PUNISHMENT DESPITE REASONABLE DOUBT

- A PUBLIC GOODS EXPERIMENT WITH UNCERTAINTY OVER CONTRIBUTIONS

KRISTOFFEL GRECHENIG

UNIVERSITY OF ST. GALLEN, DEPARTMENT OF LAW

BODANSTR. 4, 9000 ST. GALLEN, SWITZERLAND

+41 71 224 3006 ▪ KRISTOFFEL.GRECHENIG@UNISG.CH

&

MAX PLANCK INSTITUTE FOR RESEARCH ON COLLECTIVE GOODS

KURT-SCHUMACHER-STRASSE 10, 53113 BONN, GERMANY

+49 228 91416 51 ▪ GRECHENIG@COLL.MPG.DE

ANDREAS NICKLISCH

MAX PLANCK INSTITUTE FOR RESEARCH ON COLLECTIVE GOODS

KURT-SCHUMACHER-STRASSE 10, 53113 BONN, GERMANY

+49 228 91416 79 ▪ NICKLISCH@COLL.MPG.DE

CHRISTIAN THÖNI

UNIVERSITY OF ST. GALLEN, DEPARTMENT OF ECONOMICS

VARNBÜELSTR. 14, 9000 ST. GALLEN, SWITZERLAND

+41 71 224 2548 ▪ CHRISTIAN.THOENI@UNISG.CH

Under a great variety of legally relevant circumstances, people have to decide whether or not to behave pro-socially, e.g. to comply with legal norms, when they face an incentive to defect. The law sometimes provides people with sanctioning mechanisms to enforce pro-social behavior. Experimental evidence on voluntary public good provision shows that punishment stabilizes cooperation, even if punishment is costly. However, these studies focus on situations where there is no uncertainty about the others' behavior. We investigate punishment in a world with "reasonable doubt" about contributions of other people. Interestingly, people reveal a high willingness to punish when contributions are not observable and there is little information. We show that, with some non-trivial degree of uncertainty, punishment (1) cannot stabilize contributions and (2) reduces welfare (even though people could simply decide not to make use of the punishment mechanism). Our findings suggest that, given punishment is available, information about others' behavior is crucial for the stabilization of pro-social behavior and for efficiency; given that information cannot be obtained, it is sometimes optimal not to offer a sanctioning mechanism.

JEL Classifications: C91, D03, H41, K14, K42.

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Introduction

People participate in social dilemmas, where it is optimal from a welfare perspective if all individuals cooperate, but rational for individuals to defect. Among other mechanisms (like social norms and habits), the law typically serves an important function in maintaining social cooperation, as it provides participants with rights to enforce pro-social behavior and to sanction defection. Previous research has shown that decentralized costly sanctioning (although independent of legal rights) provides a robust mechanism for stabilizing cooperation in anonymous groups (e.g., Fehr & Gächter 2000; Herrmann et al. 2008, Gächter et al. 2008). However, this result is obtained vis-à-vis accurate information concerning the contributions of all group members. We argue that punishment is substantially less efficient if people are faced with uncertainty over contributions. In this case, high cooperation rates cannot be maintained even at the cost of enormous punishment as punishment becomes an ineffective measure to discipline non-cooperators. Moreover, "wrongful punishment" has a substantial negative effect on cooperators and so erodes pro-social behavior.

Even though there may be circumstances under which the behavior is perfectly observable, in the vast majority of situations either less information is available or information is prohibitively costly to obtain. Especially, legal cases typically involve uncertainty concerning crucial facts. Not surprisingly, rules of legal procedure are inherently based on the incidence of error (Shavell, 2004, 451) and the law in general takes into account that some information is private (Baird, Gertner & Picker, 2003, 79).

In contrast to previous research, we investigate how individuals cope with sanctions under uncertainty. Particularly, we analyze how cooperation behavior reacts to uncertainty concerning the individual contributions. We find that – even though the others` behavior is not perfectly observable – people punish massively. Such punishment does not work well and it does not lead to more cooperation and pro-social behavior, respectively. With some non-trivial degree of noise, efficiency is higher without a punishment mechanism, even though people could simply choose not to make use of punishment.

Our findings suggest that with some substantial degree of uncertainty regulators may be well advised not to offer sanctioning mechanisms in public good settings. Likewise, information is crucial, given that punishment is available. This supports the fact that, in public good settings, sanctions are often restricted (e.g. public international law) and/or sanctions are conditioned on a high degree of information (e.g. standards of proof). Different from many legal and economic studies that focus on the effect of sanctions on defectors, our results also shed light on the effect of (wrongful) punishment on cooperators that drives the inefficiencies of punishment.

