Collective minimum contributions to address the ratchet effect in the private provision of public goods

Carlo Gallier[a,b]

joint work with Marius Alt[b], Martin Kesternich[b,c], and Bodo Sturm[b,d]

[a] Free University of Bozen-Bolzano
[b] ZEW – Leibniz Centre for European Economic Research
[c] Kassel University
[d] Leipzig University of Applied Sciences

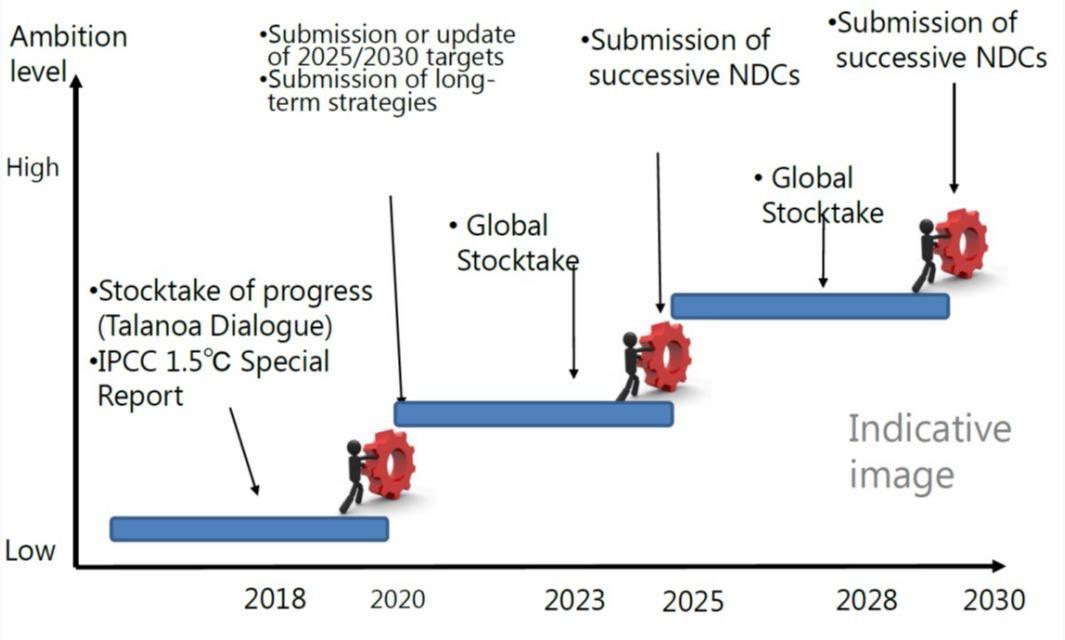
Paris agreement
UNFCCC (2015, Article 3)

- Global action plan to limit global warming to well below 2°C

- **Nationally determined contributions**
  - **Pros**: Eased entry-into force of the agreement
  - **Cons**: **Commitments fell short of achieving the 2°C goal!**

- **Ratchet-up mechanism**
  - Gradually increase parties' commitments over time
  - Ensure that the 2°C goal will be achieved

What does the ratchet-up mechanism do?



Source: IGES

'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 [...]'

Why does the ratchet-up mechanism need an amendment?

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

› **Ratchet effect**: Agents strategically restrict their true capacity, because they anticipate that higher levels of output will be met with increased requirements more lit ...

UNEP (2021) ...

› Commitments are still too low to reach the 2°C goal. Majority of updated NDCs do not meet the ratcheting condition stock take

Gallier & Sturm (2021, JEBO)

› Ratchet-up mechanism increases the risk of being free-ridden and decreases public good provision details ...

How to counteract the ratchet effect?

Collective minimum contributions
Following the principle of the *lowest common denominator*
Orzen (2008, DP), Dannenberg et al. (2014, Economica) ...

- **How do collective minimum contributions work?**
  - Agents propose a collective minimum contribution
  - Required to contribute at least the lowest common denominator of all proposals
- **Why should they counteract the ratchet effect?**
  - Reduce the risk of being free-ridden
  - Parties retain *sovereign* by possessing veto power

- Do **collective minimum contributions** counteract the ratchet effect?
- Does the effect depend on whether collective minimum contributions are **binding** or **non-binding**?

Exp. design: Cumulative public goods game

Duffy et al. (2007, JPubE) ...

Public good needs time to accumulate 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 upon contribution to public good $g_{i,t}$
  - $G_t = \sum_{j=1}^{n} g_{j,t}$ is the sum of public good contributions in t
  - individual payoff of $\pi_{i,t}(w - g_{i,t}, G_t)$

'Payday is at the end!' At the end of T, i consumes the cumulated benefits of what is left in her private account and what has been contributed to the public good:

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

more formally ...

Exp. design: Cumulative public goods game

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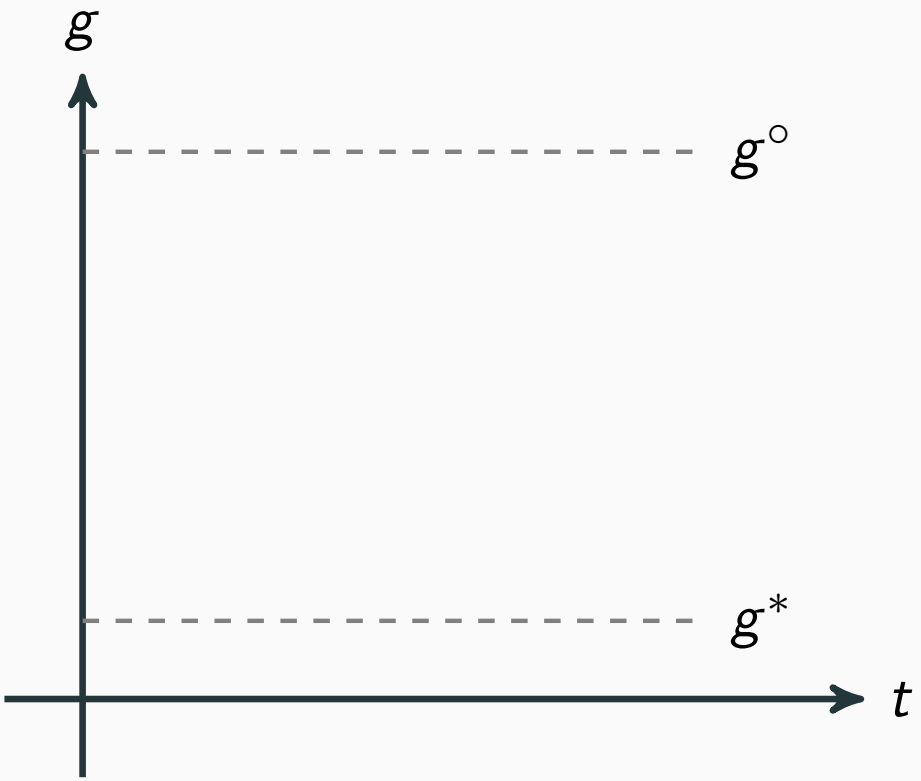
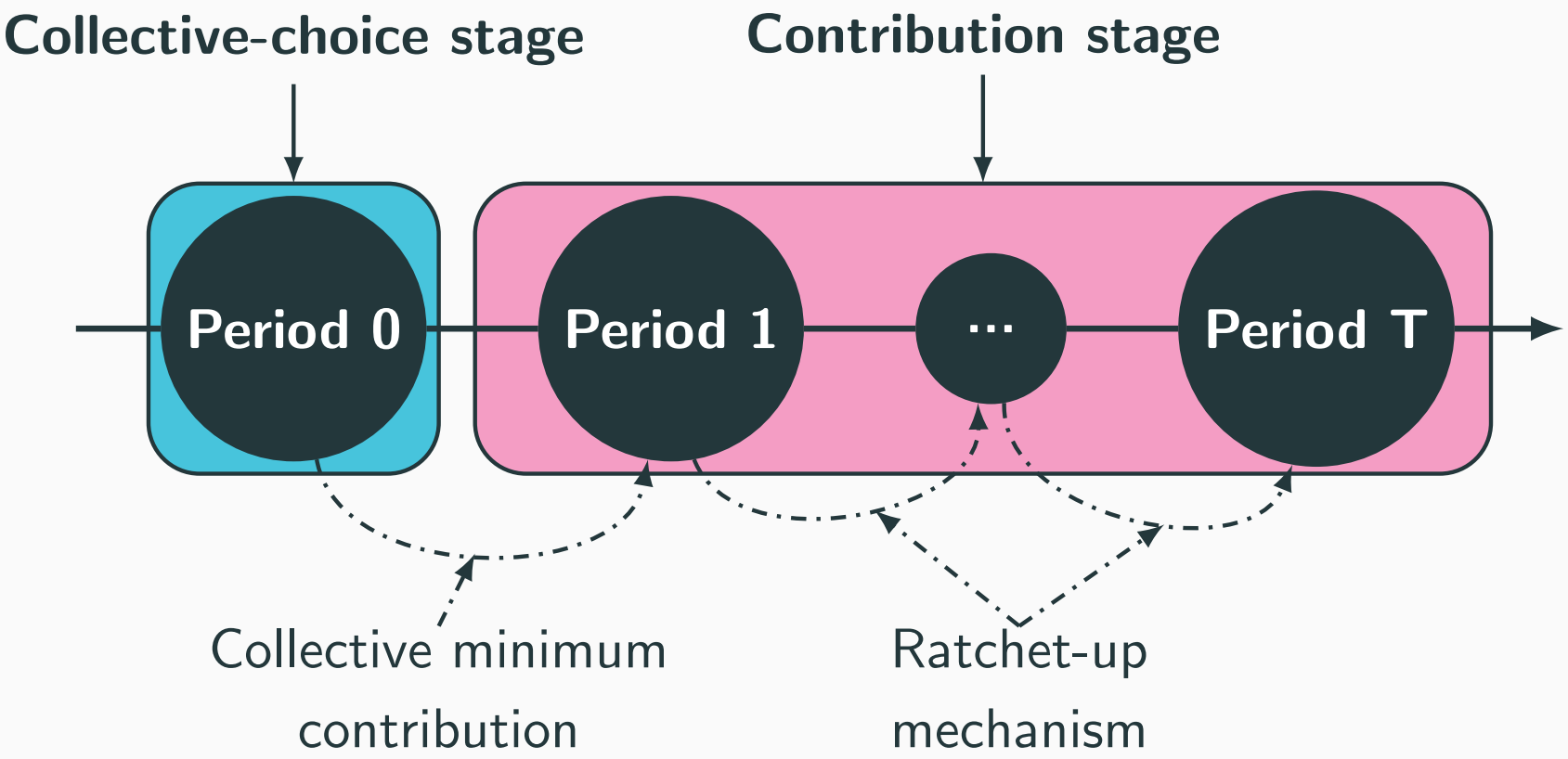


more formally ...

