The ratchet effect in social dilemmas

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September, 2021

Motivation

Minimum contribution levels to overcome free-riding incentives in social dilemma situations

Andreoni (1993), Eckel et al. (2005), Gronberg et al. (2012) ...

Minimum contribution levels do not completely crowd out voluntary public good contributions and increase overall provision levels

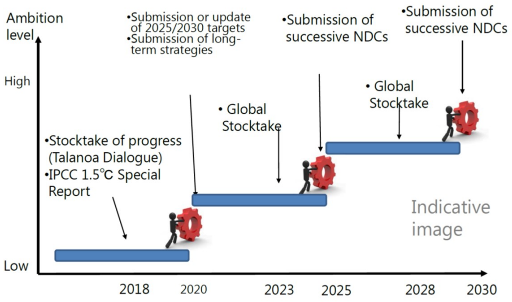
***Static* vs *dynamic* minimum contribution levels**

Static Decisions do not have dynamic implications for future minimum contribution levels

Dynamic Decisions often act as a benchmark for future minimum contribution levels

Motivation

Ratchet-up mechanism under the Paris Agreement (UNFCCC 2015)



Source: Institute for Global Environmental Strategies

"*As nationally determined contributions to the global response to climate change, all Parties are to undertake and communicate efforts [...] the efforts of all Parties will present progression over time* [...]." (Article 3)

Related Literature I: Principal-Agend Problems

Chaudhuri (1998), Charness et al. (2011) ...

Ratchet effect: Agents strategically *masquerade* low-output, relative to their true capacity, because they rationally anticipate that high levels of output will be met with increased requirements

Quotes

Amano & Ohashi (2018)

- Products (Japanese televisions) sold during a future target year must be at least as energy efficient as the most efficient product being sold in the base year
- Firms hold back on quality to be able to continue selling less efficient products for the foreseeable future

Related Literature II: Private Provision of Public Goods

Schelling (1960)
The economics of charitable giving: Small, sequential, and contingent commitments can limit the extent to which agents expose themselves to the risk of being free ridden and establish cooperation

Dorsey (1992), Kurzban et al. (2001) [, Ye et al. (2020)]
Incremental commitments that can be constantly revised in real-time facilitate the private provision of public goods

Research Questions

1. Do agents strategically restrict contributions at the beginning of a public goods game when they face the consequences of dynamic minimum contribution levels?
2. Does this effect depend on whether agents have to contribute as much or even strictly more than what they have contributed right before?
3. Is this effect strong enough to affect overall efficiency?

Exp. Design | Cumulative Public Goods Game

Cumulative voluntary contribution games

Marx & Matthews (2000), Duffy et al. (2007)

Long-term public goods need time to cumulate and provide benefits

- n identical individuals, $i \in \{1, \cdots, n\}$
- in each period $t \in \{1, \cdots, T\}$
  - i receives an endowment of w
  - i decides about contribution to public good $g_{i,t}$
  - $G_t = \sum_{j=1}^{n} g_{j,t}$ denotes the sum of contributions in t
  - i receives the payoff $\pi_{i,t}(w - g_{i,t}, G_t)$

"**Payday is at the end**." At the end of period T, i consumes the cumulated benefits of what is left of her initial endowment and contributed to the public good: $\Pi_i = \sum_{t=1}^{T} \pi_{i,t}(\cdot)$ Details

Nash equilibrium vs. social optimum

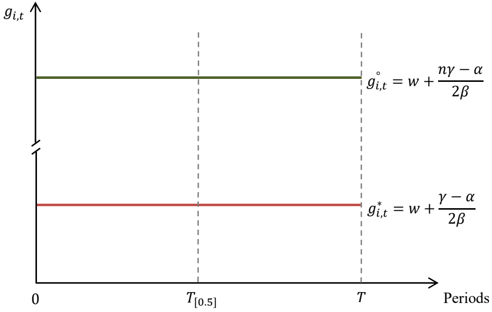
$$\Pi_i = \sum_{t=1}^{T} \pi_i(w - g_{i,t}, G_t)$$

Social optimum

$$G_i^\circ = \sum_{t=1}^{T} g_{i,t}^\circ = T\left(w + \frac{n\gamma - \alpha}{2\beta}\right)$$