Design

For our experimental analysis, we apply a standard voluntary contribution mechanism (VCM) with and without decentralized punishment. One can imagine a great variety of designs for our research question; the design chosen has been widely tested (see, e.g., Zelmer, 2003) and it allows for general applications to the law. The robust finding is that contributions decline over time if sanctioning is not available, and remain stable or increase otherwise. Given that punishment is costly for the punisher, norm enforcement by punishment itself is a public good: The entire group participates on the benefits of enforcement while the individual group member bears its costs. This design reflects the fact that enforcement of many legal rights is time consuming and does not pay from a pure monetary static point of view. This includes reports of criminal behavior to the police, economic sanctions under international law, private law suits etc.

We design a standard 10-round repeated VCM game with 4 players. The group composition of players remains constant over periods (partner design), but Interactions are anonymous: Players are identified by identification numbers, and identification numbers change randomly over periods. A constant marginal per capita return of 0.4, an endowment of 20, and a separate punishment endowment of 10 are introduced. First, players simultaneously choose their contributions g_i, where g_i {0,1,2,...,20}. After the contributions are made, each player receives a signal s_j ($j \neq i$) over the contributions of the other players such that

$$s_j = \begin{cases} g_j & \text{with } \ prob = \lambda \\ \tilde{g}_j & \text{with } \ prob = 1 - \lambda \end{cases}$$

where $g_j \neq \tilde{g}_j$

and $\tilde{g}_j$ is uniformly distributed in $\{0,1,2,...20\} / \{g_j\}$

Subsequently, the players simultaneously choose to punish the other players, where each punishment point leads to a deduction of three points on the account of the player punished. Each player can choose to punish up to his punishment endowment for each round. We denote punishment points as

$$p_i^j (i \neq j)$$

so that

$$\sum_j p_i^j \leq 10$$

After each round, the subjects learn their own payoff and the average contributions. Payoffs are accumulated. Player *i`s* payoff is

$$\pi_i = 20 - g_i + 0.4 \sum_j g_j + (10 - \sum_{j \neq i} p_i^j) - 3 \sum_{j \neq i} p_j^i$$

Parameters and payoff functions are common knowledge prior to the start of the experiment.

We compare four experimental treatment conditions, three with sanctioning mechanism and one without sanctioning:

- In the P/1 treatment, players receive accurate signals over contributions of other group members and may use the sanctioning mechanism.
- In the P/.9 treatment, players receive only with a probability of 0.9 accurate signals over contributions of other group members, while they see another random signal otherwise. Thereafter, they may use the sanctioning mechanism.
- In the P/.5 treatment, players receive only with a probability of 0.5 accurate signals over contributions of other group members, while they see another random signal otherwise. Thereafter, they may use the sanctioning mechanism.
- In the N/.5 treatment, players receive only with a probability of 0.5 accurate signals over contributions of other group members, while they see another random signal otherwise. In this treatment, however, they cannot use the sanctioning mechanism.

For comparison, we use data from Hermann, Thöni and Gächter (2008), who conducted a VCM game with accurate signals, the same set of parameters, the same subject pool and in the same lab, but without sanctioning mechanism (denoted as N/1).

In total, we ran 8 sessions with 48 groups (192 subjects), leaving us with 12 independent observations per treatment condition. The computerized experiments using zTree (Fischbacher, 2007; for recruitment we used ORSEE, Greiner 2004) were conducted at the Econ Lab of the University of Bonn in January, February and March 2009 with mostly undergraduate students from various fields. Each player participated in only one treatment condition; none of the subjects had participated in a public good experiment previously.

Once all subjects were seated, the instructions were handed to them in written form before being read aloud by the experimenter. Subjects were given the opportunity to privately ask any questions they might have. After questions had been answered individually, subjects were handed a questionnaire to test their understanding of the rules. Wrong answers were explained in private prior to the experiment.

Hypotheses

Should uncertainty about other subjects' contributions influence behavior? The most important effect is presumably the effect on punishment. In treatments with punishment, uncertainty makes it more difficult to separate free riders from cooperative subjects. Previous evidence strongly suggests that punishment is predominantly directed to free riders (though not exclusively, see Herrmann et al. 2008). Suppose that punishment attempts to enforce cooperation norms, subjects should become more resistant to use the punishment option, since there is the danger of erroneous punishment. Thus, we hypothesize that the use of punishment is decreasing in the amount of uncertainty, i.e., for the average use of punishment points in the three treatments we expect $p^{P/1} > p^{P/.9} > p^{P/.5}$.