Exp. design: Structure



Exp. design: Collective-choice stage

In **Period 0**, all players propose a public good contribution level. The *lowest common denominator* of all proposals sets the collective minimum contribution

- Individual proposals: $\tilde{g}_i \in \{0, w\}$
- Set of proposals: $\tilde{\mathbf{g}} = \{\tilde{g}_1, \ldots, \tilde{g}_n\}$
- Collective minimum contribution: $g_{min} = min\{\tilde{\mathbf{g}}\}$

▶ **Non-binding collective minimum contribution**

- In Period 1, players can freely decide upon their contributions to the public good, i.e.,

$$0 \leq g_{i,1} \leq w$$

▶ **Binding collective minimum contribution**

- In Period 1, players have to contribute at least the collective minimum contribution, i.e.,

$$g_{min} \leq g_{i,1} \leq w$$

Exp. design: Contribution stage

From **Period 1** onward, players have to decide about their individual contributions to the public good

- **Voluntary contribution mechanism**
  - Players can freely decide upon their contributions:

$$0 \leq g_{i,t} \leq w \ \forall t \geq 1$$

- **Ratchet-up mechanism**
  - Each contribution at least as high as the previous:

$$0 \leq g_{i,1} \leq w \text{ and } g_{i,t-1} \leq g_{i,t} \leq w \ \forall t > 1$$

Exp. design: Treatments

Voluntary contribution mechanism (BASE)

- ✖ No collective minimum contribution
- ✖ No ratchet-up mechanism
- ➔ Players can freely decide upon their contributions:

$$0 \leq g_{i,t} \leq w \ \forall t \geq 1$$

Exp. design: Treatments

Voluntary contribution mechanism (BASE)

- ✖ No collective minimum contribution
- ✖ No ratchet-up mechanism
- ➔ Players can freely decide upon their contributions:

$$0 \leq g_{i,t} \leq w \ \forall t \geq 1$$

Ratcheting (RAT)

- ✖ No collective minimum contribution
- ✚ Ratchet-up mechanism
- ➔ Each contribution at least as high as the previous:

$$0 \leq g_{i,1} \leq w \text{ and } g_{i,t-1} \leq g_{i,t} \leq w \ \forall t > 1$$

Exp. design: Treatments

Non-binding minimum ratcheting (NBminRAT)

- ✚ Non-binding collective minimum contribution
- ✚ Ratchet-up mechanism
- ➔ Non-binding collective minimum & each contribution at least as high as the previous:

$$0 \leq g_{i,1} \leq w \text{ and } g_{i,t-1} \leq g_{i,t} \leq w \ \forall t > 1$$

Exp. design: Treatments

Non-binding minimum ratcheting (NBminRAT)

- ✚ Non-binding collective minimum contribution
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$$0 \leq g_{i,1} \leq w \text{ and } g_{i,t-1} \leq g_{i,t} \leq w \ \forall t > 1$$

Binding minimum ratcheting (BminRAT)

- ✚ Binding collective minimum contribution
- ✚ Ratchet-up mechanism
- ➔ Binding collective minimum & each contribution at least as high as the previous:

$$g_{min} \leq g_{i,1} \leq w \text{ and } g_{i,t-1} \leq g_{i,t} \leq w \ \forall t > 1$$

Hypotheses

Purely self-interested & rational players

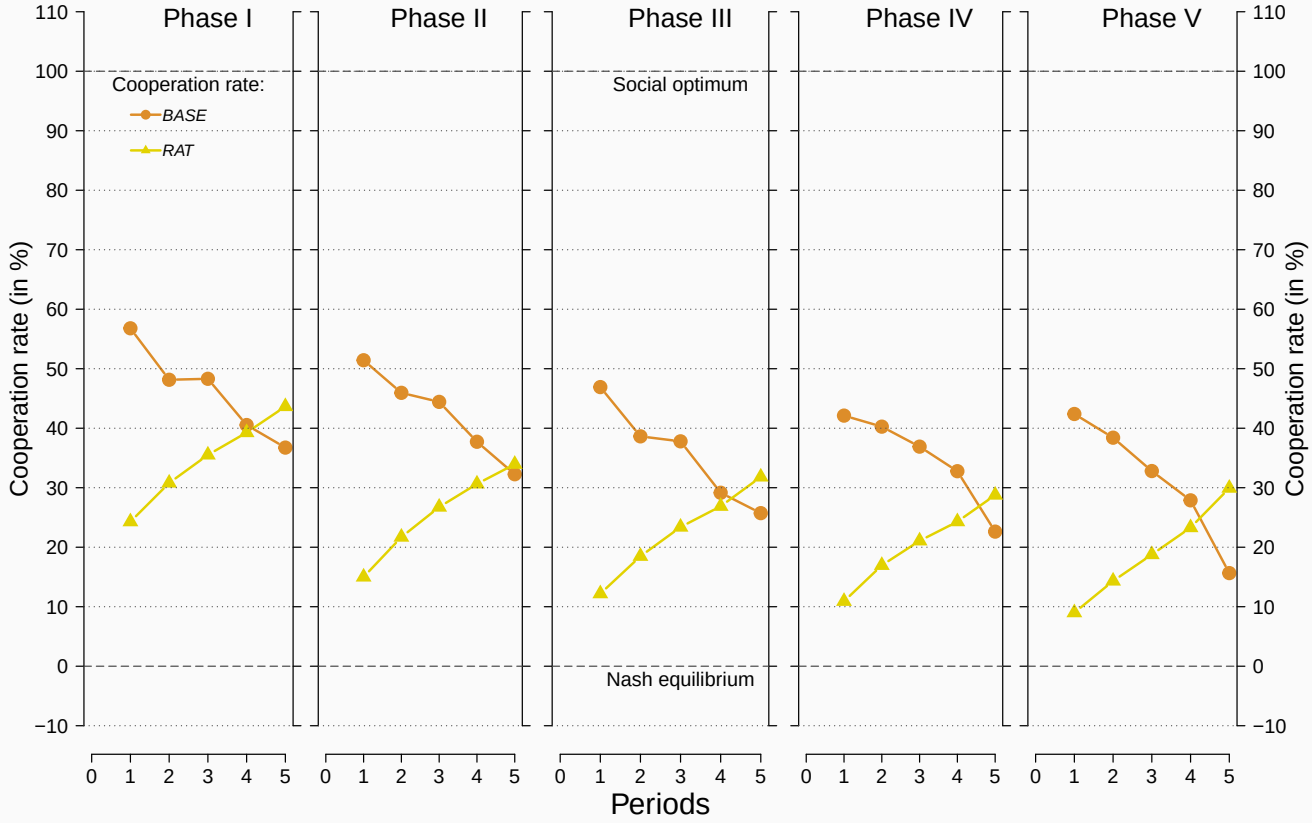
Hypothesis 1. Players in **BminRat** will contribute **more** to the public good than those in **RAT**

$$g_{i,t}^{BminRAT^*} > g_{i,t}^{RAT^*}$$

Hypothesis 2. Players in **NBminRAT** will contribute **as much** to the public good as those in **RAT**

