of each of the ten questions is available here: <http://web.ics.purdue.edu/~yrosokha/docs/quizCosts.pdf>

## B Additional Figures and Tables

### B.1 Cooperation by Session

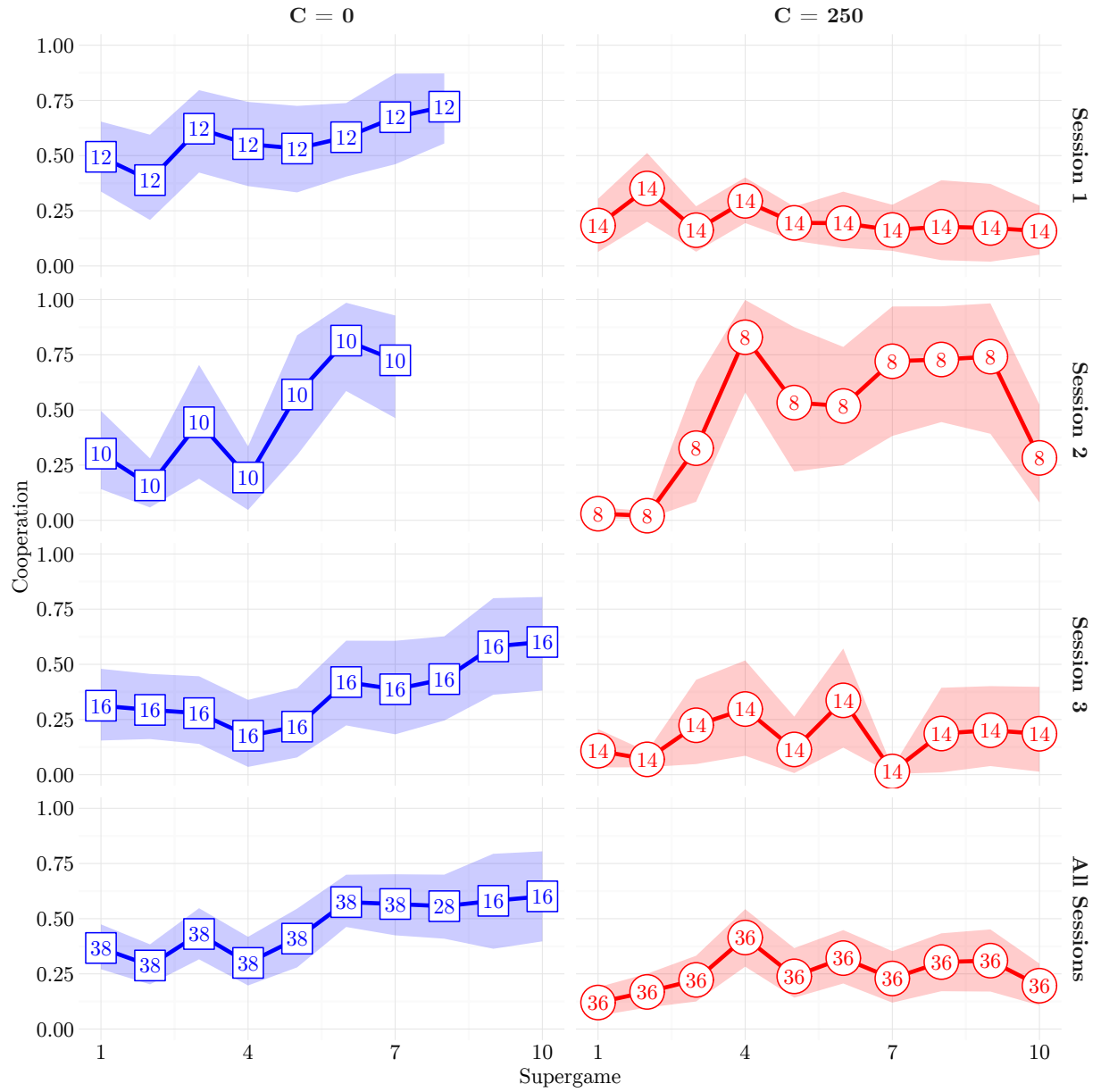


Figure 1: Evolution of Cooperation by Session. *Notes:* Cooperation is increasing in all three sessions of  $C = 0$ . Cooperation is flat in two out of three in  $C = 250$  and increasing, then decreasing, in one.