Punishment is not the only channel through which uncertainty in the contribution information might affect cooperation. At this stage it is unclear whether increased uncertainty makes subjects more optimistic or more pessimistic about other subjects' contributions. Previous evidence suggests that a large fraction of the subjects can be characterized as conditionally cooperative (Fischbacher et al. 2001), i.e., subjects who contribute only if they expect others to contribute as well. In repeated public goods setting subjects use the information of the previous period to form beliefs about others' contributions in the current period. Since individuals receive feedback over average contributions, belief formation in this way is possible. However, whether uncertainty about other players' individual contributions might affect belief formation is unclear.

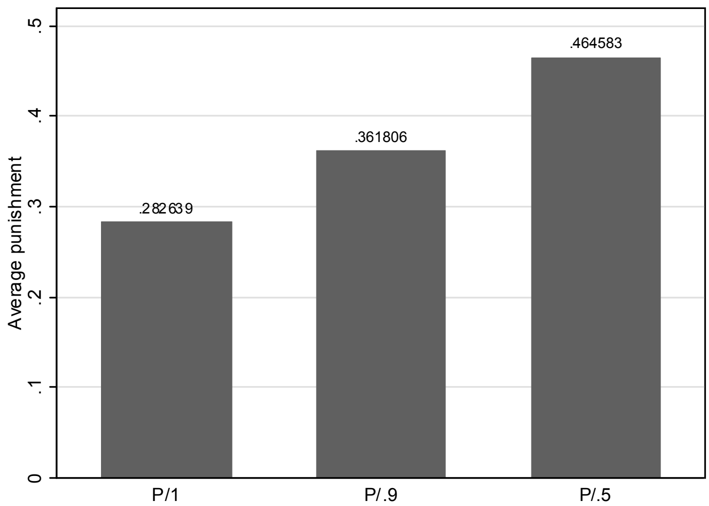
Yet, there is an addition effect in terms of signalling cooperative behavior: Subjects who expect others' to be conditionally cooperative have a strategic incentive to choose high contributions early in the game to induce other subjects to contribute subsequently. Uncertainty may decrease this effect weakening the strategic incentive to contribute initially in order to trigger conditional cooperators. It seems likely that the signal of high cooperation is distorted. In order to identify effects of signal uncertainty on contributions we compare the treatments N/1 and N/.5 suggesting the claim that $g_i^{N/1} > g_i^{N/.5}$. However, whether (and in which direction) the interaction between uncertainty and the provision of sanctioning mechanisms affect contributions remains debatable and will be subject to our experimental analysis.

Results

Ineffective Punishment

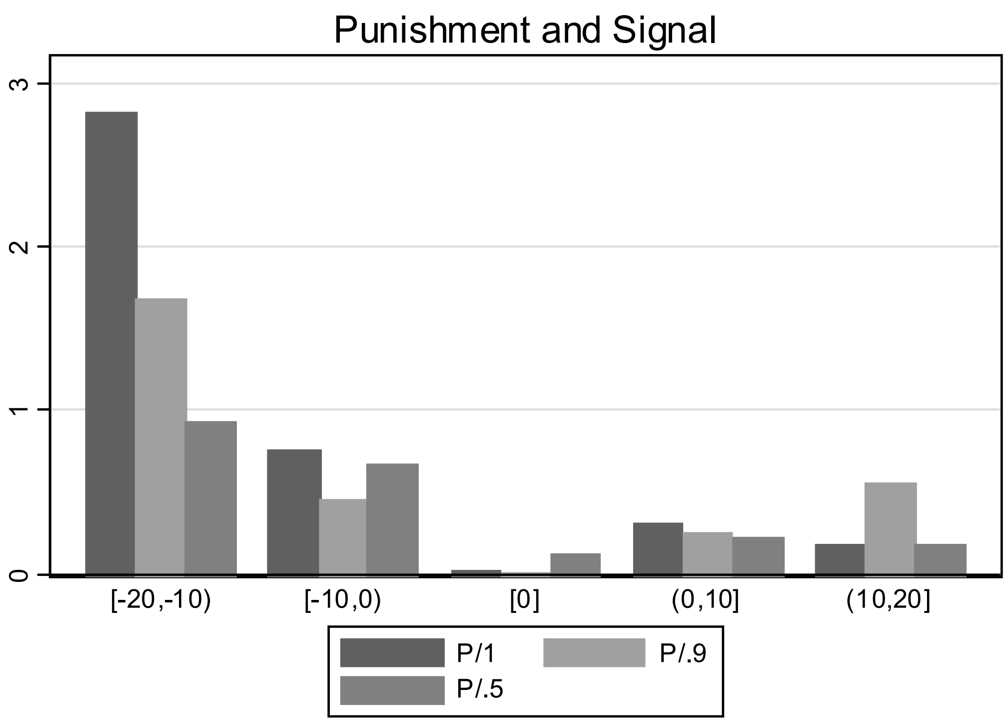
According to our hypothesis we expect less punishment in treatments with higher uncertainty. Figure 1 shows the average amount of punishment points used in the three treatments with punishment. Contrary to our hypothesis, higher uncertainty leads to more punishment on average.

