THE UNIVERSITY of ADELAIDE

School of Economics

Working Papers

ISSN 2203-6024

On the Credibility of Punishment in Repeated Social Dilemma Games

Ralph-C. Bayer

Working Paper No. 2014-08
May 2014

On the credibility of punishment in repeated social dilemma games

Ralph-C Bayer*
University of Adelaide

May 28, 2014

Abstract

Various experimental studies have shown that the availability of a punishment option can increase the prevalence of cooperative behaviour in repeated social dilemmas. A punishment option should only matter if it is a credible threat. We investigate if the degree of credibility depends on standard strategic equilibrium considerations (i.e. SPNE or NE logic) or stems from a non-strategic motivation such as reciprocity. We find that for punishment to be credible non-strategic motivations are sufficient and that subgame perfection does not further improve credibility.

- JEL Codes: D03, D62
- Keywords: Cooperation, Punishment, Credible Threats

*School of Economics, Adelaide SA 5005, Australia. Email: ralph.bayer@adelaide.edu.au. Financial support from the Australian Research Council under the Discovery Program Grant DP120101831 is gratefully acknowledged.

1 Introduction

Theory and empirical evidence point to potential future punishment as one of the most effective factors for increasing the frequency of cooperative play in social dilemma situations. In classical game theory possible threats play an important role in supporting equilibria in repeated games where players choose socially efficient actions that are not equilibria of the stage game. In infinitely repeated games the equilibria that yield cooperation in social dilemmas are supported by players' willingness to punish each other in the case of uncooperative behaviour (see e.g. the version of the Folk Theorem by Friedman, 1971).

In (long) finitely repeated games with multiple equilibria cooperation in early periods can be supported as a subgame-perfect equilibrium by the threat of switching to the stage-game equilibrium with lower payoffs if somebody deviates (shown by Benoit and Krishna, 1985). Experimental studies have shown that punishment opportunities are not only effective if exercising them is part of an equilibrium strategy. In a seminal series of experiments Fehr and Gächter (2000) showed that punishment opportunities can increase cooperation considerably even if actually executing them is never part of a subgame-perfect equilibrium. In their voluntary contribution game with a punishment phase Nash equilibria exist, which are not subgame-perfect and where the threat of non-credible punishment is sufficient to induce cooperation.[1] While this leaves room for equilibrium considerations driving the effectiveness of punishment, in the literature more emphasis is placed on reasons other than equilibrium behaviour for why punishment opportunities increase the occurrence of cooperation.

While many experimental studies have studied either the behaviour in repeated social dilemma games or the impact of explicit punishment stages in cooperation games, to our knowledge there is no study that compares the effectiveness of punishment opportunities conditional on them being part of a subgame-prefect equilibrium or just a Nash equilibrium.[2] This study provides such a comparison. A natural hypothesis is that punishment which is subgame perfect is more effective, because it is a credible threat only in that case. An alternative hypothesis could read: the fact that non-credible

[1] For a general result on finitely repeated games see (Benoit and Krishna, 1987).

[2] The study closest to ours is Angelova et al. (2013), who compare subgame-perfect punishment options that are either strict or weak stage-game Nash equilibria.

punishment has proven effective in many experimental studies, shows that credibility (in the sense of subgame perfection) of punishment is not important. A third hypothesis for why it might not matter if punishment is an equilibrium in a subgame or not is the notion that humans use punishment in a non-strategic manner. If people punish others as a reaction to perceived unfairness, rather than as a disciplining device, then punishment becomes a credible option even if it is not subgame-perfect. The design of our study is such that we can discriminate between these three hypotheses.

We find that punishment is non-strategic and therefore becomes credible regardless of the punishment being Nash in the stage game or not. The existence of punishment opportunities increases cooperation frequencies by anticipation of punishment but also by experience. Surprisingly, the increase in cooperation is not greater when punishment is a stage-game Nash equilibrium. Hence, subgame-prefection is not only not required for punishment to be credible, it does not even increase the credibility of the threat of being punished. We further find that the availability of punishment reduces over-all wellfare, as its execution is costly and provokes damaging counter-punishment. The occurence of counter-punishemt does not depend on punishment being a stage-game Nash equilibrium. This shows that also counter-punishment is rather emotional than strategic.

2 Three prisoners' dilemma games

In what follows we present three versions of a prisoners' dilemma – the standard game and two extended versions that contain a punishment action. In one of the extended games punishment is a dominated strategy, while mutual punishment is a Nash equilibrium in the other. For finitely repeated versions of these games this has strong implications for the conditions under which we can expect to observe players choosing the cooperative strategy. With standard preferences there is no Nash equilibrium in the original prisoners dilemma, where the cooperative action is ever played. In the finitely-repeated extended prisoners dilemma with non-equilibrium punishment, Nash equilibria exist that can support cooperative play in early stages. However, these Nash equilibria are not subgame perfect, as they are built on the non-credible threat of punishment. Finally, the extended prisoner's dilemma with punishment that is a stage game Nash equilibrium,

has subgame-perfect Nash equilibria, in which cooperative play occurs in early stages.

