The Importance of Being Even

restitution and cooperation

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Restoring cooperation after its breakdown

Cooperation lies at the heart of human economic and social development.

But it is *frail*, and when it *breaks down* it must be *repaired*.

The adoption of **forgiving strategies** is essential, especially in an “uncertain” world.

A thought experiment

	C	D
C	100, 100	-100, 200
D	200, -100	0, 0

$\delta = 0.9$: continuation probability

- Period 1 – you: D; the other: C
- Period 2 – you: C; the other: D

What would you choose in Period 3?

Strategies in the repeated PD

Memory-one strategies are predominant in games with perfect monitoring.
Dal Bò and Fréchette, AER 2019; Romero and Rosokha, AEJ-micro 2019

Tit for Tat emerged as a very successful strategy, albeit not subgame-perfect.
Axelrod, 1984; Nowak and Sigmund, Nature 1992; Dal Bò and Fréchette, AER 2011, JEL 2018, AER 2019

Strategic risk is key determinant of the emergence and sustainability of cooperation with perfect, but *not with imperfect monitoring*.
Blonski et al. AEJ-micro 2011; Dal Bò and Fréchette, AER 2011; Fudenberg et al. AER 2012; Ghidoni and Suetens, AEJ-micro 2020

Behavioral strategies are widespread.
Breitmoser, AER 2015; Romero and Rosokha, ECMA 2023; Fudenberg and Karreskog-Rehbinder, AEJ-micro, 2024; Backhaus and Breitmoser, 2024

The importance of being even

Restitution and Asymmetric punishment strategies

Cooperative strategies based on asymmetric punishment have been widely studied.

Theory:

- renegotiation-proofness in the repeated Prisoner's Dilemma – *Van Damme (1989)*
- repeated games with monetary payments like relational contracts – *Levin (2003)*
- tacit collusion in repeated auctions, similarities with the "chips mechanism" – *Skrzypacz and Hopenhayn (2004)*
- in pricing games, asymm. strategies perform better than strongly symmetric equilibria – *Athey and Bagwell (2001), Harrington and Skrzypacz (2007)*
- in *evolutionary game theory* – *Sugden, 1986; Boyd, 1989; Wu and Axelrod, 1995; Boerljist, Nowak and Sigmund, 1997*

Empirically, some evidence that real-life pricing cartels use asymmetric punishments – *Harrington (2006)*. No experimental evidence.

Evidence from meta-studies

Dataset:	STANDARD	NOISE	FINITE
Repeated interaction:	**Indefinite**	**Indefinite**	**Finite**
Monitoring:	**Perfect**	**Imperfect**	**Perfect**
Source:	Dal Bo & Frechette (2018)	This paper	Embrey et al.(2018)
Number of sessions:	103	27	27
Number of subjects:	1734	598	552
Number of observations:	116,644	60,334	65,720

Rate of cooperation in period 3, after CD in period 2

Outcome in period 1	Standing at start of period 3	STANDARD	NOISE Init.intention C	NOISE Init.intention D	FINITE
DC	even	0.566 (746)	0.859 (99)	0.475 (198)	0.522 (458)
DD	credit	0.282 (440)	0.521 (73)	0.186 (167)	0.242 (132)
CD	credit	0.297 (617)	0.240 (425)	0.179 (28)	0.246 (284)
CC	credit	0.239 (268)	0.632 (353)	0.100 (10)	0.217 (138)
Total		0.383 (2071)	0.472 (950)	0.325 (403)	0.367 (1012)

Rate of cooperation in period 3, after CD in period 2 – regr.

	STANDARD	NOISE		FINITE
Outcome in period 1		initial C	initial D	
DC (even)	0.332***	0.205***	0.369***	0.319***
	(0.036)	(0.045)	(0.117)	(0.054)
DD (credit)	0.048	-0.167***	0.141	0.030
	(0.038)	(0.064)	(0.108)	(0.062)
CD (credit)	0.038	-0.421***	0.064	-0.022
	(0.037)	(0.035)	(0.124)	(0.053)
Intercept	0.339***	0.508***	-0.002	0.131
	(0.088)	(0.080)	(0.148)	(0.128)
N. of observations	2071	950	403	1012
N. of subjects	949	394	244	348
R^2-overall	0.143	0.229	0.151	0.139

Implications

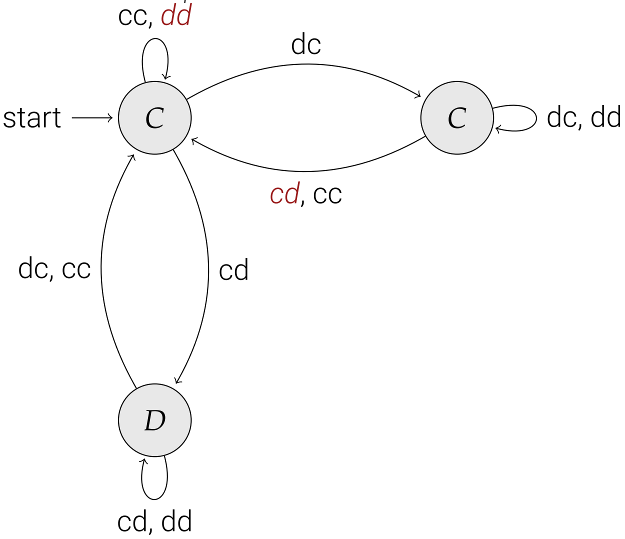
Asymmetric punishment:
The reaction to a unilateral defection by the opponent is much more cooperative when this outcome follows a deviation of opposite sign.