Figure 1: Average punishment points assigned during the ten periods in the three treatments with punishment.



Thus punishments expenditures increase with uncertainty. Does this imply that a higher number of punishment points are distributed with uncertainty? The answer is no: There are more punishment instances in P/.5 (in 25.2% percent of all cases players distribute at least one point) than in P/.9 (17.5%) than in P/1 (12.8%), but the harshness of the sanctioning for severe defectors is significantly decreased with increasing uncertainty. The literature on public goods games with punishment has identified the difference between a punisher´s contribution and the contribution of the punished subject as an important determinant of punishment. Figure 2 shows the average punishment dependent on this difference, i.e., we condition the average number of punishment points invested on the distance between the contribution signal of the punished player and the own contribution of the player who punishes. In accordance to the literature we see that large negative deviations are punished strongest. The most pronounced relationship of the deviation on punishment is observed in the treatment without uncertainty (P/1). In all treatments we observe some antisocial punishment, i.e., punishment of subjects who were more cooperative than the punisher.

Figure 2: Mean punishment



For a more detailed analysis, we use regression analyses.[1] We hypothesize that differences in efficiency and contributions are driven by the fact that some participants make high contributions but are punished nevertheless, potentially because others received low signals. Consequently, cooperative behavior is eroded. Table 1 shows Tobit estimates explaining the punishment decision. In Model 1, we only use dummies for the two treatments and the variable *Period* to identify time effects. The dummy for the high uncertainty treatment is significantly positive, indicating that punishment was stronger in the case where the signal was very unreliable. Form the literature we know that a very important determinant of the punishment decision is the deviation between the contribution of the punisher and the one of the punished subject. In Model 2, we include the difference between the signal and the punisher's own contribution as explanatory variable. We allow for different slopes for the cases where the signal is higher and lower than the punisher's contribution. The treatment dummies are insignificant once we control for the deviations in the contributions. Thus, controlled for deviations, punishment is not stronger in the treatments with less reliable signals. The absence of a negative effect is surprising. The uncertainty of the signal does not seem to discourage subjects from making use of the punishment option. Subjects punish heavily even in the presence of significant uncertainty, that is despite reasonable doubt! The deviation variables have the expected signs: For negative deviations ($s_j<g_i$) we observe a highly significant coefficient, i.e., the lower the signal the higher the punishment. For positive deviations the estimated coefficient is positive (-0.304+0.388=0.084) and significant at p=0.041. This means that overall we do find an indication for antisocial punishment in our subject pool (see Herrmann et al., 2008). In Model 3, we add the subject`s own contribution and the contribution of the other players in the group as controls. The inclusion of these variables does not change the results. Finally, in Model 3, we test whether the dependence of the punishment decision on the observed signal is similar across treatments. We introduce interaction terms for the treatment dummies and the two measures for deviation. In case of negative deviations ($s_j<g_i$), both treatments with non-perfect signals have significantly smaller slopes, indicating that punishment is less strongly connected to the deviation between the signal and the own contribution. Or, in other words, if the signal indicates that a subject is a free rider, punishment is weaker the more uncertain the signal is. In case of positive deviations only the interaction term for the treatment with high noise is significant, which means that high positive deviations are punished less strongly in P/.5 compared to the treatment with the perfect signal.

[1] We cluster error terms for groups.