## B.2 Evolution of Strategies by Session

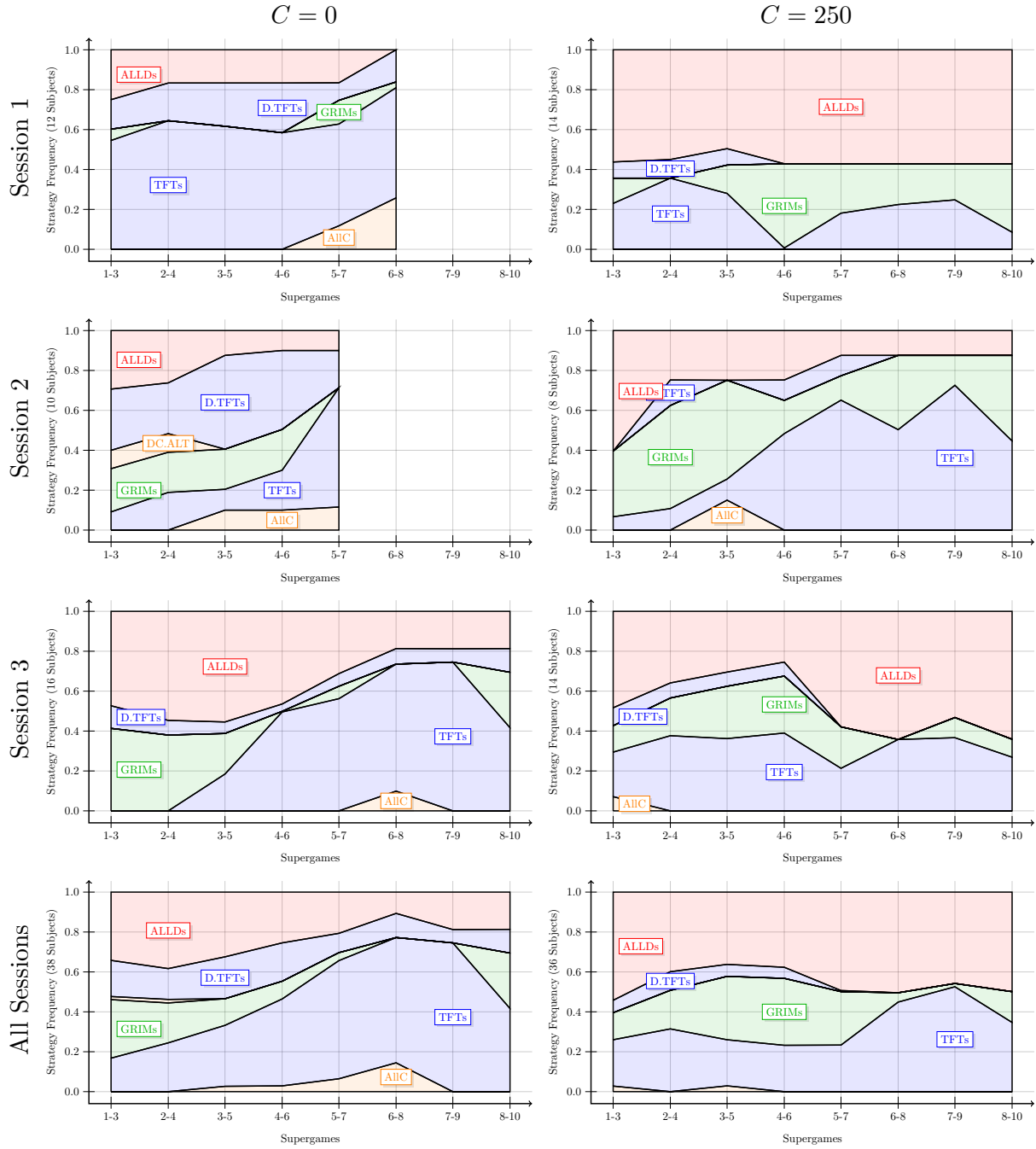


Figure 2: Evolution of Strategies by Session.