Nash equilibrium

$$G_i^* = \sum_{t=1}^{T} g_{i,t}^* = T\left(w + \frac{\gamma - \alpha}{2\beta}\right)$$



Exp. Design | Treatments

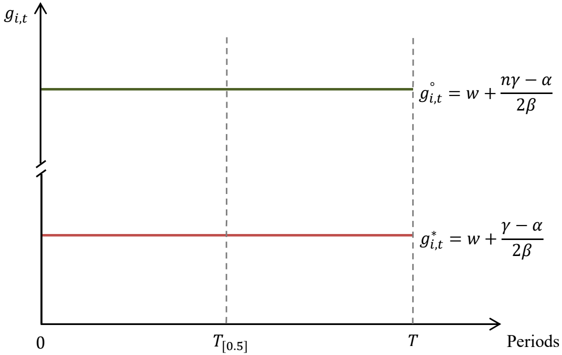
- **Baseline** (*base*): $0 \leq g_{i,t} \leq w$
- **Weak ratcheting** (*weakR*): Each contribution at least as high than the previous

$$g_{i,t-1} \leq g_{i,t} \leq w$$
$$\text{with}$$
$$0 \leq g_{i,1} \leq w$$

- **Strong ratcheting** (*strongR*): Each contribution higher than the previous

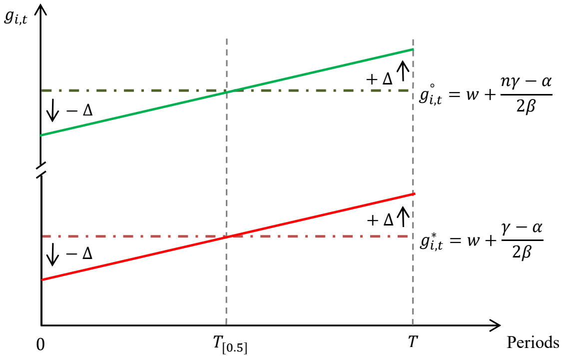
$$g_{i,t-1} < g_{i,t} \leq w$$
$$\text{with}$$
$$0 \leq g_{i,1} \leq w \text{ and } g_{i,t} = w, \text{ if } g_{i,t-1} = w$$

Hypotheses | *base & weakR*



Cumulated contribution level $G_i^* = \sum_{t=1}^{T} g_{i,t}^*$ is equally divided over all T periods

Hypotheses | *strongR*



Cumulated contribution level $G_i^* = \sum_{t=1}^{T} g_{i,t}^*$ is differently divided over all T periods:

- Less than $g_{i,t}^*$ at the beginning $(-\Delta)$
- $g_{i,t}^*$ at the median of T
- more than $g_{i,t}^*$ at the end $(+\Delta)$

Hypotheses | Summary

Hypothesis 1: In *base* and *weakR*, contribution levels per period are equal to the Nash equilibrium in any period t:

$$g_{i,t}^{base^*} = g_{i,t}^{weakR^*} = g_{i,t}^*$$

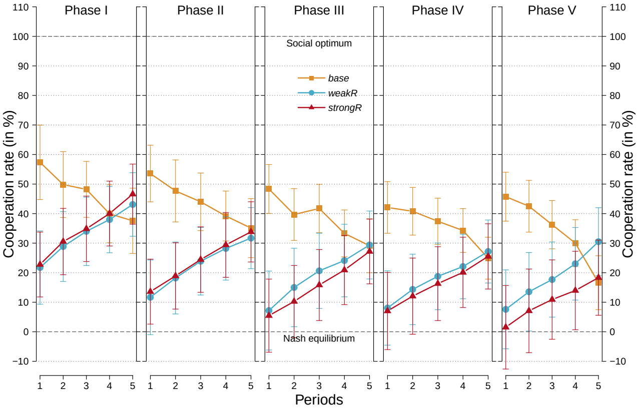
Hypothesis 2: In *strongR*, contribution levels per period are below the Nash equilibrium at the beginning and exceed those at the end:

$$\begin{array}{llll} (a) & g_{i,t}^{strongR^*} < g_{i,t}^* & if & t < T_{[0.5]} \\ (b) & g_{i,t}^{strongR^*} = g_{i,t}^* & if & t = T_{[0.5]} \\ (c) & g_{i,t}^{strongR^*} > g_{i,t}^* & if & t > T_{[0.5]} \end{array}$$