First, take a version of the classic prisoners dilemma game shown in Table 1. If this game is played repeatedly but finitely many times, then the only Nash equilibrium prescribes that $\langle D, d\rangle$ is being played all the time. We know that for reasons that are unrelated to punishment, the fraction of cooperative behaviour in (one-shot) prisoners' dilemmas is positive. This is typically reconciled by assuming that subjects either have other-regarding preferences (such as in Fehr and Schmidt, 1999; Charness and Rabin, 2002; Cox et al., 2008), that beliefs about intentions are payoff relevant (e.g., Rabin, 1993), or that reputation building is possible as a consequence of some uncertainty about the rationality of players (Kreps et al., 1982).

	c	d
C	$5, 5$	$0, 8$
D	$8, 0$	$2, 2$

Table 1: A Prisoners Dilemma (Game 1)

Now turn your attention to Table 2, which shows an extended prisoners dilemma that also contains a punishment strategy. Playing the punishment strategy costs one monetary unit to the punisher and inflicts a damage of four. If both players punish, then both pay the punishment cost and also bear its damage, which results in a payoff of negative five for both players.[3] If this game is played T times, and we are looking for a subgame-perfect Nash equilibrium, then the only equilibrium entails that $\langle D, d\rangle$ is being played in all periods. The only stage-game Nash equilibrium $\langle D, d\rangle$ will be played in the last period regardless of any history. Taking into account that play in the penultimate period cannot influence the continuation (if subgame-perfection is assumed), then $\langle D, d\rangle$ is going to be played in the penultimate period as well. This argument can be iteratively applied when working backwards to the first period.

However, there are Nash equilibria that are not subgame-perfect, where in all but the last period $\langle C, c\rangle$ is played. To see this take the following trigger strategy for the row player. Play C in the first period. In all subsequent

[3]Recall that in public goods games the cost-damage ratio of punishment has been shown to have to be below 1/3 for punishment to be effective (Nikiforakis and Normann, 2008).

	c	d	p
C	$5,5$	$0,8$	$-4,-1$
D	$8,0$	$2,2$	$-4,-1$
P	$-1,-4$	$-1,-4$	$-5,-5$

Table 2: A Prisoners Dilemma with non-Nash punishment (Game 2)

periods with $t < T$ play C if before only $\langle C, c\rangle$ has been observed. Otherwise play P. In the final period T play D if no prior deviation from $\langle C, c\rangle$ occurred. Otherwise play P. Together with the symmetric trigger strategy for the column player this forms a Nash Equilibrium. To see why this is an equilibrium, observe that if both players follow the equilibrium path, then in the last period they will play $\langle D, d\rangle$, where nobody has an incentive to deviate. In the penultimate period they are supposed to play $\langle C, c\rangle$. The best deviation is playing D and earning 8 instead of 5, a gain of 3. However, according to the strategy profile this will lead to $\langle P, p\rangle$ instead of $\langle D, d\rangle$ resulting in a payoff of -5 instead of 2 in the last round. So there is no incentive to deviate in the penultimate period. The same logic applies for earlier periods, where the one-off gain from a deviation remains the same, while the loss increases as the number of periods where $\langle P, p\rangle$ is played as a consequence of the deviation increases. So the threat of punishment that is not a stage-game Nash equilibrium can be sufficient to uphold cooperation if we do not require that threats are credible in the sense of subgame perfection.

Finally, consider the variant of the extended prisoners' dilemma in Table 3. In this version of the game we have two stage-game equilibria, which are $\langle D, d\rangle$ and now also mutual punishment $\langle P, p\rangle$. In this game the threat of punishment is credible as both players choosing the punishment strategy constitutes a stage-game Nash equilibrium. Consequently, by using credible punishment, cooperation can be implemented in earlier rounds as part of an SPNE. Now a trigger strategy as above is not only Nash in the entire game but also in any subgame. Take the same strategies as before – C up to period $T-1$ if only $\langle C, c\rangle$ has been played before and otherwise P until the end of the game. Then play D in period T if only $\langle C, c\rangle$ was observed in the past, otherwise play P. The column player plays the corresponding symmetric strategy. Now for any history, in the final period we either observe $\langle D, d\rangle$ or $\langle P, p\rangle$, which both are Nash. So the continuation after $T-1$

period is subgame-perfect. The best deviation in $T-1$ is to play D, which yields a one-off gain of 3, which will be offset by a loss of the same size, as it would trigger the continuation of $\langle P, p\rangle$ instead of $\langle D, d\rangle$. So there is no incentive to deviate in period $T-1$. Again, the one-off deviation gain remains the same for deviations in earlier periods (i.e. 3), while the loss increases since there are more periods with mutual punishment following a deviation, which strengthens the incentive to stick to cooperation in early periods.