Table 1: Tobit estimates for the punishment decision

Table 1 Alternative

	Dependent variable: Punishment		
P/.9	0.628	-0.053	0.063
	(0.703)	(0.578)	(0.626)
P/.5	1.388**	0.249	1.952***
	(0.624)	(0.584)	(0.656)
Period	-0.124***	-0.091***	-0.078***
	(0.037)	(0.033)	(0.030)
sj - gi		-0.304***	-0.474***
		(0.035)	(0.048)
max(sj - gi,0)		0.388***	0.652***
		(0.067)	(0.071)
(sj - gi) x P/.9			0.133**
			(0.059)
max (sj - gi,0) x P/.9			-0.118
			(0.098)
(sj - gi) x P/.5			0.319***
			(0.065)
max (sj - gi,0) x P/.5			-0.586***
			(0.092)
Constant	-3.086***	-3.340***	-3.829***
	(0.551)	(0.469)	(0.559)
sigma	3.422	2.907	2.804
p	0.002	0.000	0.000
ll	-3336	-3069	-3006
N	4320	4320	4320

Robust standard errors, clustered on group.

Contrary to our hypothesis punishment is not discouraged by uncertainty, yet the strength of punishment is significantly weekend.

Ineffective punishment

Exploring the response to received punishment allows us to test whether cooperative behavior is eroded by punishment under uncertainty. Under perfect information, experimental evidence suggests that punishment maintains and even enhance cooperation. However, under uncertainty, the reaction to received punishment is much less clear. On the one hand one could expect that punishment loses its legitimacy in the sense that players who receive punishment points do not respond in terms of their contributions as punishment is noisy. On the other hand, players may respond negatively to received punishment by lowering their contributions since they are punished despite the imperfect information. In order to analyze the effect of received punishment, we ran a sequence of regression analyses with the difference in contributions between two consecutive periods for a player as the dependent variable.[2] Particularly, let us define Δ_t as the contribution in period t minus the contribution in period t-1 (i.e., $\Delta_t := g^t_i - g^{t-1}_i$). Thus, a negative Δ_t indicates a decrease in contribution; a positive Δ_t indicates an increase in contributions.

As independent variables, let us define dummy variables P/.9 and P/.5. The first (second) variable is zero, if observations come from the P/.9 (P/.5) treatment and zero otherwise. Furthermore, let sum $^{t-1}p_j^i$ count the number of points player *i* receives in period t-1. Hence, sum$^{t-1}p_j^i$ measures the effect of punishment points received on contributions in the consecutive periods. Interaction terms with P/.9 and P/.5 indicate differences across treatment conditions.

Furthermore, we introduce two control variables to disentangle the effect of punishment from other variables that influence contribution decisions. First, in order to control for peer effects, we measure the sum of contributions by all other players in *t-1*, sum $g_{j\neq i}^{t-1}$. Thus the variable (interaction terms with treatment dummies) indicate positive effects of observing other players contributing to the public good for own contribution decisions. Second, we introduce the period number in t as an independent variable Period controlling for potential learning effects while playing the game.

Overall, we estimate two regression models, one for contribution decisions when the player contributed less than the average in period *t-1*; and one for contributions decisions when the player contributed the average or more than the average in period *t-1*. Thus, the separation into two models allows us to test whether received pro-social punishment differs from received punishment that can be interpreted as anti-social[3]. The results of our estimations are summarized in Table 2. The first column reports the findings for received pro-social punishment, the second column for received anti-social punishment.

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[2] Again, we cluster error terms for groups. Of course, data from period one are excluded.

[3] Of course, punishing player may base their decision on a noisy signal, and accidentally punish antisocially.

Table 2: Estimation results for the response to received punishment

	Dependent variable: Δ_t	
contributed in t-1:	less than average	more or equal average
Period	-0.262**	-0.226***
	(0.010)	(0.051)
sum $g_{j \neq i}^{t-1}$	0.053*	0.025**
	(0.027)	(0.010)
sum $g_{j \neq i}^{t-1}$ x P/.9	-0.025	-0.013
	(0.061)	(0.021)
sum $g_{j \neq i}^{t-1}$ x P/.5	-0.132***	0.020
	(0.041)	(0.042)
sum ${}^{t-1}p_j^i$	0.649***	-0.481***
	(0.172)	(0.128)
sum ${}^{t-1}p_j^i$ x P/.9	0.011	-0.057
	(0.272)	(0.397)
sum ${}^{t-1}p_j^i$ x P/.5	-0.060	0.308
	(0.326)	(0.338)
P/.9	1.096	0.181
	(2.923)	(1.254)
P/.5	5.591***	-2.132
	(1.871)	(1.910)
Constant	-0.420	-0.452
	(1.254)	(0.678)
R^2	0.12	0.07
N	462	834

Note: R^2 reports the goodness of fit according to the r-square criterion; we also report the F-test statistics assessing the improvement of the estimations against naïve models; N denotes the number of observations; asterisks indicate significance levels: *** indicates significance at a $p<0.01$ level, ** at a $p < 0.05$ level and * at a $p < 0.1$ level.