$$g_{i,t}^{NBminRAT^*} = g_{i,t}^{RAT^*}$$

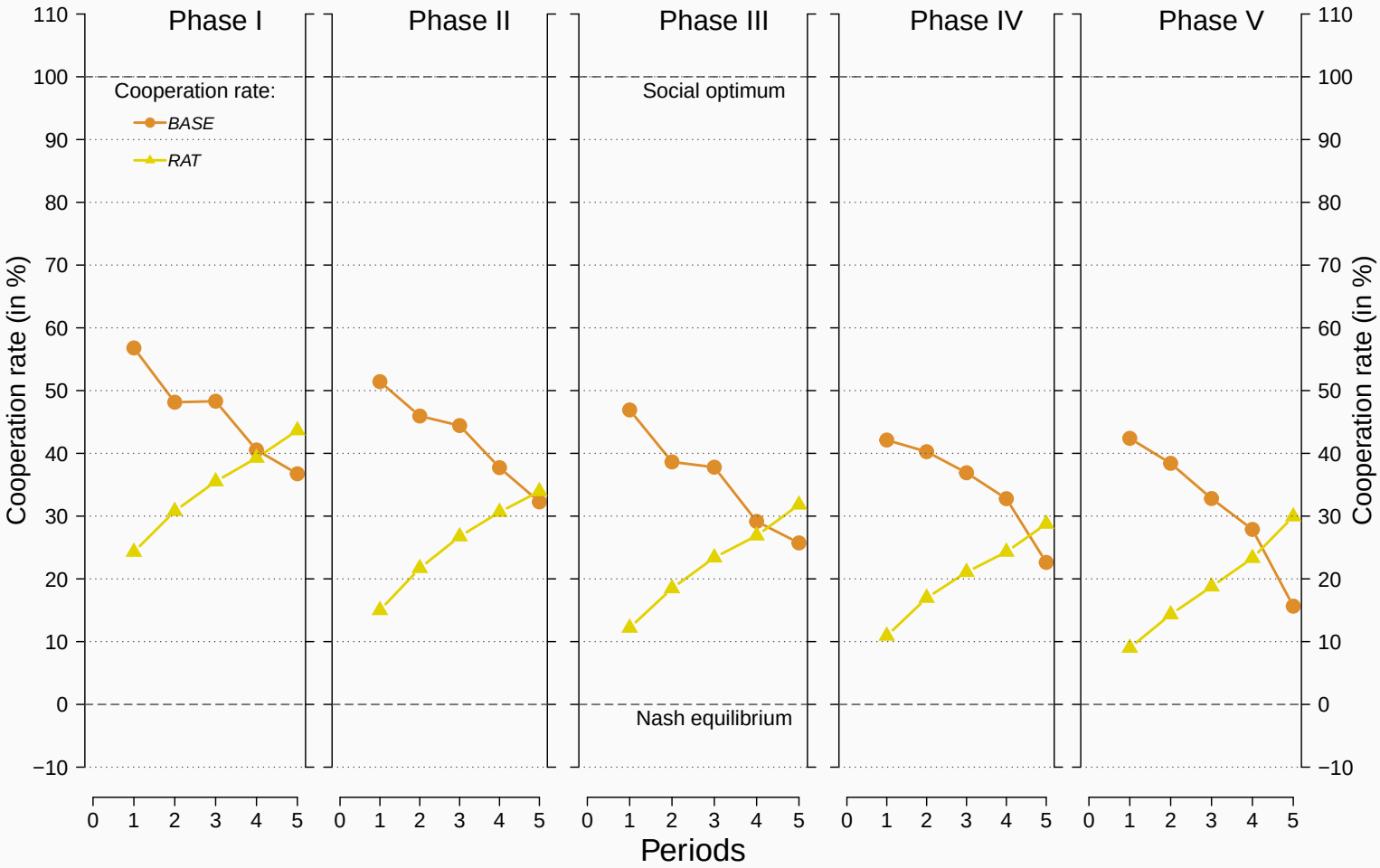
Results | How to ...



Outcome: **Cooperation rate** $c_{i,t} = \left(\frac{g_{i,t} - g^*_{i,t}}{g^\circ_{i,t} - g^*_{i,t}}\right) * 100\%$

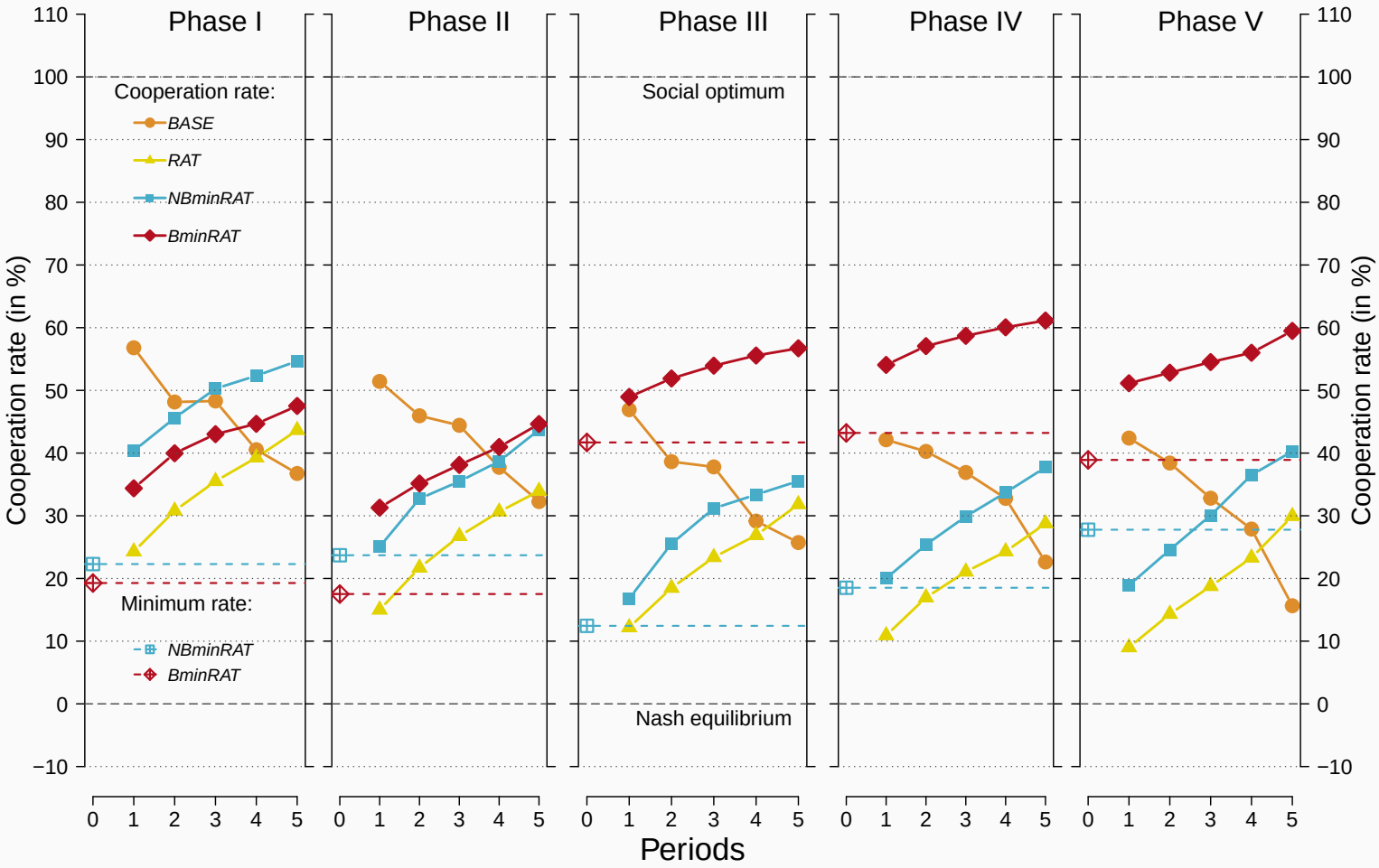
- ➜ Nash equilibrium $g^*_{i,t} \Rightarrow c_{i,t} = 0\%$
- ➜ Social optimum $g^\circ_{i,t} \Rightarrow c_{i,t} = 100\%$

Results | Ratchet effect ... plausibility check ...

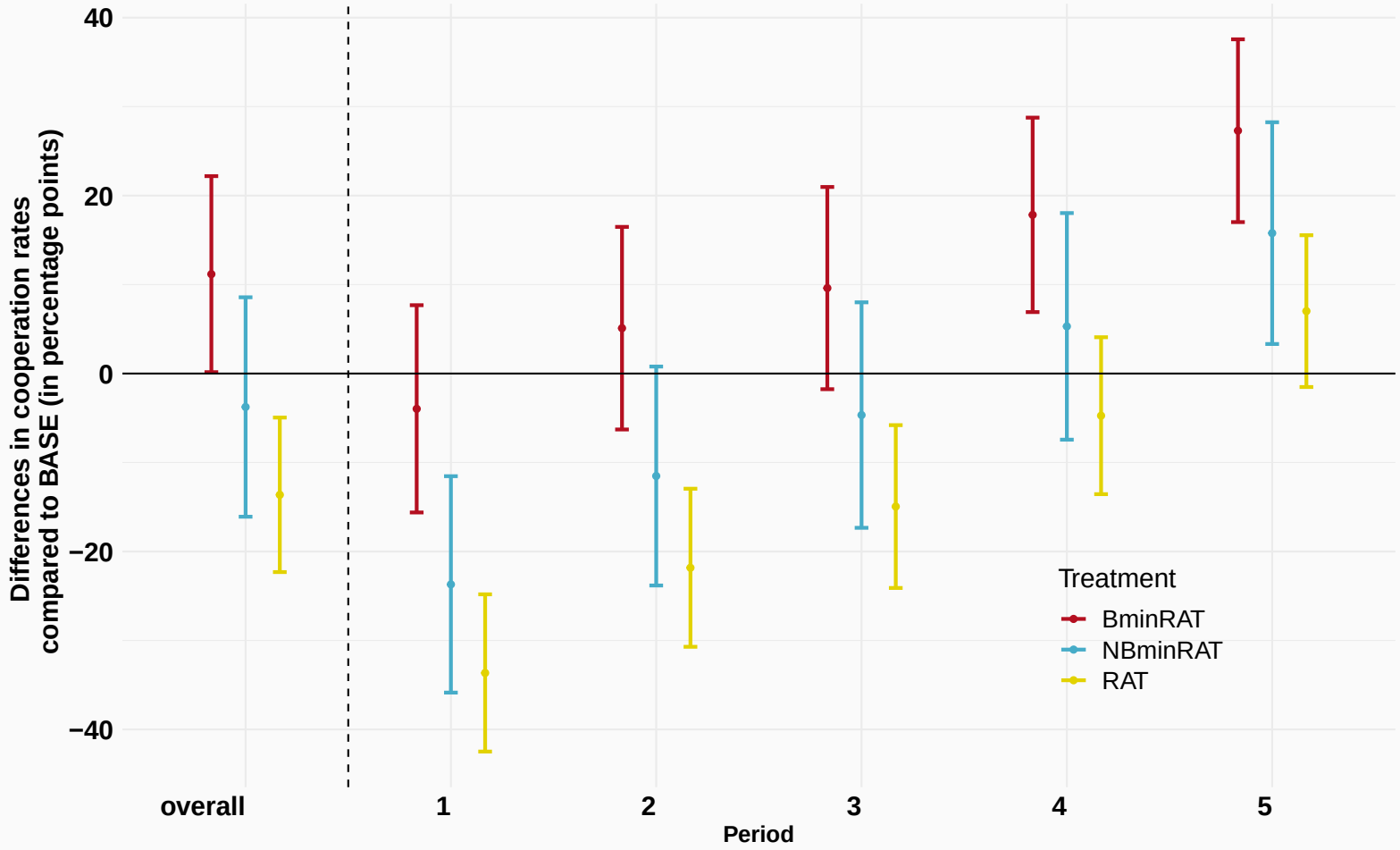


- **Obs. 0**. Ratcheting is (still) detrimental. Overall, cooperation rates in **RAT** are **lower** than those in **BASE** ($p = 0.0105$)