### B.3 Simulations with Crossover

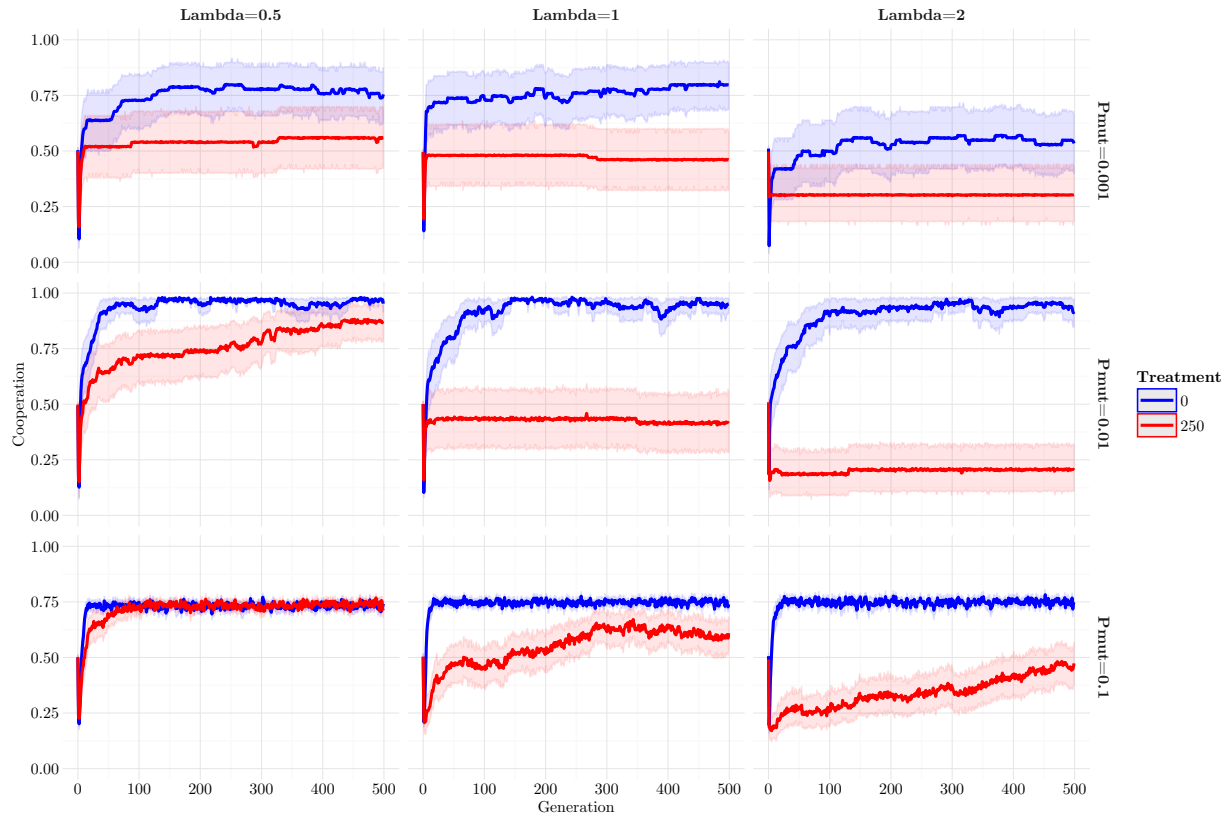


Figure 3: Evolution of Cooperation within the Population. *Notes:* Fifty simulations of population of  $n = 50$  chromosomes are conducted ( $p_{mut} = 0.01$  and  $\lambda = 1$ ). Each generation, 4 percent of the population is selected for crossover (hence  $k = 2$ ). 95 percent bootstrapped confidence intervals around the average cooperation are superimposed.

