VOTING AND TRANSFER PAYMENTS IN A THRESHOLD PUBLIC GOODS GAME

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Motivation I

UN climate negotiations as a threshold public goods game

- **Public good:** Prevention of global warming is beneficial to all countries
- **Contributions:** Each country can reduce carbon emissions
- **Threshold value:** Specified reduction goal to prevent global warming (2°C target)

Motivation II

UN climate negotiations as a threshold public goods game

- **Heterogeneity of costs:** For some countries (China, India) marginal reduction costs are lower than for others (EU, USA).
- **Transfer payments:** Emissions trading makes it possible to compensate some countries for increased reduction efforts.
- **Voting:** Repeated negotiation of reduction pledges, where consensus (unanimous agreement) is required.

Main experimental results

- **Transfer payments** are used to significantly increase efficiency of contributions (**maximize welfare**)

- This efficiency increase is achieved by **redistribution:**
  - Total contributions remain unchanged, close to threshold value
  - Individual contributions are re-allocated to more productive players (with lower marginal costs)
  - Individual payoffs are redistributed by transfers to achieve equal payoffs

- → **All player types earn significantly more with transfers**

Threshold public goods game

Choice of parameters (basic game)

- 4 players, endowment e of 30 ExCU (2 ExCU = 1 Euro)
- Individual contributions q_i from 0.00 CU to 10.00 CU
- Marginal costs of contribution:
  - 2 low-cost players (L1, L2): $c_L = 1 \frac{ExCU}{CU}$
  - 2 high-cost players (H1, H2): $c_H = 3 \frac{ExCU}{CU}$
- Total contribution Q from 0.00 CU to 40.00 CU
- Damage payment d for missing the threshold (16 CU): 25 ExCU
- Full refund of contributions, if threshold is not reached.

Individual payoff (player i)

$$\pi_i = \begin{cases} 30 \text{ ExCU} - c_i q_i & Q \geq 16 \text{ CU} \\ 5 \text{ ExCU} & Q < 16 \text{ CU} \end{cases}$$

- Contributions are determined by a **unanimous vote.**

Treatment VNOTR – Unanimous Vote

Expectation:

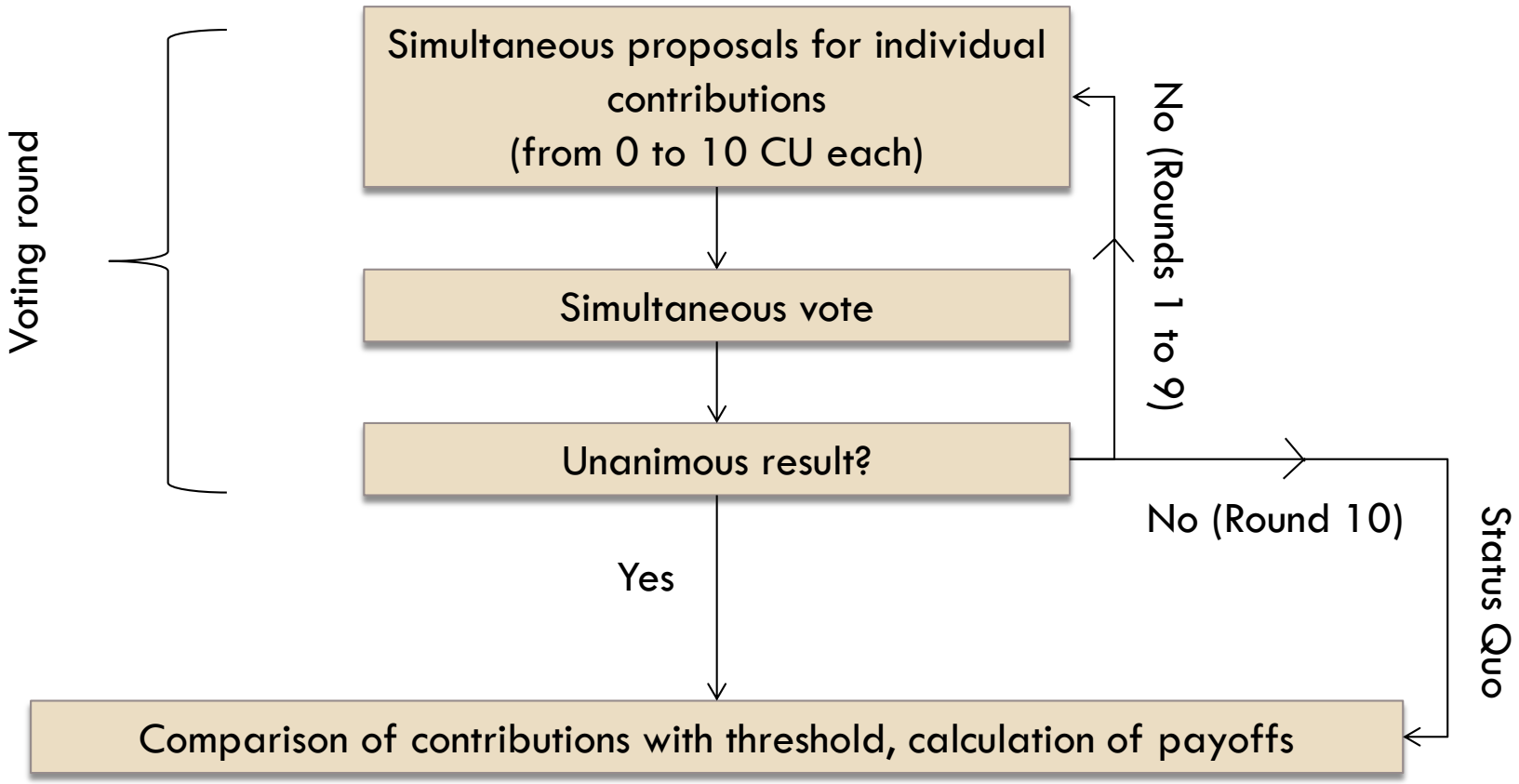
- Players negotiate contributions (non-cooperatively via votes) and agree on socially optimal choice.