Results | Overview

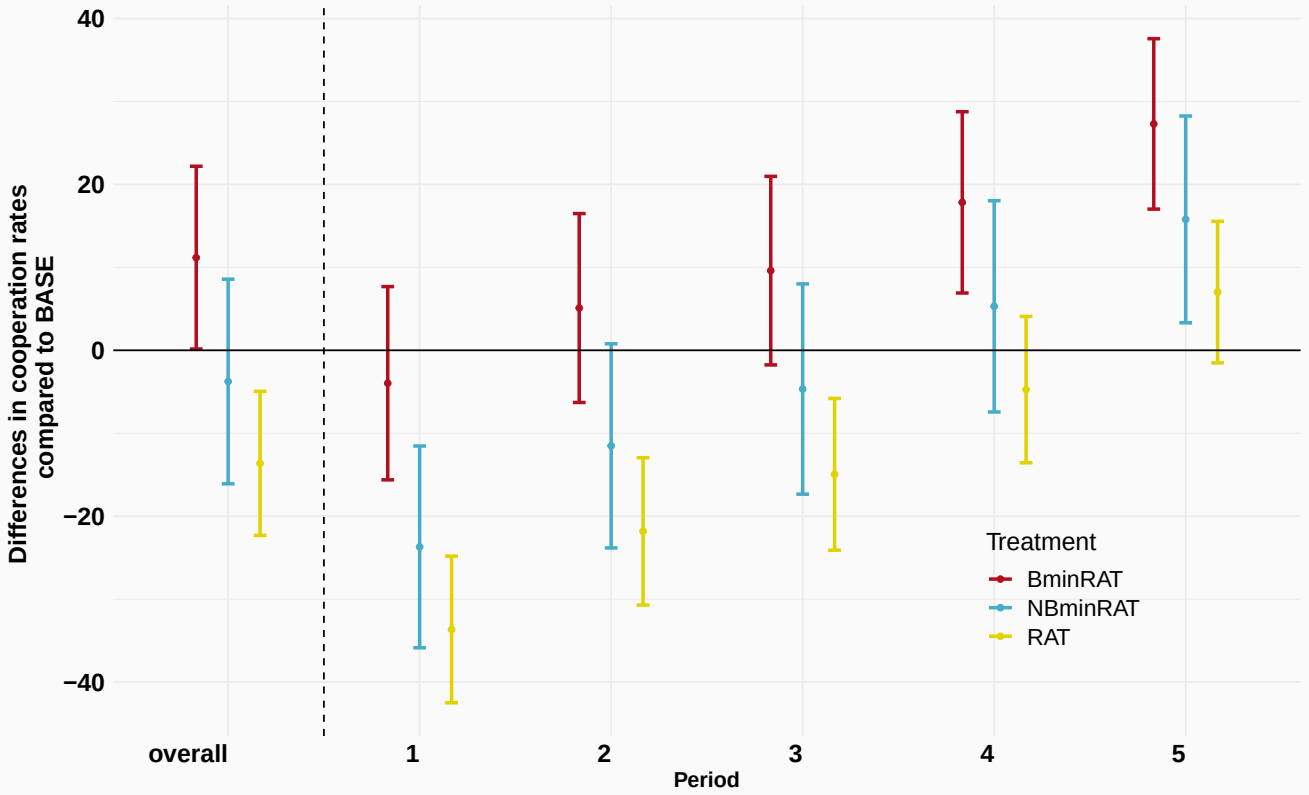


Results | Cooperation rates



Obs. 1. Overall, cooperation rates in **BminRAT** are **higher** than those in **RAT** ($p = 0.0002$)

Results | Cooperation rates

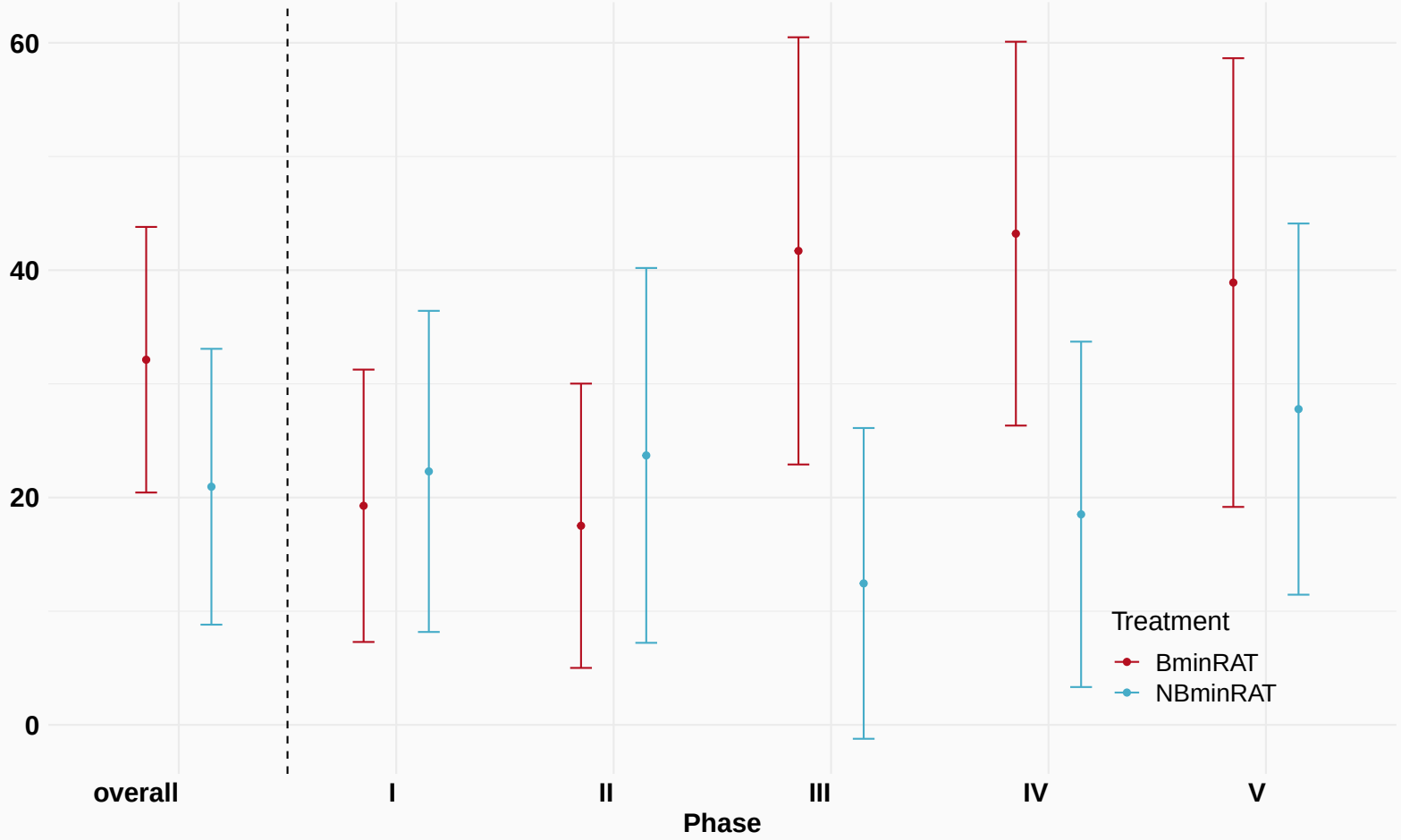


- **Obs. 2**. Cooperation rates in **NBminRAT** are not different from those in **RAT**
- **Obs. 3**. Overall, cooperation rates in **BminRAT** are **higher** than those in **NBminRAT** ($p = 0.0239$)

Why does BminRAT work and NBminRAT not?