	c	d	p
C	$5,5$	$0,8$	$-4,-1$
D	$8,0$	$2,2$	$-4,-1$
P	$-1,-4$	$-1,-4$	$-1,-1$

Table 3: A Prisoners Dilemma with Nash punishment (Game 3)

Note that in all the games above action profile $\langle D, d\rangle$ being played in all periods remains a subgame-perfect equilibrium regardless of the other equilibria described. There are many more Nash equilibria in both games with punishment. While in Game 2 no further subgame-perfect Nash equilibria exist, there are many more in Game 3.

2.1 Hypotheses

Hypothesis 1 *Punishment is only effective if it is credible (in the sense of SPNE).*

If this hypothesis is correct, then we would expect the same play in Games 1 and 2, as then the added non-Nash punishment strategy is not credible.[4] In Game 3 punishment will play a role. A priory it is unclear how behaviour would differ between Game 3 and Game 2, as credible punishment adds a variety of new equilibria. The question becomes one of equilibrium selection. Under the additional hypothesis that subjects tend to select more efficient equilibria more often we would expect to observe more cooperative play in Game 3 than in Game 2. If equilibrium selection is not guided by efficiency criteria, the fact that punishment per se is a stage-game equilibrium in this game could have a negative effect though.

[4]Under Fehr-Schmitt inquality aversion with a guilt factor for being behind of $\alpha \geq 1/3$ for both players punishment becomes a stage-game equilibrium and therefore credible. Charness and Rabin (2002, 2005) do not find significant behindness-aversion though.

Hypothesis 2 *Punishment is effective regardless of its credibility.*

If people do fear punishment regardless of it being a credible threat, then we would expect higher levels of cooperative behaviour in both extended Prisoners' Dilemmas than in the standard version.

Hypothesis 3 *Punishment is credible in both extended games, as punishment is triggered by factors other than standard equilibrium considerations.*

Suppose punishment is triggered by reciprocity considerations or by an emotion following perceived unfair behaviour. Then it becomes a credible threat also in Game 2, where it is not credible (in the sense of subgame perfection) if emotional motives are absent. In this case we can expect similar behaviour as under the previous hypothesis (i.e. more cooperation in the extended dilemmas). Observed behaviour in the last stage of the supergame can be used to discriminate between the Hypotheses 2 and 3. Hypothesis 2 predicts that we can observe punishment in the last stage in Game 3 only, while Hypothesis 3 predicts similar positive rates of punishment in the final stage (conditional on the history) in both extended prisoners' dilemmas.

3 Experimental Design

In our experiments the participants played five supergames consisting of six repetitions of a stage game. Every supergame was played with a different opponent, which was clearly indicated to the subjects. An on-screen message read "This is a new phase. You are randomly matched with a new person. You will play six periods of the game with this person." In the *Baseline* treatment the stage game underlying the six supergames was the standard prisoners' dilemma (Game 1). We call the second treatment, where Game 2 was played repeatedly *Non-Nash,* as here punishment is not a stage-game Nash equilibrium. The final treatment, where subjects faced Game 3, will be referred to *Nash,* indicating that punishment is a stage-game Nash equilibrium.

Over-all 118 subjects, recruited via the online-recruiting system ORSEE (Greiner, 2003) from the student body of the three universities in Adelaide, participated in our six sessions. The experimental sessions were computerized and conducted at the Adelaide Laboratory for Experimental Economics

(AdLab) using z-Tree (Fischbacher, 2007). Subjects earned experimental Dollars, which were converted to real Australian Dollars at the rate of one Australian Dollar for five Experimental Dollars. A session lasted about 60 minutes on average, for which subjects earned on average AUD 17.85 (approx. USD 16.75).

4 Results

In this section we will report our results. We start by assessing the impact of punishment opportunities on cooperation rates. Next, we assess the welfare implications and finish with discussing the underlying motivation for punishment behaviour.

4.1 Cooperation rates

We start by comparing the frequencies of subjects choosing the cooperative action across treatments. Figure 1 shows the evolution of the fraction of cooperative actions chosen in the different stages of the supergames. In all three treatments the fraction of cooperative actions declines within a supergame. Cooperation rates in the standard repeated prisoners' dilemma are quite high in the first stage game (59 percent) but fall continuously to end at 11 percent in the last period. These dynamics are remarkably similar to findings in other repeated prisoners' dilemma studies (e.g. Selten and Stoecker, 1986; Andreoni and Miller, 1993; Cooper et al., 1996; Normann and Wallace, 2012; Angelova et al., 2013). The fraction of cooperative actions in the two games with punishment is slightly higher but follows a very similar path.