Procedure

V-(V-V-V-V-V-V-V-V-V)-Q

- (repeated) unanimous binding vote (V)
- Only one threshold event (Q)
- Status quo if no agreement after 10 rounds:
  $q^0 := \{q | \forall\, i:\ q_i = 0\,\mathrm{CU}\} \rightarrow Q = 0\ \mathrm{CU}$
- Non-cooperative voting mechanism (no communication)
- Proposals are contribution vectors:
  $(q_{L1}, q_{L2}, q_{H1}, q_{H2})$

Voting Procedure for Treatment VNOTR



Pure-strategy equilibria of VNOTR (final voting round)

Status quo

- If one or more players already vote for $\mathbf{q^0 = (0, 0, 0, 0)}$, voting for anything else does not change the outcome (no agreement → q^0).

Threshold allocations

- All threshold allocations (**sum of contributions = 16 CU**) can be implemented as equilibria, because they are Pareto improvements over q^0.
- These outcomes are **Pareto efficient** and constitute the **NTU core set** of this game.
- → They are "renegotiation-proof" (e.g. Finus, 2001), which also ensures individual compliance with agreement.

Pure-strategy equilibria of VNOTR (final voting round)

Other voting equilibria

- Even more equilibria with **Q > 16 CU** exist, which also constitute Pareto improvements over $q^0 = (0, 0, 0, 0)$, but are **not Pareto efficient.**
- Compliance is not ensured in these cases, because contributions are inefficiently high.
- **Proposing/voting** for such allocations is **individually optimal** if everybody else does the same.
- **Contributing** the agreed-upon share is **not individually optimal,** because the threshold will also be reached at a slightly lower share and at lower costs.

Equilibrium selection

Problem

- Large number of Nash equilibria makes coordination of strategies difficult.

Selection criteria

- Type-symmetric welfare-maximizing equilibrium (welfmax)
- Equal-payoff equilibrium with highest welfare (eqpay)
- Equal-contribution equilibrium with highest welfare (eqcont)

	q_H	q_L	π_H	π_L	Π
welfmax	0 CU	8 CU	30 ExCU	22 ExCU	104 ExCU
eqpay	2 CU	6 CU	24 ExCU	24 ExCU	96 ExCU
eqcont	4 CU	4 CU	18 ExCU	26 ExCU	88 ExCU

In VNOTR, no equilibrium is <u>both</u> welfare-maximizing (welfmax) <u>and</u> equal-payoff (eqpay)!