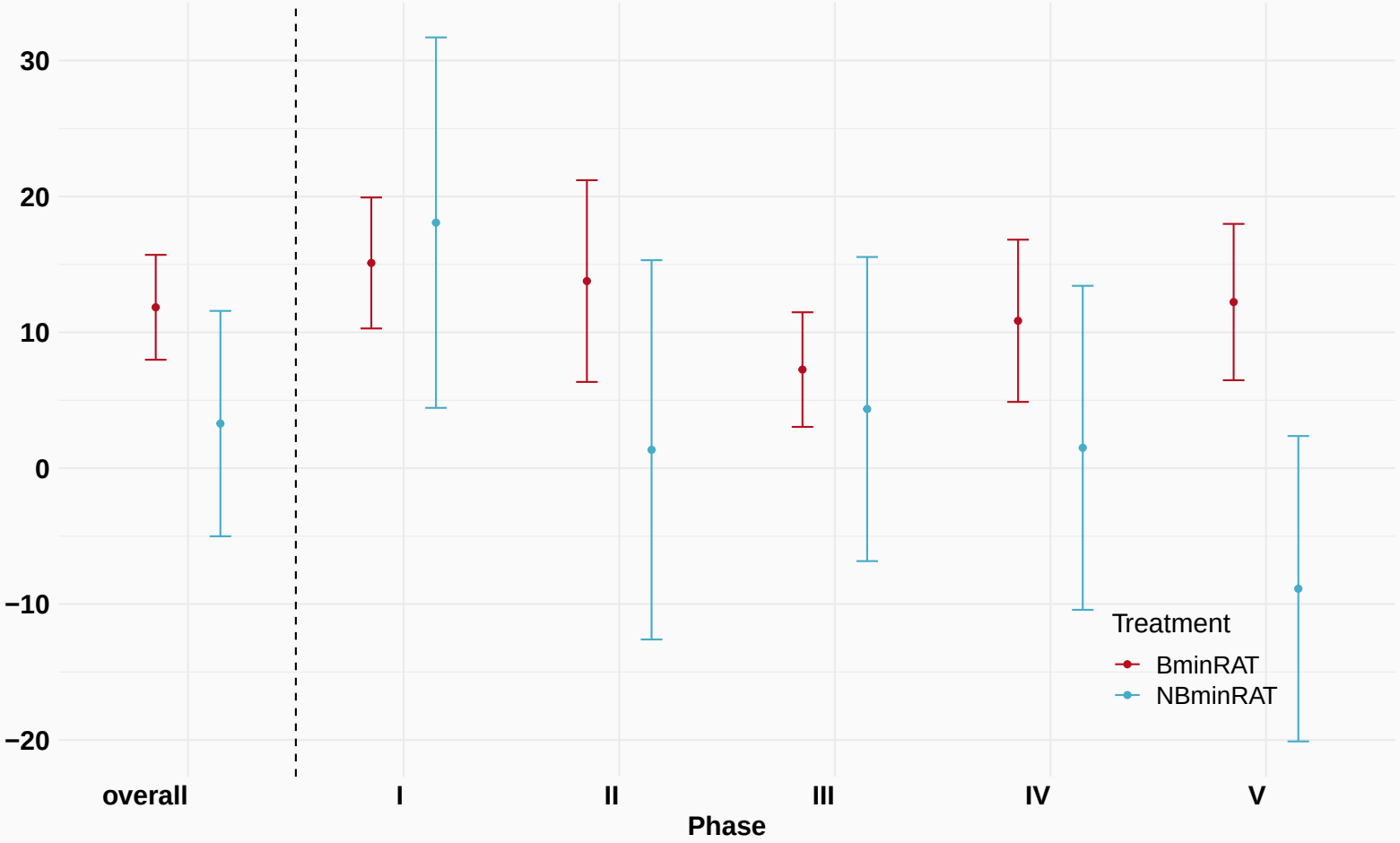
Cooperation rate	Minimum cooperation rate	Excess cooperation rate
Panel A. NBminRAT		
24.23***	20.95***	3.28
(6.115)	(6.778)	(4.634)
Panel B. BminRAT		
43.96***	32.12***	11.84***
(5.736)	(6.633)	(2.192)
Panel C. Difference between *BminRAT* and *NBminRAT*		
19.73**	11.17	8.56
(8.384)	(9.484)	(5.126)

Results | Minimum cooperation rates



Obs. 4. Minimum cooperation rates in **BminRAT** are **higher** than those in **NBminRAT** in Phase III ($p = 0.0269$) and IV ($p = 0.0553$)

Results | Excess cooperation rates



Obs. 5. Excess cooperation rates in **BminRAT** are **higher** than those in **NBminRAT** in Phase V ($p = 0.0050$)

Results | Non-compliance with minimum contributions

Overall	Phase II	Phase III	Phase IV	Phase V
Panel A. Minimum cooperation rates				
-0.08***	-0.024	-0.112**	-0.094**	-0.084
(0.026)	(0.065)	(0.045)	(0.044)	(0.057)
Panel B. Excess cooperation rates				
-9.842***	-13.664*	-7.090*	-6.209	-14.162***
(2.489)	(7.246)	(4.092)	(3.849)	(4.759)

- **Obs. 6**. In **NBminRAT**, non-compliant group members cause others do reduce minimum and excess cooperation rates

Summary & conclusion

Ratchet effect: Ratchet-up mechanism decreases efficiency

- **Binding collective minimum contributions**
  - Reduce the risk of being free-ridden
  - Counteract the ratchet effect
  - **BUT**: Hardly feasible at international level
- **Non-binding collective minimum contributions**
  - At the beginning (Phase I), promote cooperation
  - **BUT**: Non-compliance reduces cooperation over time
  - **Overall**: Do not counteract the ratchet effect
- **Ratchet-up mechanism**: No *easy fix*, because of the lack of enforceable commitments at the international level

Thank you!

If you have questions or comments, please let me know

Carlo.Gallier@unibz.it

Appendix

Related Literature

Minimum contribution levels in social dilemmas

Static minimum contribution levels

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

- Decisions do not have dynamic implications for future minimum contribution levels
- Do not completely crowd out voluntary contributions and increase public good provision

Dynamic minimum contribution levels

Dorsey (1992), Kurzban et al. (2001), Gallier & Sturm (2021) ...

- Decisions act as benchmark for future contribution levels
- Set incentive to strategically restrict contributions and can decrease overall public good provision

Related Literature

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

➔ Agents subject to performance pay strategically restrict their true capacity, because they anticipate that higher levels of output will be met with increased requirements

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➔ Agents subject to performance pay strategically restrict their true capacity, because they anticipate that higher levels of output will be met with increased requirements

Amano & Ohashi (2018)

➔ Firms (Japanese televisions) strategically hold back on energy efficiency to be able to continue less efficient products for the foreseeable future

Related literature

Dorsey (1992), **Kurzban et al. (2001)**

If contributions can be constantly revised, ratcheting

- decreases the risk of being exploited
- increases overall public good provision

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If contributions can be constantly revised, ratcheting

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Gallier & Sturm (2021)

If contributions cannot be constantly revised, ratcheting

- increases the risk of being exploited
- decreases overall public good provision

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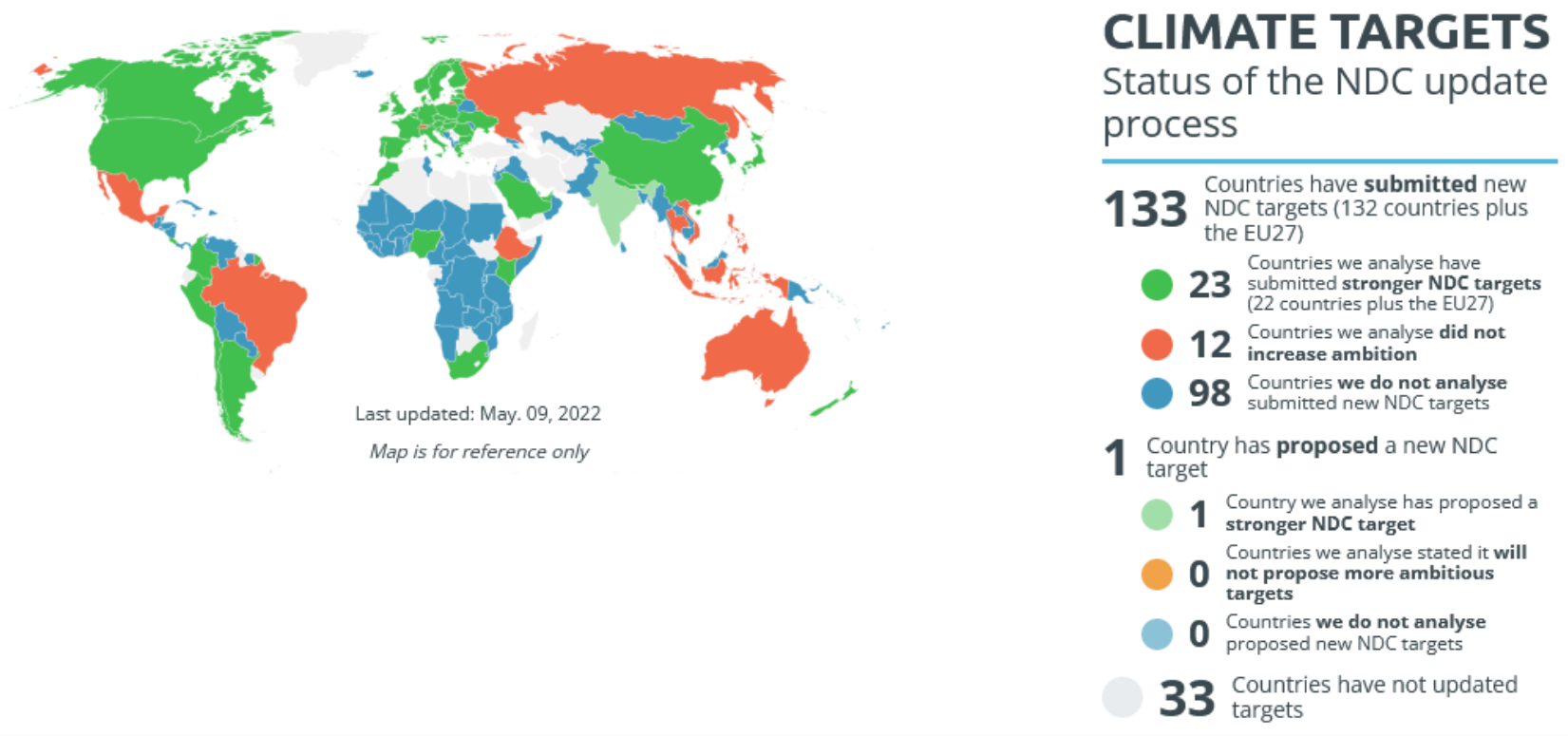
Motivation