In order to be able to test if there are significantly different rates of cooperation across the treatments we use the number of cooperative actions chosen per supergame. As a supergame lasts for six periods and there are two players, this measure ranges from zero to twelve. Figure 2 shows the distributions of the measure across the three treatments.

It is very instructive that the distributions are bimodal in all three treatments. Sustaining cooperation among two players in a supergame either works very well or not at all. While the distributions of the number of cooperative actions look almost indistinguishable between the two treatments with punishment opportunities, in the *Baseline* treatment the density is

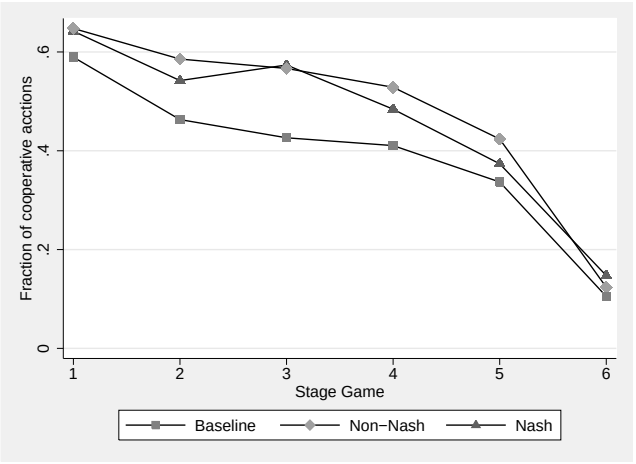


Figure 1: Average cooperation rates by period and treatment

higher at the less cooperative end. More than 35 percent of supergames in the *Baseline* treatment result in none or only one cooperative action, while for the other two treatment less than 20 percent fall into this category. The average number of cooperative actions taken is similar in the *Nash* and *Non-Nash* treatments (5.53 vs. 5.75) and lower in the Baseline treatment (4.15). The differences between the two punishment treatments and the *Baseline* are statistically significant (*Nash* vs. *Baseline* $p < 0.075$, *Non-Nash* vs. *Baseline* $p < 0.03$; Mann-Whitney U-Tests)[5].

Result 1 *Punishment is effective in increasing the fraction of cooperative choices regardless of it being credible (in the sense of subgame perfection) or not.*

4.2 Efficiency

The higher fraction of cooperative choices in the punishment treatments does not necessarily imply that social welfare is higher in those treatments. The addition of a punishment option, might not only lead to more cooperation due to the threat of punishment but also to welfare losses due the actual use of the punishment action. Depending on which effect dominates punishment options increase or decrease social welfare.

[5]The M-W test is the preferred test here, as it performs quite well for bimodal distributions, while the t-test lacks power. Kolmogorov-Smirnov tests on the equality of the distributions and t-tests with unequal variance correction lead to similiar results.

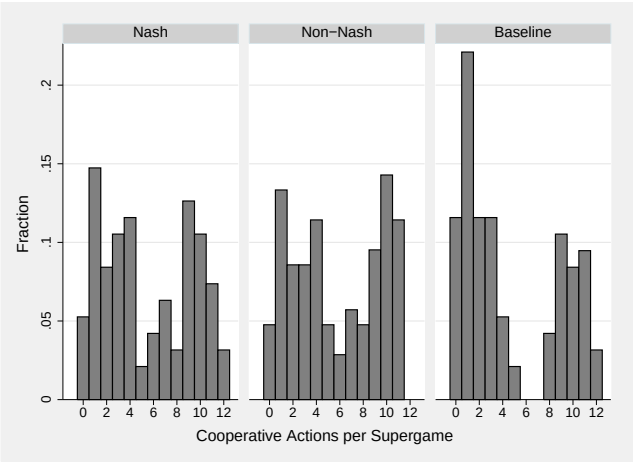


Figure 2: Distributions of the number of cooperative actions by treatment

Figure 3 plots the distribution of welfare per supergame (i.e. the sum of total profits for the two players in a supergame). Note that the minimum welfare in the Baseline treatment is 24, while it can be much lower (and even negative) in the two other treatments if subjects choose the punishment strategy. Actual punishment had a negative influence on the welfare in many supergames. In both treatments where punishment was possible about 30 percent of the supergames led to welfare lower than the minimum welfare in the standard Prisoners' Dilemma. In other words, in the punishment treatments about 30 percent of the supergames ended with lower payouts than if the players had just played the defect equilibrium in all rounds. This welfare-destroying impact of actual punishment is not offset by the slightly higher proportion of supergames with near maximum welfare (45 to 60) in the punishment treatment.[6]

Average welfare is very similar in the punishment treatments (*Nash* 33,67, *Non-Nash* 34.2), while it is significantly higher in the *Baseline* treatment (39.36, $p < 0.018$ vs. *Nash* and $p < 0.026$ vs. *Non-Nash*: two-sided, two-sample t-tests).[7] This observation is not surprising in the *Nash*

[6]This is similar to the observation in stranger-matching public goods games with punishment, where the increased level of contributions is not sufficient to outweigh welfare lossed from exectuted punishment (Fehr and Gächter, 2000).