Our regression results show that there is a significant negative time trend for the change in contribution. If there is an increase in contributions, the change in contributions decreases over the course of the experiment, while if there is a decrease in contributions, the change increases in the course of the experiment. Overall, contributions decline towards the end of the experiment.

With respect to the response to punishment, we find a negative response for received anti-social punishment, whereas there is a positive response in terms of contributions for received pro-social punishment. Astonishingly, there is no significant difference across treatment conditions. Response to punishment does not reflect the level of noise under which has been issued. Therefore, we find a major source for decreasing efficiency once we introduce noisy punishment: Compared to the P/1 treatment, players need to distribute more pro-social punishment in order to counterbalance the negative effects of antisocial punishment that occurs more frequently under noise.

Another reason for the negative development of contributions particularly in the P/.5 treatment comes for the peer effect, the results indicate (weakly) significant for players who contribute (less) more than the average or the average. Indeed, higher sums of contributions by others trigger higher contributions in the consecutive periods. Yet, this effect is reversed for P/.5. Once we introduce punishment under severe noise, as indicated by the significant positive coefficient of P/.5, contributions seem to increase constantly at the beginning of the experiment (in later periods, there is the negative effect of learning). However, this effect is counterbalanced for groups of high contributors. Here, we find a negative peer effect: higher sums of contributions leads to lower contributions in the consecutive periods. It seems that players attempt to trigger contributions by others up to a certain threshold and try to exploit contributions above this threshold.

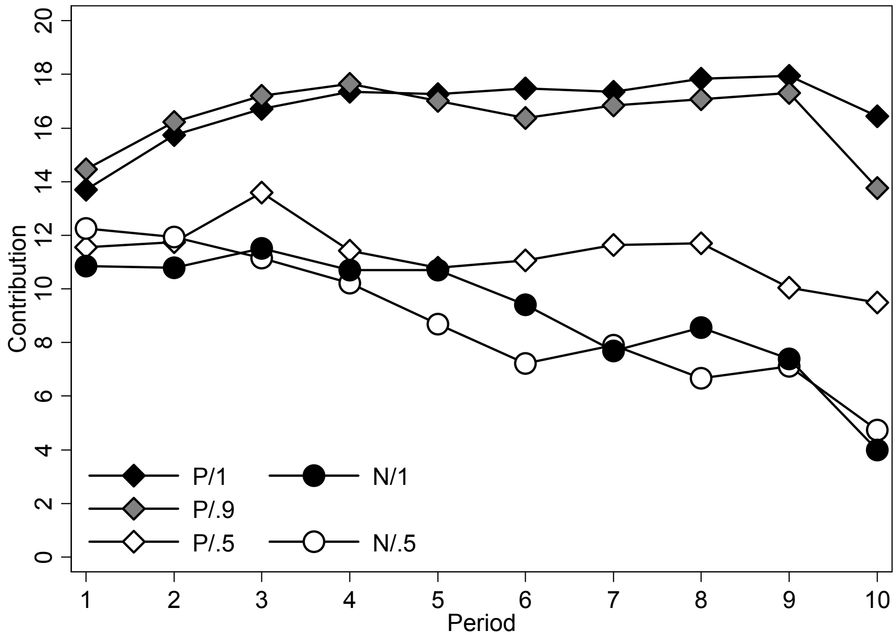
To summarize the findings, we find two negative effects of noisy punishment. First, responses to received anti-social punishment do not differentiate between the accuracy of information on which basis the punishment has been issued. Second, there is negative peer effect of contributions by others under the treatment condition of severe noise.

No stabilization of unobservable contributions

Of course, development of contributions reflects the interaction between uncertainty and punishment. When participants are perfectly informed over contributions of the other participants, we find significantly more cooperation when a (costly) punishment mechanism is available ($p<0.001$, Wilcoxon rank-sum test, two-sided). This well-known result in the literature (Fehr & Gächter, 2000, 2002) does not hold when we introduce uncertainty. With (some non-trivial degree of) uncertainty, punishment does not lead to significantly higher contributions ($p=0.14$ comparing P/.5 and N/.5, Wilcoxon rank-sum test, two-sided). This result implies that punishment is not driving cooperation, when contributions are not observable.