Memory $>$1:
The decision to cooperate in a period does not only depend on the outcome in the period immediately before.

Experience and learning:
With experience, repayment strategies *increase in indefinitely repeated games*, where they can be rational equilibrium behavior, while they disappear in finitely repeated ones where they could only be justified by non-equilibrium behavior (e.g. *fairness concerns*).

The Payback strategy

a.k.a Sophisticated-TfT or Contrite-TfT



Cooperation in a noisy environment

In games with noise, **unintended deviations** happen **on the equilibrium path**.

Symmetric punishments become very costly for the players.

In contrast, asymmetric punishments in Payback can **keep the total payoff high** while still providing **sufficient incentives for cooperation**.

Value of cooperation in noisy environments

2 players wish to coordinate on mutual cooperation: both start playing C in period 1.

With probability E, the action of either of them is changed to D.

- Grim $\rightarrow$ switch to mutual defection until the end of the supergame.
- TfT $\rightarrow$ sequence of asymmetric cd-dc outcomes.
  Revert to (C,C) only when a second random error materializes.

Payback instead reverts to mutual cooperation after a single period of punishment.

Proposition 1

for all $g = l > 0$, $\delta \in (0, 1)$ and $E \in (0, \frac{1}{2})$ such that both Grim and Payback are a PPE, the **expected payoff in the Payback PPE is strictly higher** than the expected payoff in the Grim PPE (V_{Grim}).

Smaller critical discount factor

Value of cooperation not the only ingredient for the success of a cooperative strategy.

Incentive compatibility constraints are also important.

In a game with noise, **forgiveness** is helpful to reduce the cost of false-positive punishments, but can **undermine the incentives to follow the equilibrium strategies**.

Proposition 2

For all $g = l > 0$ and $E \in (0, \frac{1}{2})$, the **critical discount factor** for the Payback strategy to be a public perfect equilibrium is **lower than** the one for **Grim**.

Risk-dominance and SizeBAD

(Blonski and Spagnolo, 2015; Dal Bo and Fréchette, 2018)

	C	D
C	$1, 1$	$-l, 1+g$
D	$1+g, -l$	$0, 0$

$\Rightarrow$

	Grim	AD
Grim	$\frac{1}{1-\delta}, \frac{1}{1-\delta}$	$-l, 1+g$
AD	$1+g, -l$	$0, 0$

SizeBAD: "... SizeBAD is ... the maximum probability of the other player following [grim] such that playing AD is optimal."

Without noise: "Cooperation rates are increasing in how robust cooperation is to strategic uncertainty, especially when cooperation is risk dominant."

Proposition 3

For all $g = l > 0$ and $E \in (0, \frac{1}{2})$ **strategic risk (SizeBAD) is lower** for Payback than for Grim and TFT.

Strategy estimation – w/o and with Payback

Strategies	Standard		Noise		Finite	
Payback	/	0.10***	/	0.09***	/	0.02*
TFT	0.24***	0.16***	0.07***	0.02***	0.08***	0.06***
ALLC	0.02***	0.02***	0.05***	0.05***	0.02***	0.02***
TF2T	0.03***	0.02*	0.11***	0.08***	0	0
TF3T	0.01**	0.01***	0.05***	0.05***	/	/
2TFT	0.03***	0.02**	0.07***	0.07***	0	0
2TF2T	0.03***	0.02***	0.10***	0.10***	/	/
Grim	0.14***	0.14***	0.06***	0.06***	0.05***	0.05***
Grim-last2	0.01**	0.02***	0.06***	0.06***	0.03***	0.03***
Grim-last3	0.02***	0.02***	0.10***	0.09***	/	/
ALLD	0.30***	0.30***	0.28***	0.28***	0.35***	0.35***
D-TFT	0.17***	0.17***	0.05***	0.05***	0.10***	0.10***
Threshold $t-3$	/	/	/	/	0.12***	0.12***
Threshold $t-2$	/	/	/	/	0.13***	0.13***
Threshold $t-1$	/	/	/	/	0.13***	0.13***
Gamma	0.37	0.37	0.48	0.48	0.38	0.38
Number of observations	50218		11696		13144	

Conclusions

Restitution strategies such as Payback can be **subgame-perfect** in indefinitely repeated PD.

They represent a good **empirical alternative to TFT** in classifying subjects' choices...

... and have relevant **theoretical advantages**, in environments with imperfect monitoring or unintentional mistakes.

The inclusion of restitution strategies in empirical and theoretical analyses of repeated social dilemmas can improve our **understanding** of the **determinants of cooperation**.