[7]Here a non-parametric Mann-Whitney test is not appropriate, as the null-hypothesis of equal distributions can never be satisfied due to the different domains, which makes the interpretation of the p-values impossible. Despite of well-known skewness issues, the Welch-Satterthwaite corrected t-test for unequal variances, which we chose, performed best in a recent Monte-Carlo study in cases on data with similar characteristics (inhomogenous

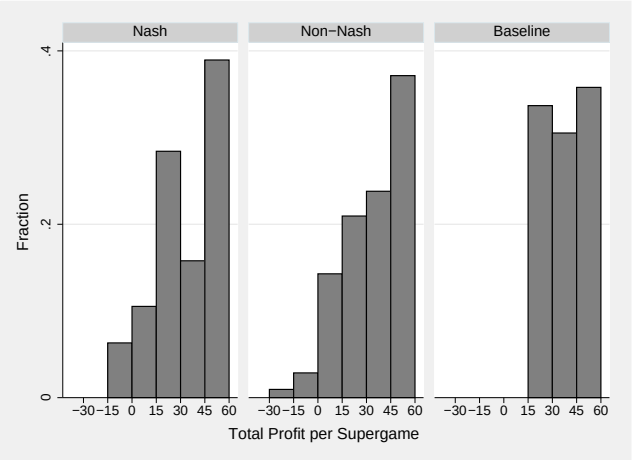


Figure 3: Total Welfare Distributions in the Different Treatments

treatment, as there subgame-perfect Nash equilibria exist where punishment takes place. In the *Non-Nash* treatment no sub-game perfect Nash equilibria exist where punishment is an outcome. This suggests that punishment might not only be used as a strategic tool to induce cooperation but also for other reasons such as negative reciprocity.[8] We state the following result and discuss the role of punishment in more detail in the next Section.

Result 2 *Despite of inducing more cooperative choices, punishment opportunities decrease over-all welfare as punishment is actually executed. This effect does not depend on punishment being a stage-game equilibrium.*

4.3 The Role of Punishment

One might expect that punishment behaviour differs depending on the game played (i.e. *Nash* or *Non-Nash*) and the behavioural assumptions made. If we assume that subjects play selfish equilibrium (subgame-perfect Nash) then we would only expect to see punishment in the *Nash* treatment. In a disequilibrium world, where punishment is used as a strategic tool, in order to induce others to cooperate, one might expect punishment to occur in both the treatments where it is available. However, one would expect

skewness and sample size of about 100) as ours (Fagerland and Sandvik, 2009).

[8]We consider it unlikely that the occurence of punishment in the *Non-Nash* treatment is based on non-subgame-perfect Nash logic. Subjects would have to implement mutual punishment using the threat of further punishment. While such equilibria exist, we are struggeling to find a rationale for them to be selected.

punishment to be more prominent in earlier periods, as then the future cooperation induced is more likely to outweigh the cost. In contrast to this intuition, punishment frequencies are increasing in both treatments, with the fraction of punishment choices being highest in the last period in both treatments. Figure 4 documents this.

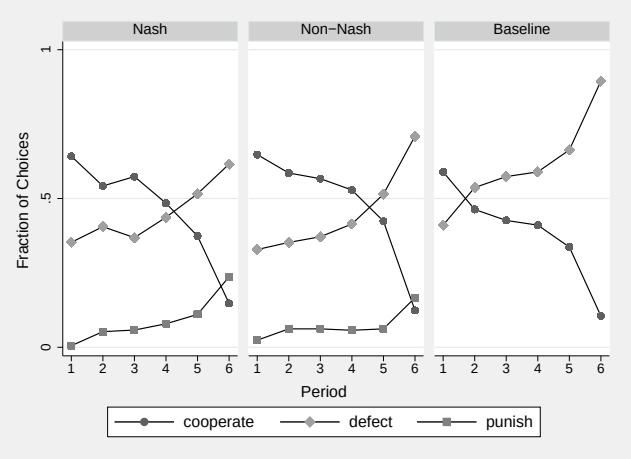


Figure 4: Fraction of Choices by Treatment over Time

The finding that punishment rates are highest in the last period in the *Non-Nash* treatment (and at comparable levels as in the *Nash* treatment – 16.7 vs. 23.7 percent) suggests that a large proportion of punishment is non-strategic and stems from negative reciprocity. The strongest evidence supporting this view comes from the fraction of punishment in the last period in the *Non-Nash* treatment. There, punishment in the final stage of the supergame cannot be the result of equilibrium logic, as no Nash equilibrium exists where anybody actually punishes in the last stage. Moreover, off-quilibrium strategic teaching motives cannot be the cause since there are no future periods. Non-strategic motivation such as reciprocity are likely drivers of punishment behaviour. This result is consistent with findings that punishment occurs in one-shot public goods games with punishment opportunities (Walker and Halloran, 2004).