Hypothesis 3: Cumulated contribution levels are equal to the Nash equilibrium in all treatments:

$$G_i^{base^*} = G_i^{weakR^*} = G_i^{strongR^*} = G_i^*$$

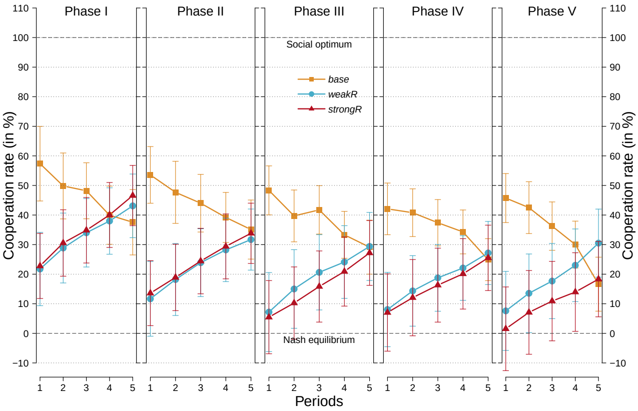
Results | How to



Cooperation rate, $c_{i,t} = (\frac{g_{i,t} - g^*_{i,t}}{\overset{\circ}{g}_{i,t} - g^*_{i,t}}) * 100\%$, as primary outcome variable:

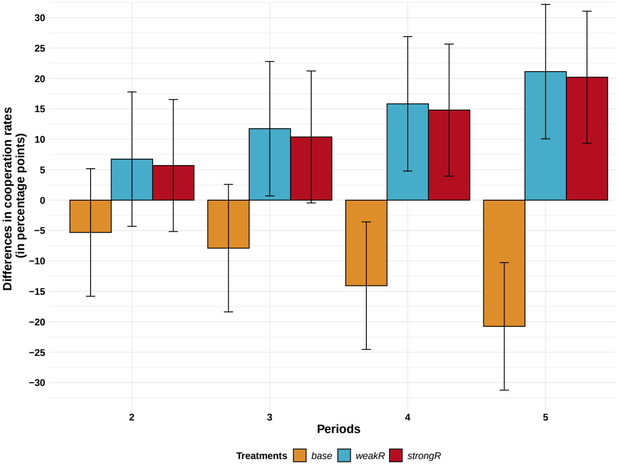
- Nash equilibrium: $g^*_{i,t} \rightarrow c_{i,t} = 0\%$
- Social optimum: $\overset{\circ}{g}_{i,t} \rightarrow c_{i,t} = 100\%$

Results | Ratchet Effect



Obs. 1: At the beginning of each phase, cooperation rates in *weakR* (p-value < 0.001) and *strongR* (p-value < 0.001) are significantly lower than those in *base*

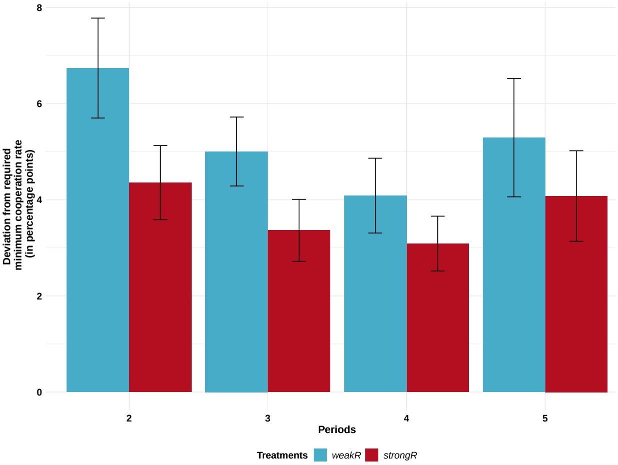
Results | Trends



Obs. 2: In *base*, cooperation rates decrease over time. Cooperation rates in *weakR* and *strongR* increase over time

Regs

Results | Excess Cooperation Rates



Obs. 3: In *weakR* and *strongR*, cooperation rates increase by more than they have to

Regs

Results | Efficiency

	Overall	First period	Last Period
Panel A. baseline (*base*)			
Cooperation rate (in %)	39.81	49.42	28.66
	(2.094)	(4.302)	(4.518)
Panel B. weak ratcheting (*weakR*)			
Cooperation rate (in %)	22.34	11.25	32.27
	(1.602)	(3.039)	(3.691)
Panel C. strong ratcheting (*strongR*)			
Cooperation rate (in %)	20.30	10.08	30.29
	(1.656)	(3.365)	(3.700)

Obs. 4: Overall cooperation rates in *weakR* (p-value = 0.0016) and *strongR* (p-value = 0.0004) are significantly below the cooperation rate in *base*

What Drives the Ratchet Effect?