## B.4 Simulations for Different Expected Supergame Lengths

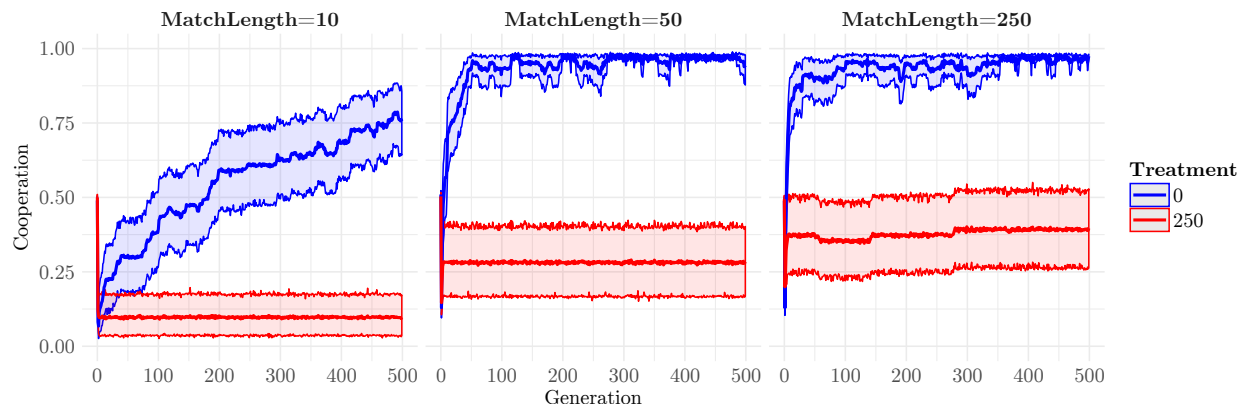


Figure 4: Evolution of Cooperation For Different Supergame Lengths. *Notes:* Fifty simulations of population of  $n = 50$  chromosomes are conducted ( $p_{mut} = 0.01$ ,  $\lambda = 1$ , and  $k = 2$ ). 95 percent bootstrapped confidence intervals around the average cooperation are superimposed.

## B.5 Simulations for Different Payoff Matrix

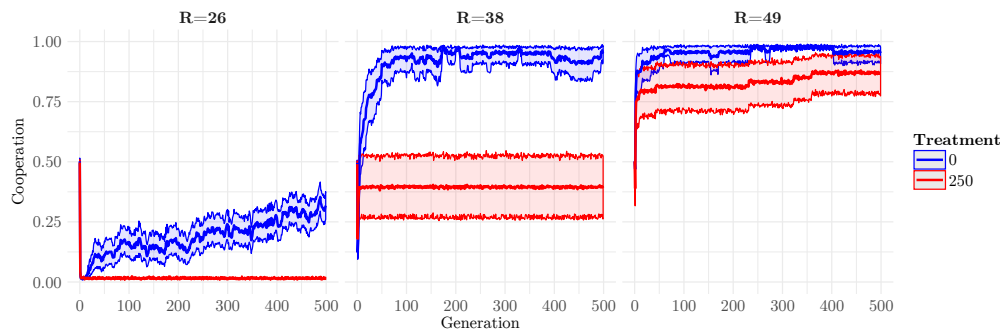


Figure 5: Evolution of Cooperation For Different Values of  $R$ . *Notes:*  $R$  denotes benefit to cooperation. Fifty simulations of population of  $n = 50$  chromosomes are conducted ( $p_{mut} = 0.01$ ,  $\lambda = 1$ , and  $k = 2$ ). 95 percent bootstrapped confidence intervals around the average cooperation are superimposed.

## C Original Set of Experiments

Six sessions of the experiment were conducted, with sessions in May and September 2015. The following list summarizes the differences from the experiment described in the main body of the paper:

1. In the original set of experiments, each period lasted exactly four seconds.
2. In order to provide sufficient time to modify the strategies, we did not restrict the strategy construction to be done within one period. Instead, subjects incurred a cost of one point per second when rules were unlocked. Fixed costs for clicking the “Unlock Rules” button were the same as in the current experiment.
3. There was no split into two groups based on quiz scores.
4. The first five supergames were implemented using the game method. In other words, to get familiar with the game, subjects played the first five supergames via direct-response.