We ran a multinomial logit regression in order to further investigate the role of punishment in the two treatments. We estimate how previous play of the opponent, the treatment and the previous-play-treatment interaction influence the likelihood that a player cooperates, defects or punishes. We control for demographics of the subjects as well as for time trends within

and across supergames.[9] Table 4 reports the results. On the left part of the Table we report the estimated coefficients, while we give the average marginal effects on the right-hand side. For both we report the standard errors in parentheses and stars denote significance on the five (single star) and one-percent level (double star).[10]

	coeff. (base: defect)		**avg. marginal effect**		
decision	**cooperate**	**punish**	**cooperate**	**defect**	**punish**
otherdecision$_{t-1}$ (base: cooperate)					
defect	-2.794^{**}	1.418^{**}	$-.538^{**}$	$.404^{**}$	$.134^{**}$
	(.291)	(.458)	(.027)	(.029)	(.019)
punish	$-.869^{*}$	2.641^{**}	$-.316^{**}$	.083	$.233^{**}$
	(.248)	(.601)	(.044)	(.061)	(.043)
otherdecision$_{t-1}$ × Non-Nash treatment					
defect	−.134	−.268	–	–	–
	(.396)	(.564)			
punish	−.480	−.513	–	–	–
	(.561)	(.836)			
Non-Nash treatment	.010	.178	−.008	.012	−.004
	(.222)	(.515)	(.025)	(.035)	(.019)
stage	$-.489^{**}$	$.197^{*}$	$-.076^{**}$	$.054^{**}$	$.022^{**}$
	(.067)	(.089)	(.008)	(.009)	(.006)
male	.211	$.601^{*}$	.023	−.063	$.040^{*}$
	(.196)	(.287)	(.028)	(.036)	(.020)
university level (base: undergraduate)					
pg research	1.028^{*}	−.349	$.157^{**}$	−.119	−.034
	(.402)	(.435)	(.027)	(.064)	(.025)
pg coursework	−.001	.011	.000	.000	.001
	(.343)	(.357)	(.050)	(.056)	(.026)
Controls (age, course, maths level, supergame)					
included	*yes*	*yes*	*yes*	*yes*	*yes*
constant	1.711^{*}	-4.128^{**}	–	–	–
	(.707)	(.985)			
Log Pseudo$\mathcal{L}$		−1366.820			
Observations		2000			

Table 4: Multinomial logit explaining choices in the punishment treatments

Surprisingly, we find that the dummies that capture the interaction be-

[9] We allow for clustering of errors on the subject level.

[10] We report the average marginal effects of primary variables only, as the average marginal effects of the interaction terms are hard to interpret.

tween treatment and past choice of the opponent are not significantly different from zero ($p > 0.95$, F-Test with the null hypothesis that the dummies are jointly equal to zero). This means that how subjects react to past behaviour of their opponent does not depend on whether punishment is a Nash equilibrium of the stage game or not. So the likelihood of punishing conditionally on the action of the opponent in the period before is independent from punishment being a stage-game Nash strategy. This suggests that actual punishment is motivated by other factors than equilibrium considerations. This further implies that the threat of punishment is credible in both treatments.

As expected, we find that the likelihood of choosing the punishment action is greater after the opponent defected than after the opponent cooperated ($p < 0.003$, Wald Test). Less intuitive is that being punished in the period before makes it even more likely for a subject to choose the punishment strategy ($p < 0.001$, Wald Test). The fact that choosing the punishment strategy is most likely after having been punished, documents the occurrence of feuds and explains a large fraction of the upwards trend of punishment over time.[11]

Moreover, having been punished the period before, reduces the probability of cooperating significantly ($p < 0.043$, Wald Test) compared to the case where the opponent cooperated in the period before. Punishment is at least more effective in inducing cooperation of the opponent than defecting ($p < 0.001$, Wald Test). This means that executed punishment is effective, to a certain extent, at inducing future cooperation. However, in many cases, punishment leads to counter-punishment. This can potentially be attributed to the absence of a feeling of guilt of the punished as shown by Hopfensitz and Reuben (2009). This occurence of escalation of punishment is partly responsible for the negative effect of punishment opportunities on average welfare, despite of the induced increase in the fraction of cooperative actions (see Nikiforakis and Engelmann, 2011, who obtain similar results in a public goods setting).[12]

[11] There still remains an unexplained upwards trend of about two percentage points per period.

[12] Some interesting result that are not related to the immediate research question are that PhD students are more cooperative than undergraduate and coursework masters students, that males tend to punish more often and that economics and science students are less cooperative than medicine, law and engineering students.