Fear of the risk of being free ridden

Yamagishi & Sata (1986), De Cremer (1999), Cubitt et al. (2017)

Subjects are reluctant to take social risks where outcomes depend on other persons who can exploit the risk-taker

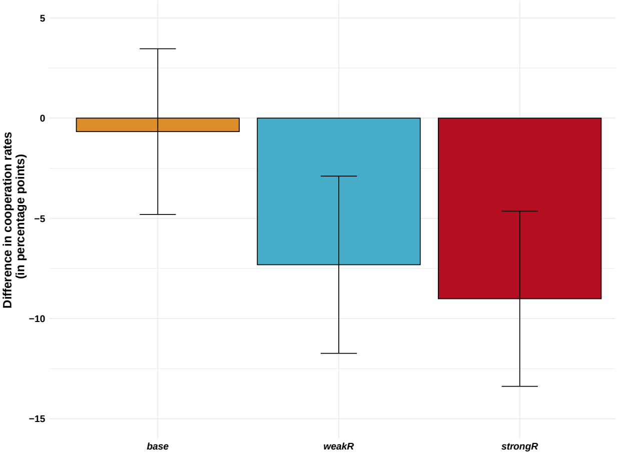
- **Monetary component** (e.g., Dawes et al. 1986): Subjects fear that they will receive no payoff from their contributions
- **Non-monetary component** (e.g., Bohnet et al. 2008): Subjects fear disutility from betrayal or non-reciprocated trust

What Drives the Ratchet Effect?

Fear of the risk of being free ridden & ratcheting
Contributions are bounded from below and non-cooperative behavior cannot directly be negatively reciprocated

- At the beginning of each phase ($t = 1$):
  The risk of being exploited is higher in *weakR* and *strongR* than in *base*, because the extent to which participants can be exploited is larger
- Once the first period is completed ($t > 1$):
  The extent to which participants can be exploited decreases over the course of a phase with ratcheting, because the number of remaining periods and the magnitude of exploitation decline

Exploitation Effect



Obs. 5: In *weakR* (p-value $= 0.0012$) and *strongR* (p-value < 0.001), exploited participants contribute significantly less in the subsequent phase than non-exploited participants

Regs Over time

Summary & Concluding Remarks

Ratchet effect

- Participants reduce contributions at the beginning of the game
- Positive trends in contributions are not sufficient to compensate losses at the beginning
- Ratcheting decreases overall contribution levels

Fear of the risk of being free ridden & ratcheting

- ***A priori*** ($t = 1$)
  Extent to which participants can be exploited is increased
- ***A posteriori*** ($t > 1$)
  The extent to which participants can be exploited decreases

What's next?

Thank You!

Quotes from Mathewson (1931)

[. . .] *the piece workers pushed their earnings up to $12 a day. Said an employee in this department, "The rate was immediately cut. [...] . It would be possible for us to do much more but we are careful not to."* [. . .]

[. . .] that the more your superiors find they can get out of you the more they come to expect. The only way to protect yourself is never to work at anything like full capacity. [. . .]

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At the end of period T

$$\Pi_i = \sum_{t=1}^{T} \pi_{i,t}(\cdot) = \sum_{t=1}^{T} \psi(w - g_{i,t}) + \sum_{t=1}^{T} \phi(G_t) - \sum_{t=1}^{T} \tau$$

$$= \alpha \sum_{t=1}^{T} (w - g_{i,t}) - \beta \sum_{t=1}^{T} (w - g_{i,t})^2$$

$$+\gamma \sum_{t=1}^{T} G_t - \sum_{t=1}^{T} \tau$$

with

$$0 \leq g_{i,t} \leq w$$

and

$$\alpha,\ \beta,\ \gamma,\ \tau > 0$$

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Appendix | Procedure

MaXLab
Magdeburger Experimentallabor
für Wirtschaftsforschung

Laboratory & software

- MaXLab at the University of Magdeburg
  - May 2019: 3 pilot sessions
  - June 2019: 17 sessions
- z-Tree for programming & hroot for recruiting