For small uncertainty we find no significant difference of average contributions between P/1 and P/.9 ($p=0.34$, Wilcoxon rank-sum test, two-sided). That is, with mild uncertainty, cooperation seems to be stabilized. However, cooperation is maintained at the costs of large expenditures for punishment (see below). Not surprisingly, we find a highly significant difference between the punishment treatments P/1 and P/.5 (p<0.001, Wilcoxon rank-sum test, two-sided), whereas there is no significant difference in the treatments without punishment N/1 and N/.5 (p=0.82, Wilcoxon rank-sum test, two-sided). As long as there is no punishment mechanism available, the contribution rates are almost identical across treatments (as shown in Figure 4), suggesting that uncertainty by itself has no effect. Punishment with accurate or nearly accurate information over contributions and punishment shifts contributions to its upper bound (see densities in Figure 5).

Figure 4: Contributions over periods

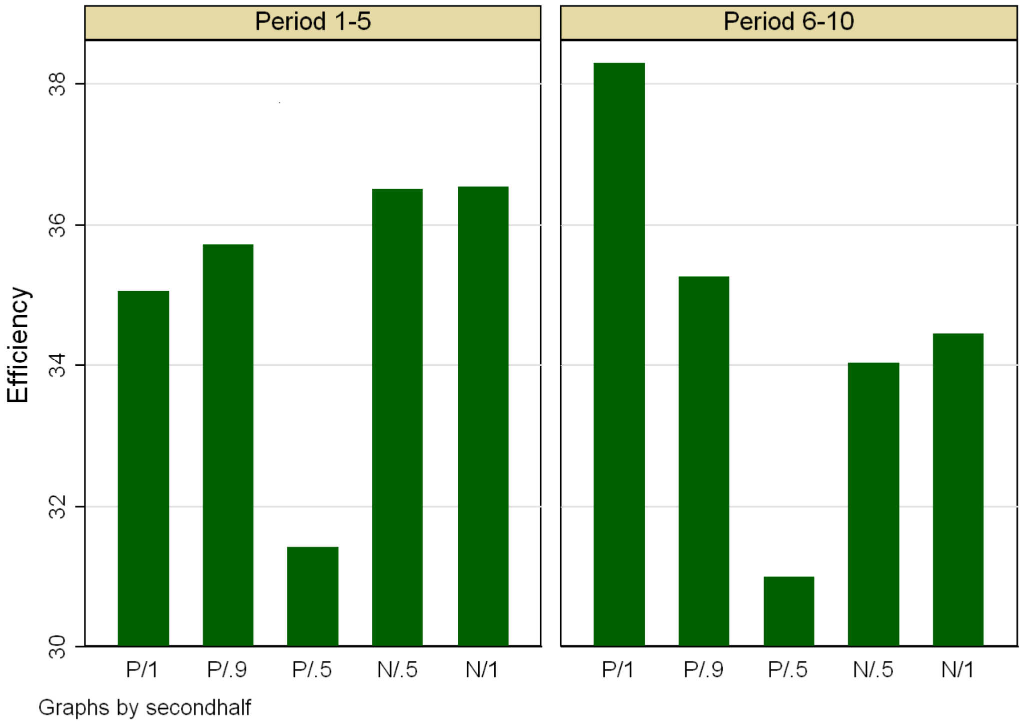


Welfare losses when punishment is available

In a next step we investigate how uncertainty affects overall efficiency. In the treatments without punishment, efficiency is defined by contributions. In treatments with punishment there is an additional efficiency loss due to the punishment option. Comparing P/.5 and N/.5 shows that if uncertainty is at play, overall welfare is significantly lower when sanctioning mechanism is available (p=0.007, Wilcoxon rank-sum test, two-sided). Given that efficiency in P/.5 is decreasing (though insignificantly), this result is likely to represent the long term effect. Our results are surprising, since participants could simple choose not make use of the punishment mechanism and end up as if there were no punishment available. If anything, the threat of punishment should have a positive effect.

Our finding differ from the ones obtained when contributions are perfectly observable (see Figure 5). As expected, overall welfare is not lower but higher, though insignificantly (p=0.16, Wilcoxon rank-sum test, two-sided). This insignificance is due to the fact that punishment does not yield immediate effects but needs some time to fully discipline non-cooperators. Thus, a substantial amount of efficiency is vanished in order to maintain and increase cooperation. For the second part of the experiment (periods six to ten), we find significant differences in efficiency with certainty when punishment is available (p = 0.007 Wilcoxon). Here, the sanctioning mechanism enhances efficiency.