Result 3 *The use of punishment does neither follow equilibrium nor a logic for strategic teaching and is consistent with negative reciprocity.*

Result 4 *Punishment is effective at increasing future cooperation (compared to playing defect) but often also provokes counter-punishment.*

5 Conclusion

Punishment opportunities have been shown to be very effective in public goods games, despite of being non-credible in the sense of subgame-perfection (Fehr and Gächter, 2000).[13] It is unclear, if the effectiveness of punishment there has to do with Nash equilibrium logic in the supergame, with punishment being credible as a strategic teaching tool or as a means of exerting negative reciprocity. This paper uses variants of prisoners' dilemma games in order to investigate this question. We find that the effectiveness of punishment is neither related to Nash or sugame-perfect Nash equilibrium logic. Punishment is credible, as it is motivated by reciprocity. While punishment opportunities increase the fraction of cooperative play, welfare decreases, as the cost for punishment exceeds the welfare gains from slightly more cooperation. The welfare damaging effect of punishment opportunities is stronger than expected, since some subjects react to punishment with furhter welfare-damaging counter-punishment.

A Sample Instructions

(*Here are the instructions for the baseline treatment. The instructions for the other treatments are identical up to the added action in the screenshot and the reference table at the end.*)

Experimental Instructions

Welcome to the experiment. Before we start, please read the instructions carefully.

During the experiment, your earnings will be calculated in points rather than dollars. Accumulated points will then be converted to Dollars at the following exchange rate at the end of the session to determine your payment:

[13] The effectiveness seems to depend on factors such as the feedback format though (Nikiforakis, 2010)

5 points = AUD $1.00

You will be paid in cash immediately after the experiment. You are not allowed to communicate with other participants during the experiment. Should you have any questions, please raise your hand and we will attend to you individually. Failure to comply with the outlined rules will result in exclusion from the experiment and we reserve the right to forfeit your payment.

Summary

You will be playing 5 identical games consecutively.

Each game consists of 6 rounds and you will be asked to select one action per round. You will be playing this game with another participant who will be randomly assigned by a computer.

After every 6 rounds, you will be randomly paired with another participant until you have played a total of 5 games.

The Game

This is a 2-player game. After you have been randomly assigned to another participant by a computer, you and this other player will play a game consisting of identical rounds. In each round, you will be asked to choose an action. Similarly, the other player will also be asked to choose an action at the same time.

You will be presented with two actions (A or B) to choose from. The other player will also be presented with two actions (X or Y) to choose from.

Your payoffs for every possible combination of actions that you and the other player may make are shown on the same screen in a table. The other player's payoffs will be displayed in a similar fashion in a separate table beneath your payoffs table.

You then indicate your choice of action at the bottom of the screen and finalize your decision by clicking the "OK" button.

Payoffs

Both yours and the other player's choice of action, and respective payoffs for the current round will then be revealed after you have both finalized your decisions.

The final payoff you receive in each round depends on:

1. The action that you have selected; and

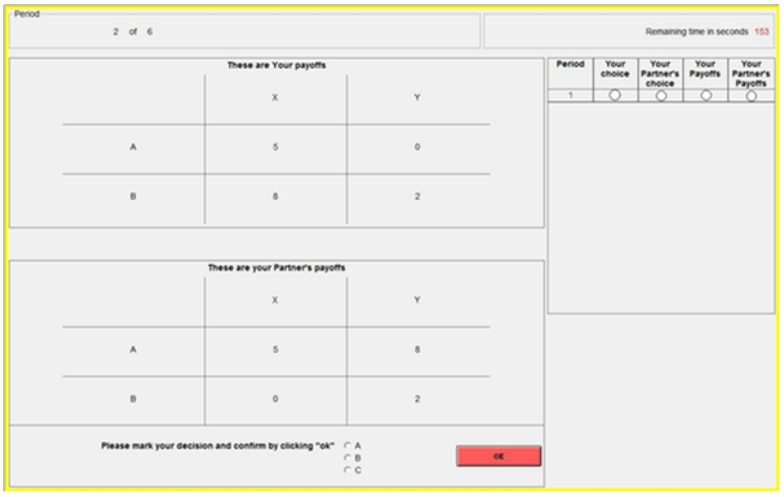
2. The action that the other player has selected.

The payoff the other player receives depends on:

1. The action he/she has selected; and

2. The action you have selected.

The following is a screenshot to familiarize you with what to expect during each round.