In the experiments presented in the main body of the paper, we chose to modify these four items in order to 1) provide a sufficient amount of time; 2) simplify the cost structure; 3) ensure that subjects who do not understand the interface do not influence the outcome; and 4) ensure that learning via direct-response under different costs had no effect on the initial propensity to cooperate via strategy-method. Table 1 summarizes parameters and sessions for the original set of experiments.

Treatment	Stage Game Payoff	Continuation Probability	Sessions	N. Sub.	Description									
$C = 0$		$\delta = .98$	2	34	<i>Costless</i> strategy adjustment within supergames									
$C = 25$	<table border="1"> <thead> <tr> <th></th> <th>C</th> <th>D</th> </tr> </thead> <tbody> <tr> <th>C</th> <td>38,38</td> <td>12,50</td> </tr> <tr> <th>D</th> <td>50,12</td> <td>25,25</td> </tr> </tbody> </table>		C	D	C	38,38	12,50	D	50,12	25,25	$\delta = .98$	2	36	<i>Medium Costs</i> to strategy adjustment within suupergames
	C	D												
C	38,38	12,50												
D	50,12	25,25												
$C = 250$		$\delta = .98$	2	32	<i>High Costs</i> to strategy adjustment within suupergames									

Table 1: Treatments summary

### C.1 Cooperation

Cooperation rates in the original set of experiments are comparable to those of the main experiment. There are some differences in the dynamics of cooperation for the  $C = 0$  treatment. These differences may be attributed to including all subjects and having supergames 1-5 use the game method.

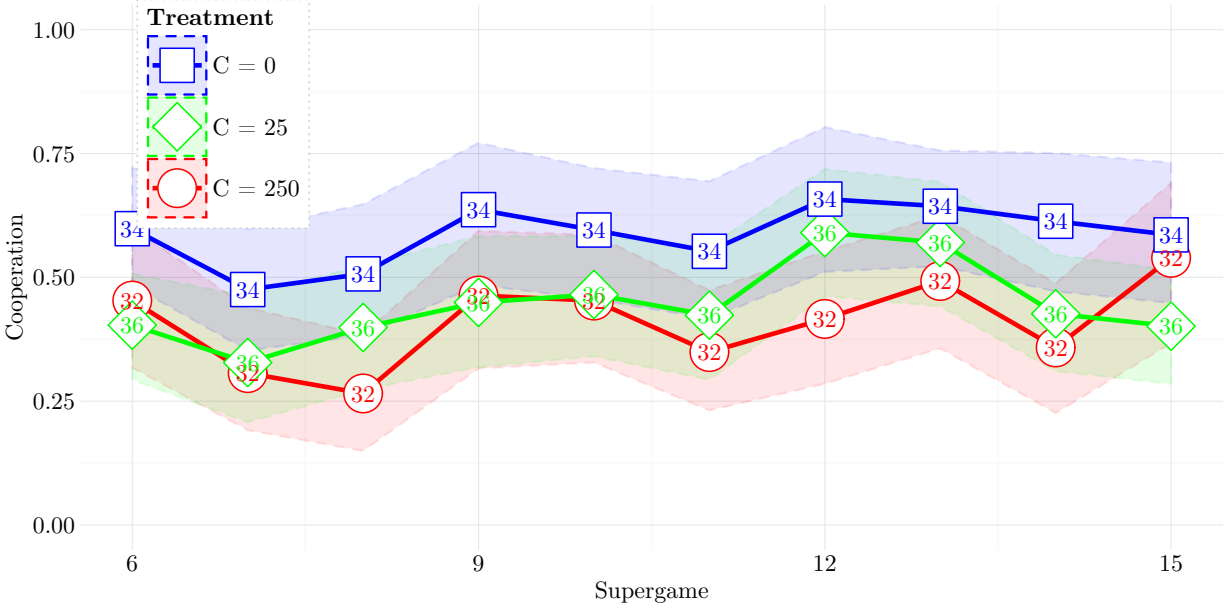


Figure 6: Cooperation. *Notes:* Unit of observation is subject’s average cooperation over all periods in the supergame. Number inside circle/rectangle represents number of subjects. 95 percent bootstrapped confidence intervals are superimposed.