Procedures

- Registration / certification via GfeW
- All in all, 340 participants (85 obs.)
- “Five phases à five periods”-design (partner matching)
- A session lasted around one hour
- Exchange rate 125 LD = 1 EUR
- Average payoff of 10 EUR

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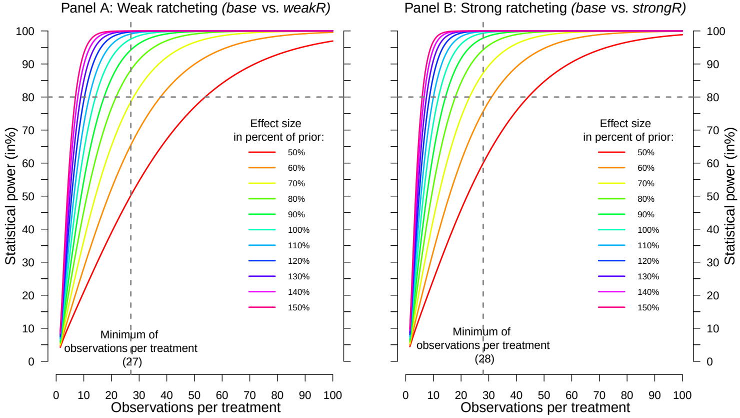
Appendix | Power Calculation



We are able to detect an effect size similar to our prior (pilot sessions) at the 5%-level with a statistical power of more than 95% in *weakR* and *strongR*

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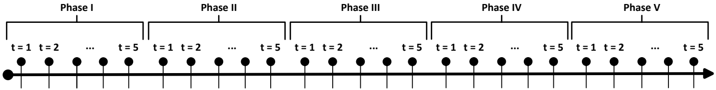
Parametrization

Needs to fulfill the following four properties:

(a) Contributions in Nash and the social optimum easy to calculate, i.e., integers
(b) Substantial differences between contributions in Nash and the social optimum
(c) Substantial gain in payoff between Nash and the social optimum
(d) Substantial loss in efficiency between Nash and the social optimum

Parametrization:

- $n = 4$, $T = 5$, $w = 100$, $\alpha = 4.4$, $\beta = 0.002$, $\gamma = 1$, and $Tax = 100$
- Five phases à five rounds in fixed groups



Appendix | Parametrization

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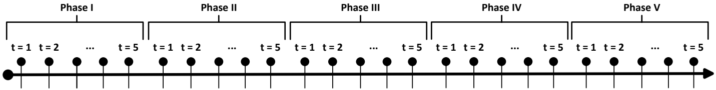

Prediction	Value
g_t^*	15
g_t°	90
$g_{t=1}^{strongR^*}$	13
$g_{t=5}^{strongR^*}$	17
$g_{t=1}^{strongR^\circ}$	88
$g_{t=5}^{strongR^\circ}$	92

Prediction	Value
$\sum \pi_t^*$	947.5
$\sum \pi_t^\circ$	1510
$\sum \pi_t^* / \sum \pi_t^\circ$	1.6
$\sum \pi_t^{strongR^*}$	947
$\sum \pi_t^{strongR^\circ}$	1510
$\sum \pi_t^{strongR^*} / \sum \pi_t^{strongR^\circ}$	1.6

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Appendix | Ratchet Effect & Trends

	Dependent variable: Cooperation rate		
	(1)	(2)	(3)
weakR	-17.474***	-17.474***	-38.169***
	(5.386)	(2.633)	(5.175)
strongR	-19.513***	-19.513***	-39.337***
	(5.492)	(2.669)	(5.368)
period 2		2.140	-5.316
		(3.179)	(6.032)
period 3		4.366	-7.896
		(3.244)	(6.331)
period 4		4.940	-14.067**
		(3.298)	(6.313)
period 5		6.042*	-20.753***
		(3.440)	(6.134)
weakR x *period 2*			12.056
			(7.420)
strongR x *period 2*			11.006
			(7.637)
weakR x *period 3*			19.641**
			(7.714)
strongR x *period 3*			18.284**
			(7.921)
weakR x *period 4*			29.899***
			(7.763)
strongR x *period 4*			28.869***
			(7.947)
weakR x *period 5*			41.879***
			(7.723)
strongR x *period 5*			40.960***
			(7.858)
Constant	39.809***	36.312***	49.416***
	(4.316)	(2.744)	(4.230)
Observations	85	425	425
R^2	0.167	0.154	0.239
Adjusted R^2	0.147	0.141	0.213