2021 United Nations Climate Change Conference (COP26)



Source: CAT

- **Nationally determined contributions**: Ratcheting condition is not met sufficiently

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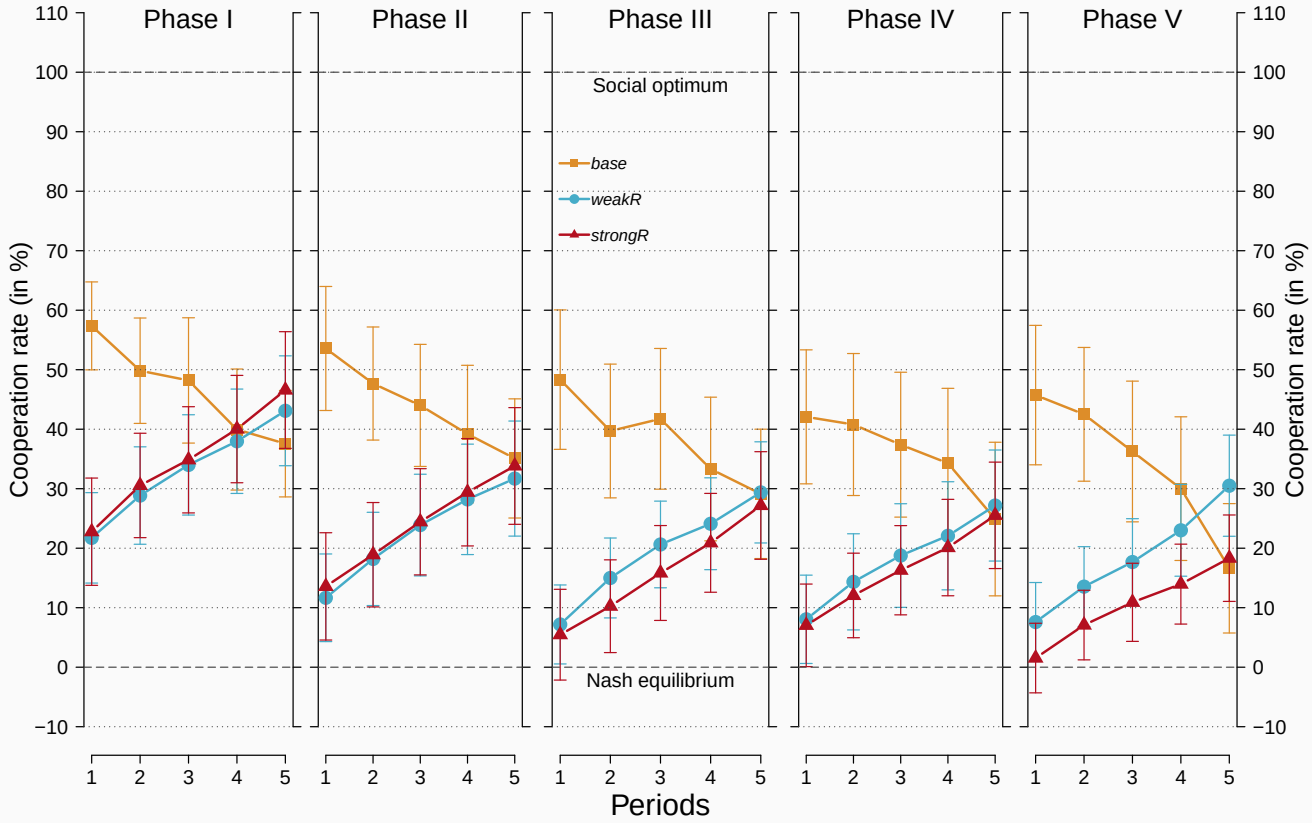
Motivation

Gallier & Sturm (2021, JEBO)



Ratchet effect: Ratcheting is detrimental

- Ratcheting increases the risk of being free-ridden
- Ratcheting decreases overall public good provision

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Exp. design: Cumulative public goods game

At the end of period T:

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

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

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

with

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

and

$$\alpha, \beta, \gamma, \tau > 0 \text{ with } \gamma < \alpha$$

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Exp. design: cumulative public goods game

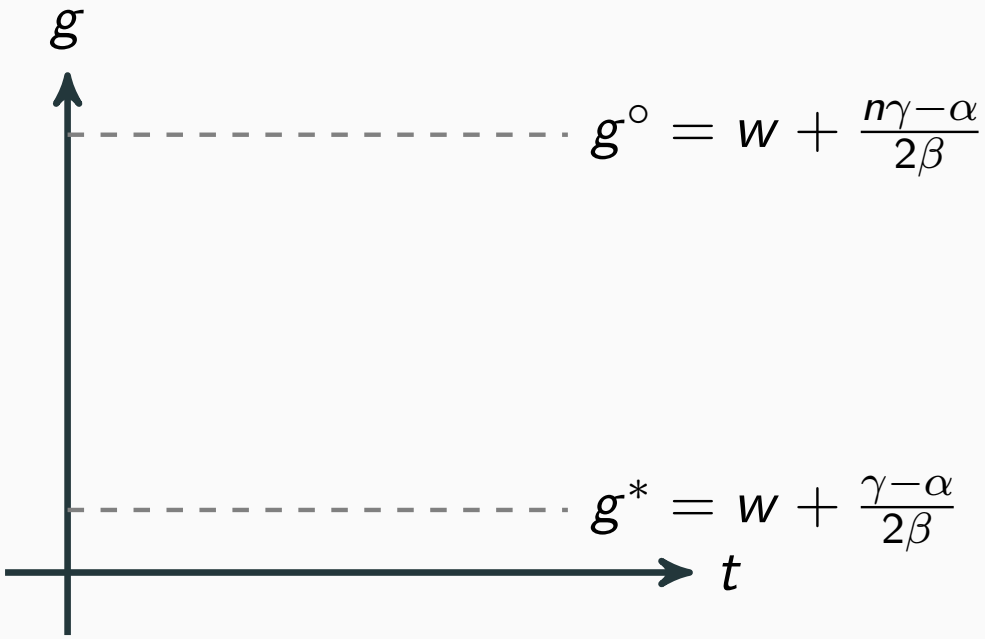
$$\Pi_i = \sum_{i=1}^{T} \pi_{i,t}(w - g_{i,t}, G_t)$$

Social optimum

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

Nash equilibrium

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



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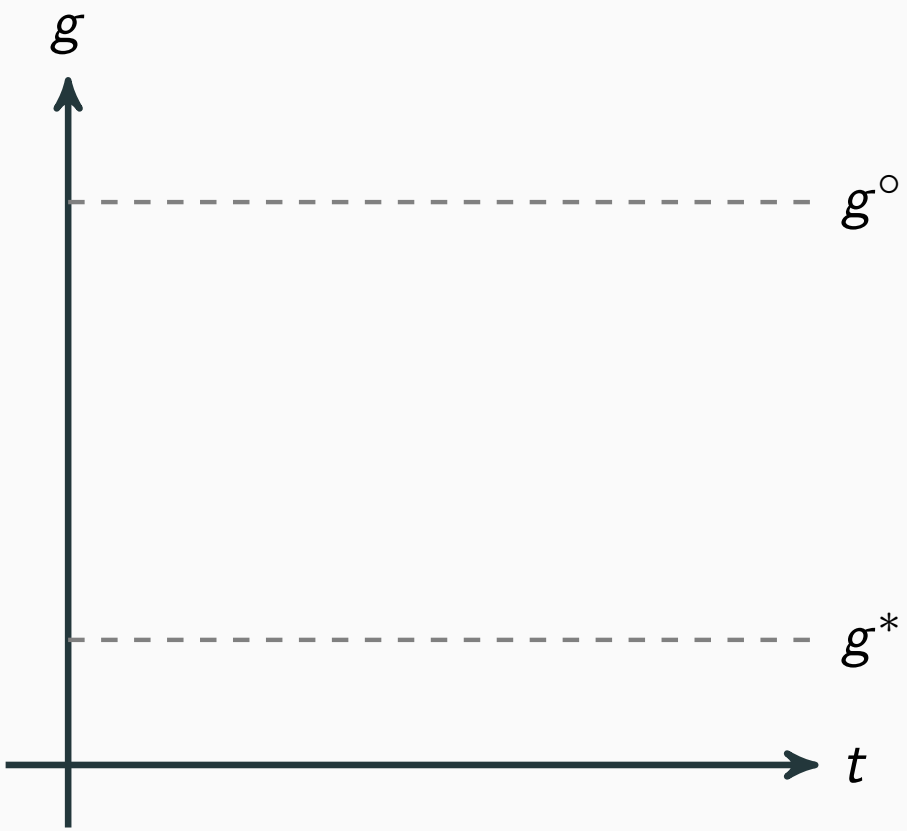
Theoretical considerations