## C.2 Strategy Estimates

Supergames	Cost	Strategy															$\beta$	Subjects		
		TFT	ALLD	GRM	D.TFT	2TFT	CToD	ALLC	GRM2	GRM3	TF2T	DC.ALT	2TF2T	D.TF2T	TF3T	D.TF3T			WSLS	
1-3	0	0.31*** (0.12)	0.09* (0.07)	0.04 (0.06)		0.08* (0.06)	0.17** (0.1)	0.04 (0.05)	0.04 (0.06)	0.1* (0.06)	0.04 (0.06)	0.02 (0.03)		0.03 (0.03)			0.04 (0.04)	0.88 (0.03)	34 (1.41)	
	25	0.09 (0.08)	0.18** (0.1)		0.2** (0.1)		0.11* (0.08)	0.09* (0.06)	0.1* (0.07)			0.08* (0.06)					0.07 (0.06)	0.03 (0.04)	0.87 (0.02)	36 (2.94)
	250	0.19** (0.1)	0.28*** (0.1)	0.12* (0.09)	0.03 (0.04)	0.04 (0.07)	0.1* (0.06)	0.06 (0.05)			0.03 (0.04)	0.03 (0.03)					0.06 (0.05)	0.06 (0.06)	0.91 (0.02)	32 (0.0)
5-7	0	0.42*** (0.14)	0.18** (0.09)		0.08 (0.08)		0.02 (0.02)		0.17** (0.09)	0.04 (0.05)		0.02 (0.02)		0.06* (0.04)				0.94 (0.02)	34 (1.39)	
	25	0.13* (0.08)	0.23** (0.1)	0.08 (0.08)	0.04 (0.04)	0.16* (0.11)		0.03 (0.06)				0.03 (0.04)	0.09* (0.07)		0.1* (0.06)	0.04 (0.03)		0.93 (0.01)	36 (2.86)	
	250	0.18** (0.1)	0.19** (0.08)	0.2** (0.1)	0.06* (0.04)		0.07 (0.05)	0.12 (0.1)		0.05 (0.04)	0.03 (0.04)	0.04 (0.03)	0.05 (0.05)		0.01 (0.04)			0.92 (0.03)	32 (0.0)	
8-10	0	0.32*** (0.1)	0.17** (0.1)		0.05 (0.05)	0.15* (0.09)	0.03 (0.04)		0.06 (0.07)	0.03 (0.06)	0.13* (0.09)			0.02 (0.04)			0.04 (0.05)	0.94 (0.03)	34 (1.43)	
	25	0.2*** (0.07)	0.18*** (0.06)	0.11* (0.07)	0.12** (0.07)	0.04 (0.05)	0.01 (0.02)	0.08 (0.06)			0.05 (0.06)	0.03 (0.03)		0.06 (0.05)			0.03 (0.04)	0.89 (0.02)	36 (2.83)	
	250	0.16** (0.09)	0.17*** (0.07)	0.1 (0.1)	0.06* (0.05)	0.12 (0.11)	0.02 (0.04)	0.04 (0.04)	0.05 (0.05)	0.13** (0.08)	0.06 (0.07)		0.05 (0.04)					0.93 (0.02)	32 (0.0)	

Table 2: MLE Strategy Estimates. *Notes:* Bootstrapped standard errors are in parentheses. \*, \*\*, \*\*\*, denote significance at the 0.10, 0.05, and 0.01 levels, respectively. Labels 1-3, 5-7, etc. refer to strategy-method ordering (6-8, 10-12, etc. overall). Values of 0.00 are dropped for ease of reading. Strategies that have less than 0.10 weight when summed over all estimations are not shown.