Results from the literature I

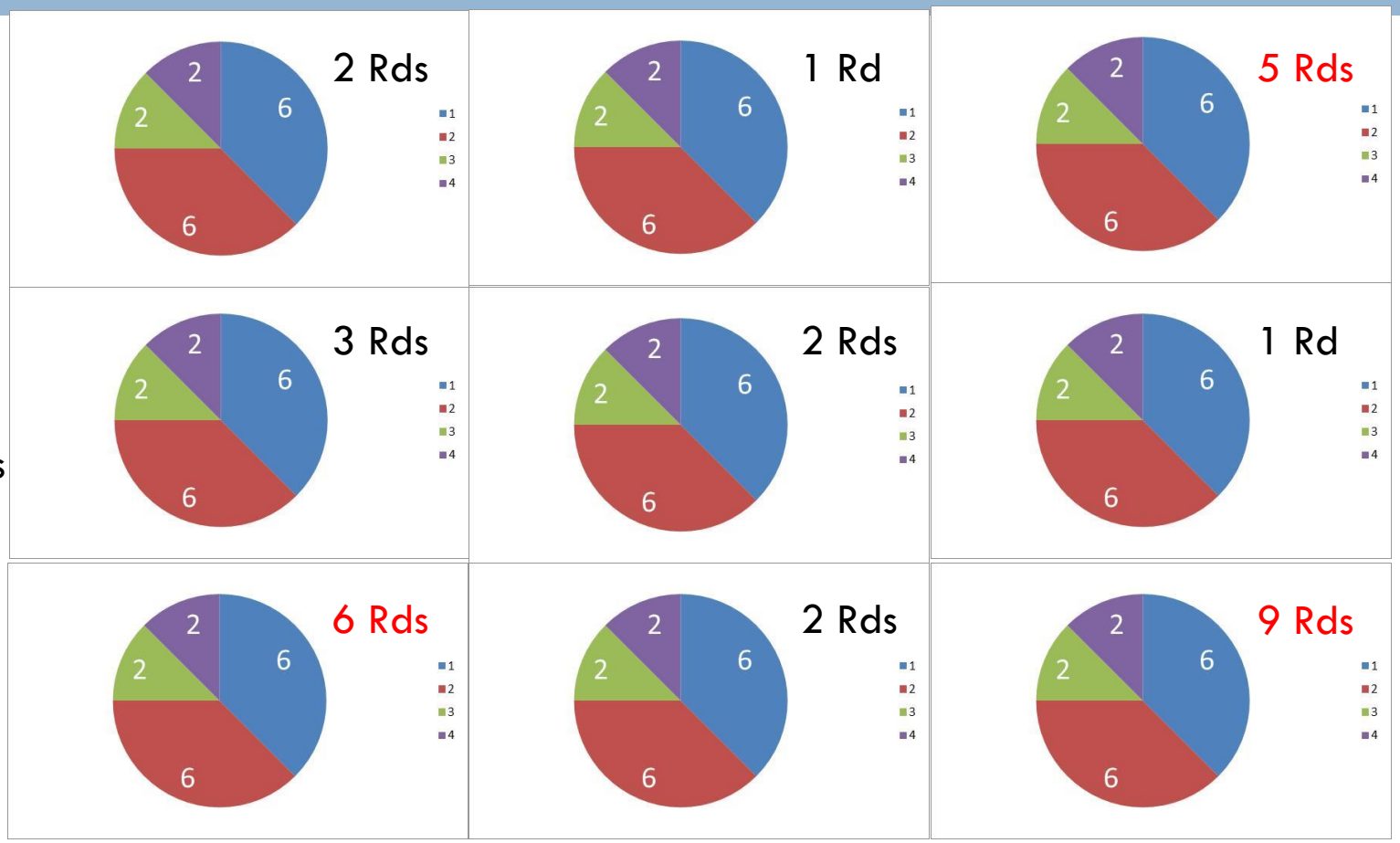
- Early committee voting experiments (e.g. Fiorina & Plott, 1978):
  - Core makes good predictions
  - **No comparison of payoffs** → no equal-payoff outcomes

- More recent studies related to public goods:
  - Feige, Ehrhart & Krämer (2014): **equal payoffs** in threshold public goods game (unanimous vote), but **not welfare-maximizing**
  - Margreiter, Sutter & Dittrich (2005) (see also Walker, Gardner, Herr & Ostrom, 2000): inefficient allocations with **unequal payoffs** in common-pool resource game (majority rule)
  - Frohlich, Oppenheimer & Eavey (1987a,b), Frohlich & Oppenheimer (1990): efficiency and highest minimal payoff both determine choice of payoff vector (unanimous vote, not a public good)