Purely self-interested & rational players



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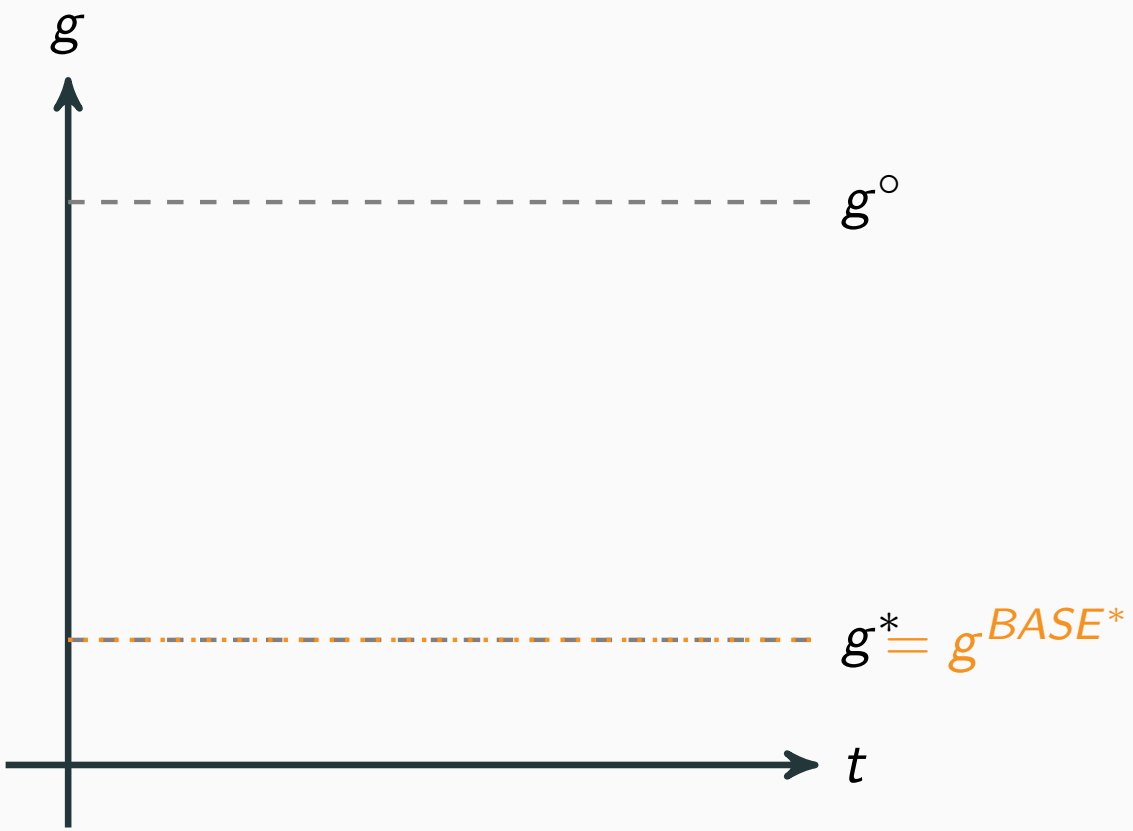

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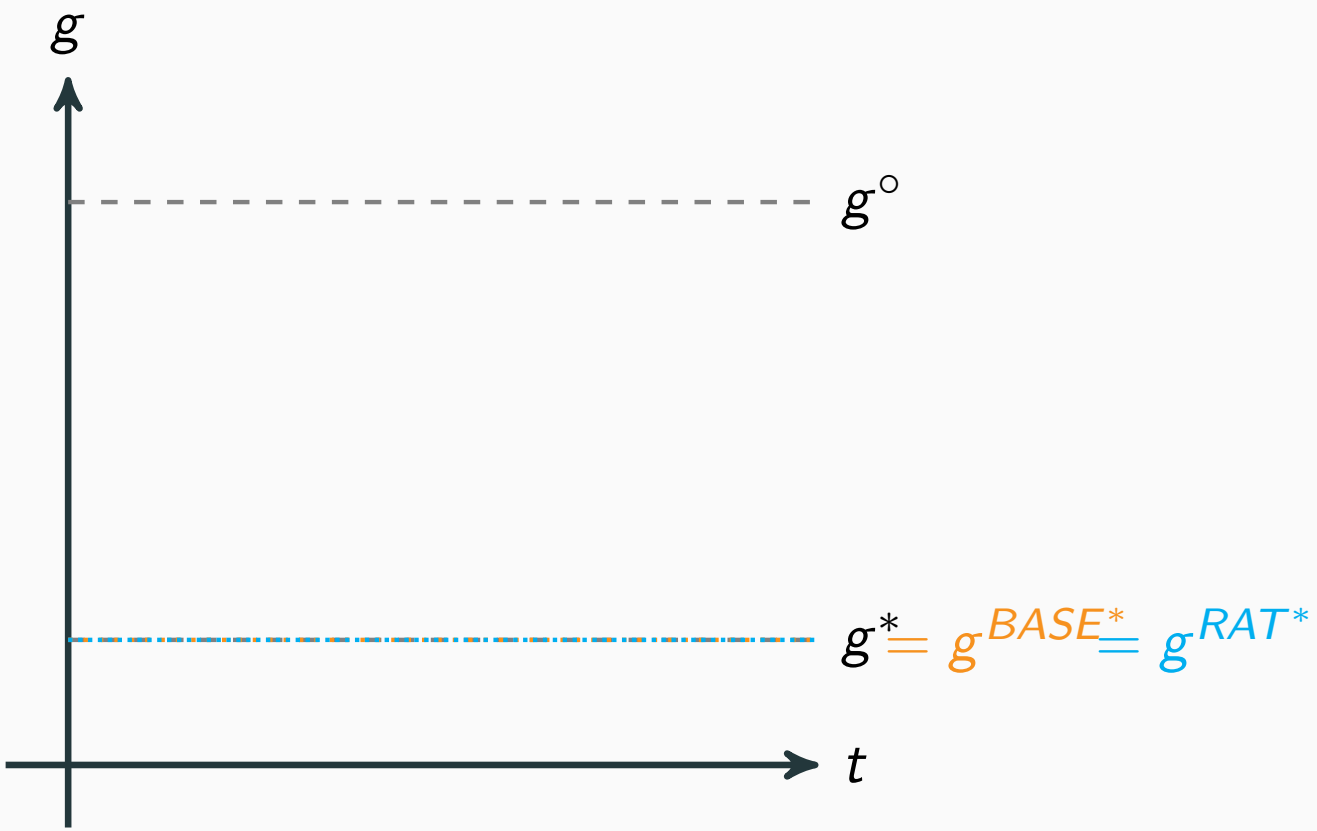

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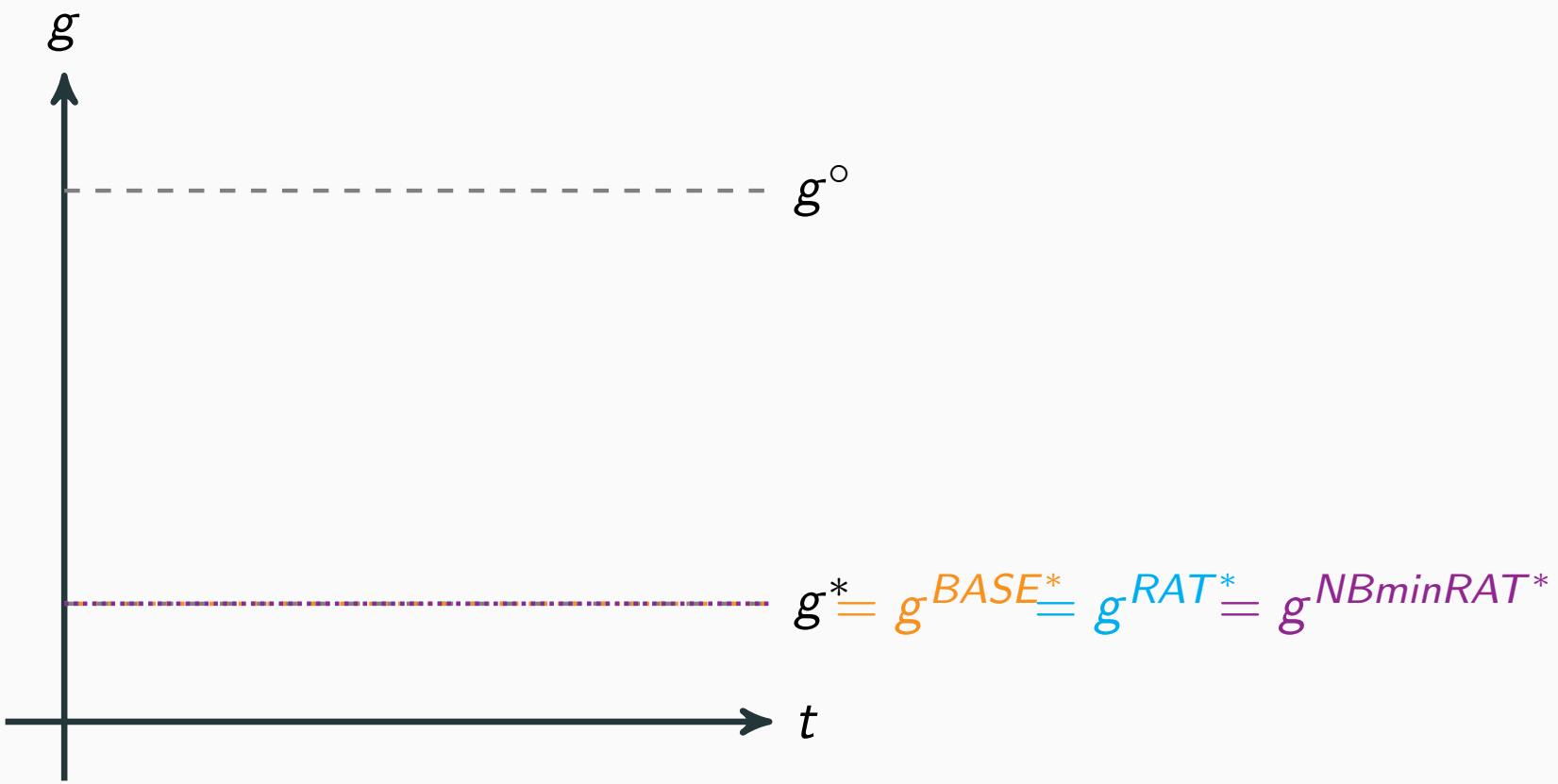