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Appendix | Excess Cooperation Rates

Dependent variable: Deviation from required minimum cooperation rate			
	(1)	(2)	(3)
strongR	-1.559***	-1.559***	-2.384***
	(0.312)	(0.311)	(0.660)
period 3		-1.358***	-1.736***
		(0.410)	(0.644)
period 4		-1.949***	-2.654***
		(0.410)	(0.663)
period 5		-0.852*	-1.447*
		(0.513)	(0.822)
strongR x *period 3*			0.743
			(0.824)
strongR x *period 4*			1.385*
			(0.824)
strongR x *period 5*			1.168
			(1.031)
Constant	5.281***	6.321***	6.741***
	(0.247)	(0.385)	(0.530)
Observations	4,400	4,400	4,400
R^2	0.006	0.010	0.011
Adjusted R^2	0.005	0.010	0.010

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Appendix | Exploitation Effect

	Dependent variable: Cumulated cooperation rates per phase		
	(1)	(2)	(3)
exploitation	-6.365***	-5.405***	-0.673
	(1.268)	(1.254)	(2.096)
weakR		-6.471***	-3.188*
		(1.640)	(1.819)
strongR		-9.086***	-5.006***
		(1.578)	(1.793)
exploitation x *weakR*			-6.642**
			(3.000)
exploitation x *strongR*			-8.339***
			(2.860)
sum con Phase prev	0.721***	0.683***	0.686***
	(0.026)	(0.028)	(0.028)
Constant	6.941***	12.660***	10.163***
	(0.771)	(1.388)	(1.431)
Observations	1,360	1,360	1,360
R^2	0.490	0.504	0.507
Adjusted R^2	0.489	0.503	0.505

Appendix | Exploitation Effect over Time

Overall	Per phase			
	Phase II	**Phase III**	**Phase IV**	**Phase V**
Panel A. baseline (*base*)				
-0.67	-2.85	-0.98	-0.20	-0.46
(2.096)	(4.444)	(4.148)	(4.147)	(3.934)
Panel B. weak ratcheting (*weakR*)				
-7.32***	-15.90***	-9.28*	-6.65	0.38
(2.267)	(4.635)	(4.822)	(4.171)	(4.173)
Panel C. strong ratcheting (*strongR*)				
-9.01***	-14.00***	-12.03***	-4.80	-6.50*
(2.045)	(4.578)	(3.591)	(4.176)	(3.855)

Obs. 6: Exploitation effect tends to fade out over the course of the game

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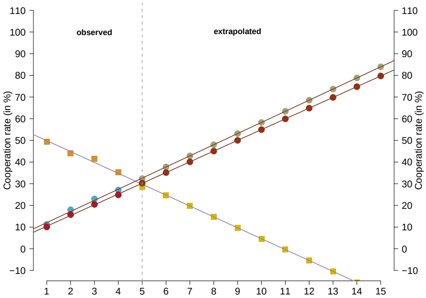
What's Next? Ratcheting in the Long-run

If we can extrapolate trends in contributions per treatment, ratcheting could have a positive effect on cumulated public good provision levels in the long-run



Alternatively: Do participants restrict contributions at the beginning of the game even more?

What's Next? Ratcheting in the Long-run

Does ratcheting increases efficiency if the number of contribution decisions is sufficiently large? (aka Dorsey 1992 & Kurzban et al. 2001 *vs.* us)

		Experiment is conducted in	
		discrete time	**continuous time**
Contribution decisions are	**limited**	**A.** *Standard public goods game*	**B.** *Continuous public goods game with limited decisions* (à la Opera 2014)
	unlimited	**C.** *Infinitely repeated public goods game* (à la Lugovsky et al. 2017)	**D.** *Continuous public goods game* (à la Dorsey 1992)

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What's Next? How to Counteract the Ratchet Effect?