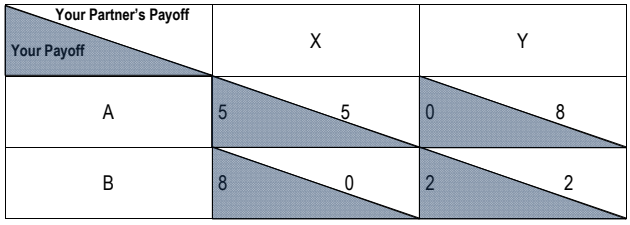
The header on the top left hand corner of the screen indicates the current round you and the other player are playing. The table beneath the header shows your payoffs for all possible combinations of yours and the other player's actions. The box on the right side of the screen records your payoffs and your partner's payoffs for every round played. [*Note: Every game will be the same throughout the whole experiment. As a guide, please refer to the table attached at the back of these instructions which tells you your payoffs corresponding to all possible combinations of actions that you and the other player may choose.*]

A new game commences and you will be randomly paired with another participant after every 6 rounds. This process repeats until 5 games have

been played. After all 5 games have been played, your total profit will be recorded and you will be paid in cash.

[*Note: Please refer to the table attached at the back of these instructions which tells you your payoffs corresponding to all possible combinations of actions that you and the other player may choose*]

-End of Instructions-



The table above illustrates payoffs in the game. Your payoffs are denoted by numbers within the shaded triangles whereas the other player's payoffs are denoted by numbers within the un-shaded triangles. For example, if you chose 'B' and the other player chose 'X' in particular round, payoffs for that particular round are:

Your Payoff = 8

Your Partner's Payoff = 0

References

Andreoni, J. and J. H. Miller (1993). Rational cooperation in the finitely repeated prisoner's dilemma: Experimental evidence. *The Economic Journal 103*(418), pp. 570–585.

Angelova, V., L. V. Bruttel, W. Güth, and U. Kameke (2013). Can subgame perfect equilibrium threats foster cooperation? an experimental test of finite-horizon folk theorems. *Economic Inquiry 51*(2), 1345–1356.

Benoit, J.-P. and V. Krishna (1985). Finitely repeated games. *Econometrica 53*(4), pp. 905–922.

Benoit, J.-P. and V. Krishna (1987). Nash equilibria of finitely repeated games. *International Journal of Game Theory 16*(3), 197–204.

Charness, G. and M. Rabin (2002). Understanding social preferences with simple tests. *Quarterly Journal of Economics 117*(3), 817–869.

Charness, G. and M. Rabin (2005). Expressed preferences and behavior in experimental games. *Games and Economic Behavior 53*(2), 151–169.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross (1996). Cooperation without reputation: Experimental evidence from prisoner's dilemma games. *Games and Economic Behavior 12*(2), 187 – 218.

Cox, J. C., D. Friedman, and V. Sadiraj (2008). Revealed altruism. *Econometrica 76*(1), 31–69.

Fagerland, M. W. and L. Sandvik (2009). Performance of five two-sample location tests for skewed distributions with unequal variances. *Contemporary Clinical Trials 30*(5), 490 – 496.

Fehr, E. and S. Gächter (2000). Cooperation and punishment in public goods experiments. *American Economic Review 90*, 980–994.

Fehr, E. and K. Schmidt (1999). A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics 114*(3), 817–868.

Fischbacher, U. (2007). Z-tree - Zurich toolbox for readymade economic experiments. *Experimental Economics 10*(2), 171–178.

Friedman, J. (1971). A non-cooperative equilibrium for supergames. *Review of Economic Studies 38*, 1–12.

Greiner, B. (2003). An online recruitment system for economic experiments. In K. Kremer and V. Macho (Eds.), *Forschung und wissenschaftliches Rechnen*. Ges. fr Wiss. Datenverarbeitung.

Hopfensitz, A. and E. Reuben (2009). The importance of emotions for the effectiveness of social punishment. *The Economic Journal 119*(540), 1534–1559.

Kreps, D. M., P. Milgrom, J. Roberts, and R. Wilson (1982). Rational cooperation in the finitely repeated prisoners' dilemma. *Journal of Economic Theory 27*, 245–252.

Nikiforakis, N. (2010). Feedback, punishment and cooperation in public good experiments. *Games and Economic Behavior 68*(2), 689 – 702.

Nikiforakis, N. and D. Engelmann (2011). Altruistic punishment and the threat of feuds. *Journal of Economic Behavior & Organization 78*(3), 319 – 332.

Nikiforakis, N. and H.-T. Normann (2008). A comparative statics analysis of punishment inpublic-good experiments. *Experimental Economics 11*(4), 358–369.

Normann, H.-T. and B. Wallace (2012). The impact of the termination rule on cooperation in a prisoner's dilemma experiment. *International Journal of Game Theory 41*(3), 707–718.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *The American Economic Review 83*(5), 1281–1302.

Selten, R. and R. Stoecker (1986). End behavior in sequences of finite prisoner's dilemma supergames a learning theory approach. *Journal of Economic Behavior & Organization 7*(1), 47 – 70.

Walker, J. and M. Halloran (2004). Rewards and sanctions and the provision of public goods in one-shot settings. *Experimental Economics 7*(3), 235–247.