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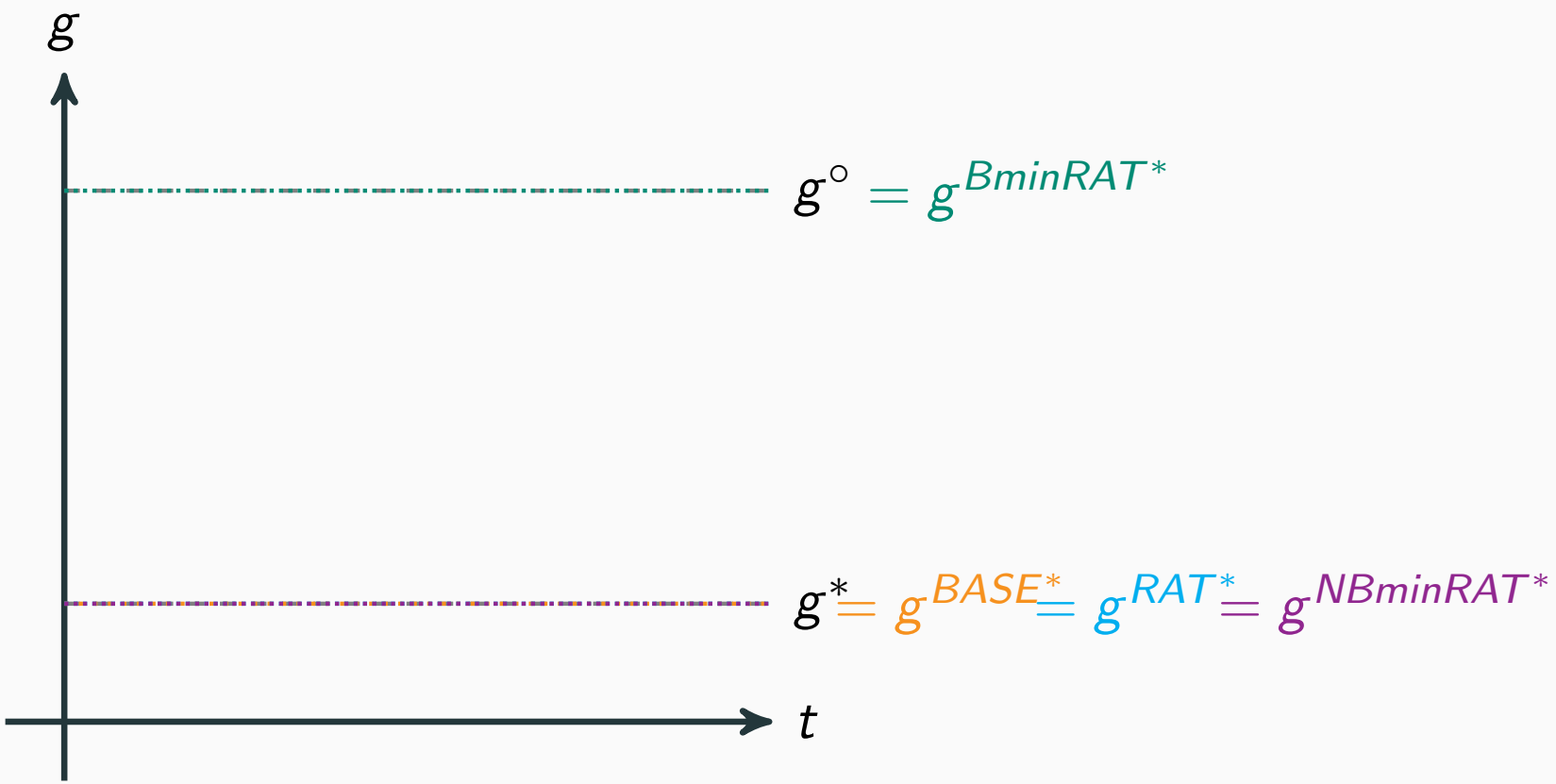

Procedure (aka the odyssey)

#1 – June 2020

- MaXLab
- z-Tree
- Covid – first wave

#2 – November 2020

- MaXLab
- z-Tree
- Hygiene concept
- Covid – second wave

#3 – July 2021

- Fully online
- o-Tree

#4 – October 2021

- Fully online
- o-Tree

#5 – February 2022

- Fully online
- o-Tree

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Treatment	Ratchet-up mechanism	Collective minimum contribution	👥
BASE	✖	✖	39♻
RAT	✚	✖	37♻
NBminRAT	✚	non-binding	18
BminRAT	✚	binding	22
		Total	**116**

♻ Recycled *base* and *weakR* data from Gallier & Sturm (2021):

- ➔ **BASE**: 30 *base* + 9 NEW
- ➔ **RAT**: 27 *weakR* + 10 NEW

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Procedure

Treatments	Period	G&S (2021)	NEW	p-value
Panel A. base vs. BASE				
	Avg.	0.3981	0.3238	0.4971
	1	0.4942	0.4298	0.6127
	2	0.4410	0.3621	0.5365
	3	0.4152	0.3514	0.5965
	4	0.3535	0.2784	0.4454
	5	0.2866	0.1973	0.2815
Panel B. weakR vs. RAT				
	Avg.	0.2234	0.3021	0.4476
	1	0.1125	0.2246	0.2964
	2	0.1799	0.2710	0.3812
	3	0.2299	0.3078	0.4635
	4	0.2708	0.3373	0.5189
	5	0.3237	0.3699	0.6508

- **G&S (2021)** vs. **NEW**: It makes no difference

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Power analysis: priors & calculation

Ratchet-up mechanism
Gallier & Sturm (2021). With ratcheting:

- Avg. contribution of ≈ 32
- Standard deviation of ≈ 13

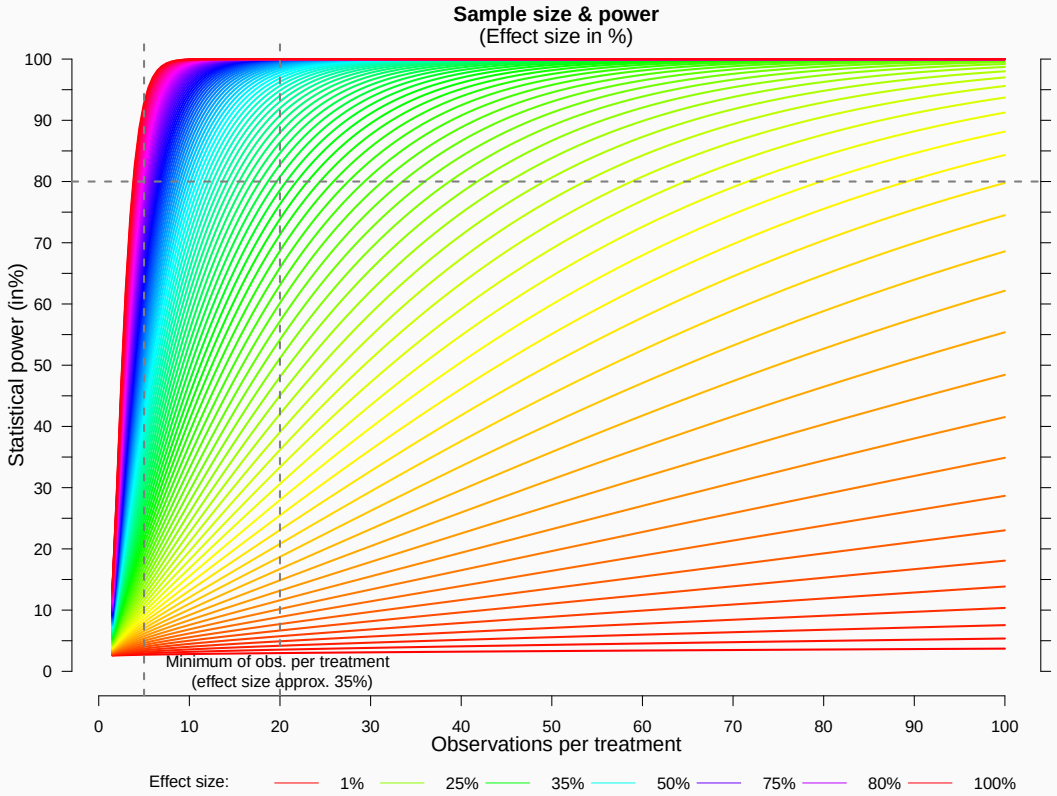
Collective minimum contribution
Dannenberg et al. (2014). With *minimum contribution stage*:

- Effect size of 80 %

Calculation

- </> Resources: **pwr** package for **R**
- Two-sample t test (two sided, equal standard deviation)
- Effect sizes between: 1 % and 100 %

Power analysis: results



➔ 20 groups per treatment sufficient to detect an effect size of more than 35 %

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BminRAT vs. BASE: *Short- & long-run*

	Period					
	1	**2**	**3**	**4**	**5**	**Avg.**
Panel A. Phase 1						
	-22.4161***	-8.1756	-5.2925	4.1282	10.7716	-4.1969
Panel B. Phase 2						
	-20.1395**	-10.7972	-6.3213	3.2432	12.3714	-4.3287
Panel C. Phase 3						
	2.0400	13.2615	16.1445	26.4068***	30.9856***	17.7677**
Panel D. Phase 4						
	11.9410	16.7957*	21.7910**	27.2828***	38.5124***	23.2647***
Panel E. Phase 5						
	8.7432	14.4079	21.7117**	28.1197***	43.8353***	23.3636**
Panel F. Avg.						
	-3.9663	5.0984	9.6067	17.8361***	27.2953***	11.1740*

- Especially in the *long-run* – in late Periods of late Phases – cooperation rates in **BminRAT** are higher than those in **BASE**

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Thank you!