Figure 5: Welfare



Legal Sanctions – Two General Applications

Our results shed some light on laws that restrict sanctions in public good settings and/or require a high degree of information. Public international law often deals with public good settings (pollution, use of natural resources, nuclear activities etc.), where actions are imperfectly observable by the parties. Due to the nature of the issues and sovereignty of the states, information is typically difficult or impossible to obtain (Shaw, 2008). The fact that public international law is characterized by few (decentralized) sanctioning mechanisms and by many treaties with information obligations goes in line with our findings. Even though these features have historically evolved for different reasons (Brownlie, 2008; Shaw, 2008), our results suggest that they may be good from a welfare perspective.

Standards of proof range from high requirements in criminal to relatively low requirements under civil procedure. Convictions under criminal law require proof beyond reasonable doubt of every fact necessary to constitute a crime (United States Supreme Court, 1970). Laws of civil procedure often require „clear and convincing evidence“ or „preponderance of the evidence“ (United States Supreme Court, 1982). Various quantifications of the „reasonable doubt“ standard have been offered for both criminal offenses (Newman, 1993; Tillers, 2006) and civil procedure (Kaye, 1982; Sanchirico, 1997; Hay & Spier, 1997). For public good settings, our results emphasizes the substantial negative effect of wrongful sanctions, due to the response of people subject to such sanctions. Given that people are willing to impose sanctions on other, even under high uncertainty, rules of evidence that require substantial information may be socially optimal.

Summary

Our experimental results show that uncertainty crucially influences the effect of punishment on cooperation. The consequences are drastic. Not only does punishment lose its effect on disciplining non-cooperators, it decreases efficiency substantially. People spend a substantial amount on punishment, while cooperation is poorly maintained. The legal implications are two-fold: insofar as enforcement has to cope with uncertainty, it may be better not to offer sanctions. Since cooperative behavior may be eroded, a system based on intrinsic motivations may be superior to a system with sanctions. Insofar as punishment is available, conditioning sanctions on substantial information is crucial.

References

Baird D., Gertner R., Picker R. (2003), Game Theory and the Law. Harvard.

Brownlie, I. (2008), Principles of Public International Law. Oxford.

Herrmann, B., Thöni, C., & Gächter, S., 2008. Antisocial Punishment Across Societies. Science, 319, 1362-1367.

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

Fehr, E. & S. Gächter (2002), Altruistic punishment in humans, Nature 415, 137-140.

Fischbacher, U. (2007), z-Tree: Zurich toolbox for ready-made economic experiments, Experimental Economics 10, 171-178.

Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. Economics Letters, 71, 397-404.

Gächter, S., Renner, E., Sefton M. (2008). The Long-Run Benefits of Punishment, Science 322, 1510.

Goeree, J., & T. Offerman (2002), Efficiency in auctions with private and common values: An experimental study, American Economic Review 92, 625–643.

Greiner, B. (2004), An online recruitment system for economic experiments, in: K. Kremer & V. Macho (eds.), Forschung und wissenschaftliches Rechnen 2003, Bericht der Gesellschaft für wissenschaftlichen Dateverarbeitung Göttingen 63, 79-93.

Hay B. & Spier, K. (1997), Burdens of Proof in Civil Litigation: An Economic Perspective, Journal of Legal Studies 26, 413-431.

Kaye, D. (1982), The limits of the Preponderance of the Evidence Standard, American Bar Foundation Research Journal 7, 487-516.

Myerson, R.B. (1998), Population uncertainty and Poisson games, International Journal of Game Theory 27, 375-392.

Newman, J. (1993), Beyond "Reasonable Doubt", 68 N.Y.U.L. Rev. 979.

Sanchirico, C. W. (1997), The Burden of Proof in Civil Litigation: A Simple Model of Mechanism Design, International Review of Law and Economics 17, 431-447.

Shavell, S. (2004), Foundations of Economic Analysis of Law. Harvard.

Shaw, M. (2008), International Law. Cambridge.

Tillers, P. & Gottfried, J., (2006), Case Comment—United States v. Copeland, 396 F. Supp. 2d 275 (E.D.N.Y. 2005): A Collateral Attack on the Legal Maxim that Proof Beyond a Reasonable Doubt is Unquantifiable?, 5 LAW, PROBABILITY & RISK 135 (2006).

United States Supreme Court, In re Winship, 397 U.S. 358 (1970).

United States Supreme Court, Santosky v. Kramer, 455 U.S. 745 (1982).

Zelmer, J. (2003), Linear public goods. A meta-analysis, Experimental Economics 6, 299-310.

Zuckerman, Theories of Inference and Adjudication: Law, Fact or Justice?, 66 B. U. L. Rev. 487 (1986)).