## D Description of Strategies

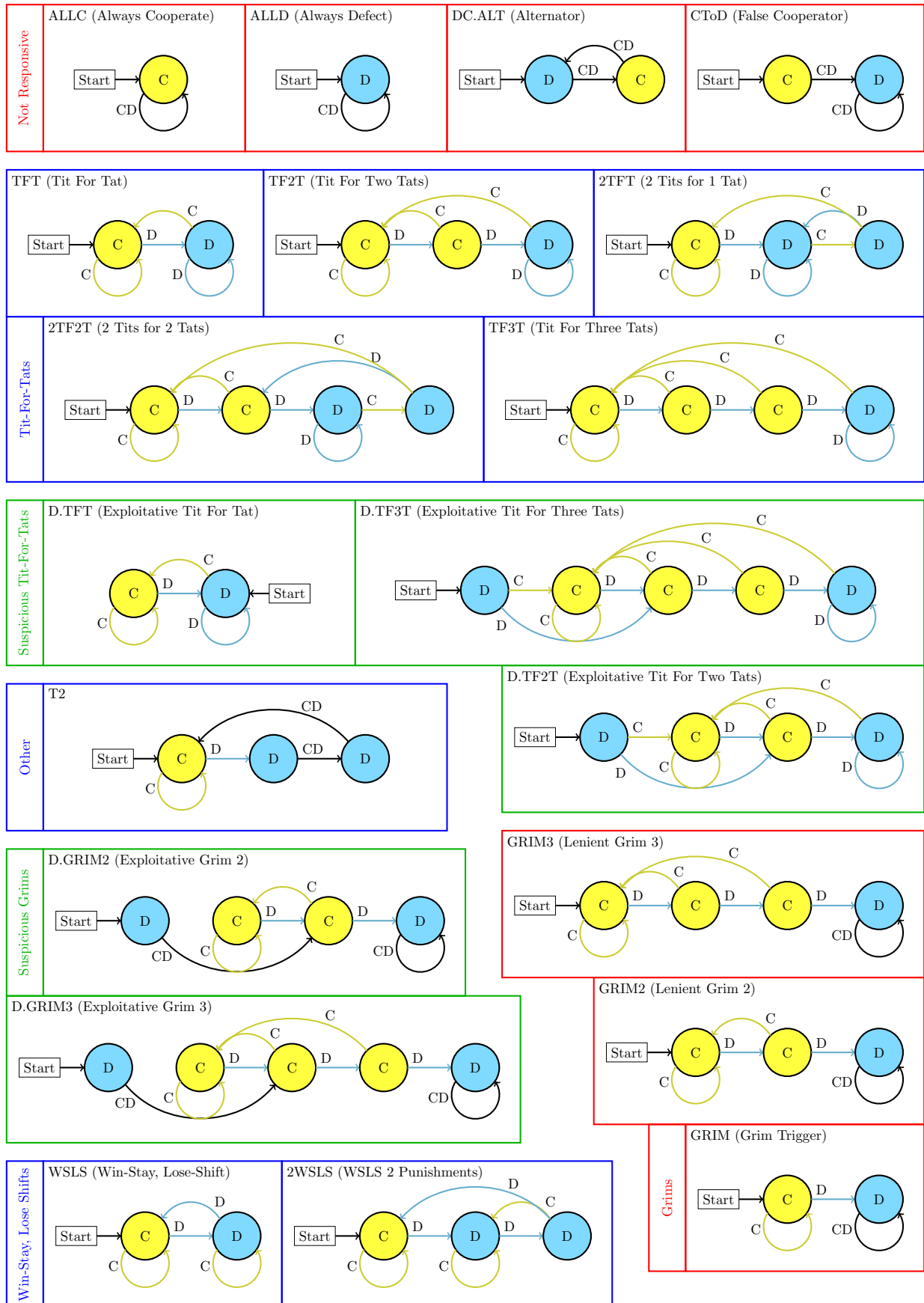


Figure 7: Strategies Used in the Estimation.