Contributions & Voting Rounds VNOTR

- Player L1
- Player L2
- Player H1
- Player H2

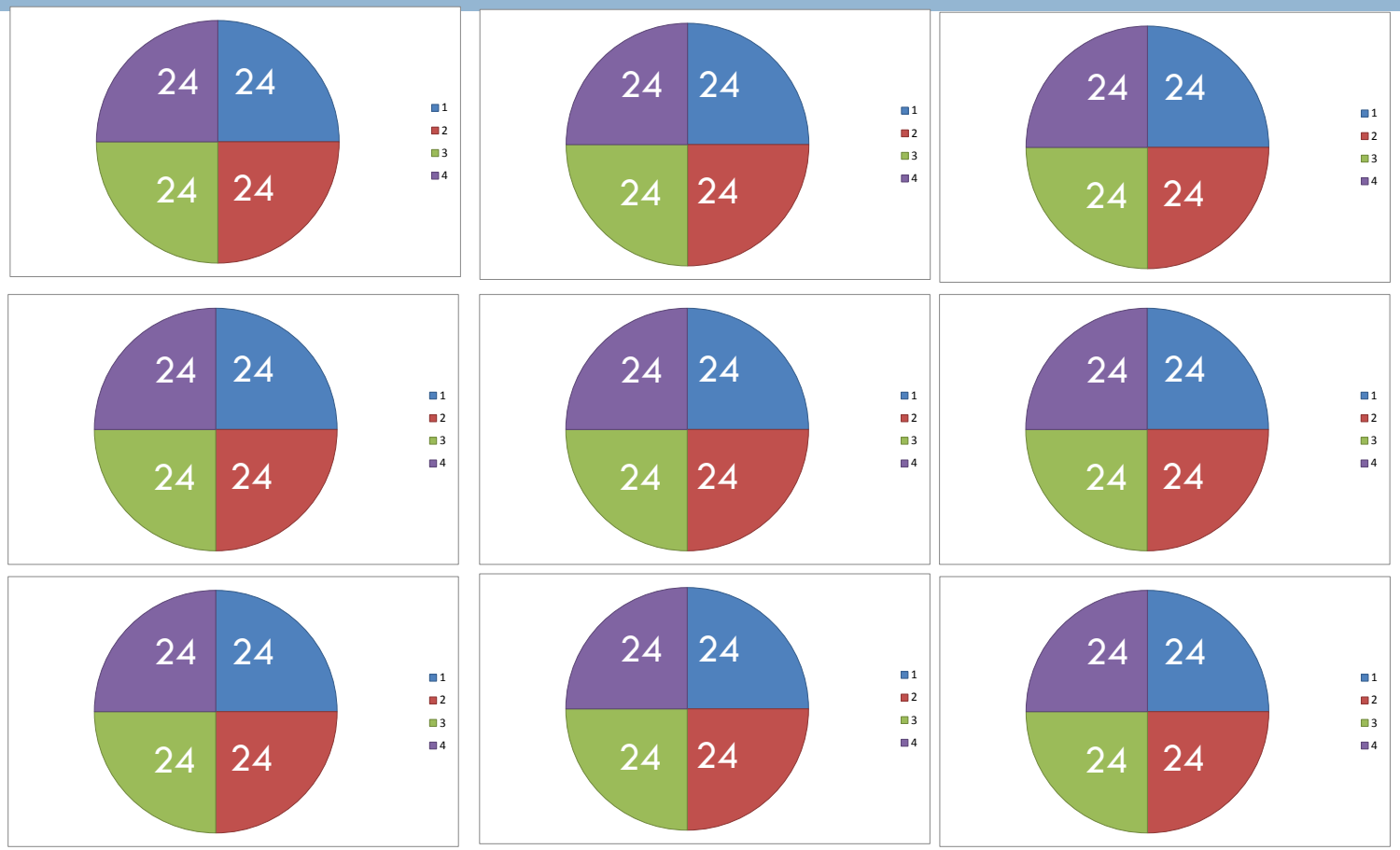
(contributions in CU)



- All groups agree on equal payoffs. No group maximizes total payoffs.
- 6 of 9 groups reach agreement in 3 rounds or less.

Payoffs VNOTR

- Player L1
- Player L2
- Player H1
- Player H2 (payoffs in ExCU)



- All groups agree on equal payoffs. No group maximizes total payoffs.

Transfer payments

- Transfer payments can redistribute payoffs to achieve an outcome that maximizes welfare and has equal payoff:

	q_H	q_L	π_H	π_L
welfmax	0 CU	8 CU	30 ExCU	22 ExCU
welfmax&eqpay	0 CU	8 CU	26 ExCU	26 ExCU

- **Idea:** Unanimous vote on contributions and transfers at the same time
- **Result:** Additional equilibria in which transfers are used for redistribution (→ welfmax & eqpay) (welfmax contained in TU core)
- **But:** Transfers and contributions must be implemented at the same time to retain compliance with agreement.

Treatment VTR – Unanimous Vote & Transfer

Expectation:

- By negotiating contributions and transfers **simultaneously,** the players can allocate contribution costs in a socially optimal way.

Procedure

V-(V-V-V-V-V-V-V-V-V)-Q&T

- (repeated) unanimous binding vote (V)
- Only one threshold event (Q)
- Status quo if no agreement after 10 rounds:

$$q^0 := \{q | \forall\, i:\ q_i = 0\,\mathrm{CU}\} \rightarrow Q = 0\ \mathrm{CU}$$

- Non-cooperative voting mechanism (no communication)
- Transfer payments are part of the contribution proposal:

$$((q_{L1}, q_{L2}, q_{H1}, q_{H2}), (t_{L1}, t_{L2}, t_{H1}, t_{H2}))$$

$$t_{L1}, t_{L2} \geq 0 \qquad t_{H1}, t_{H2} \leq 0 \qquad t_{L1} + t_{L2} + t_{H1} + t_{H2} = 0$$

More results from the literature

Transfer payments in committee voting experiments

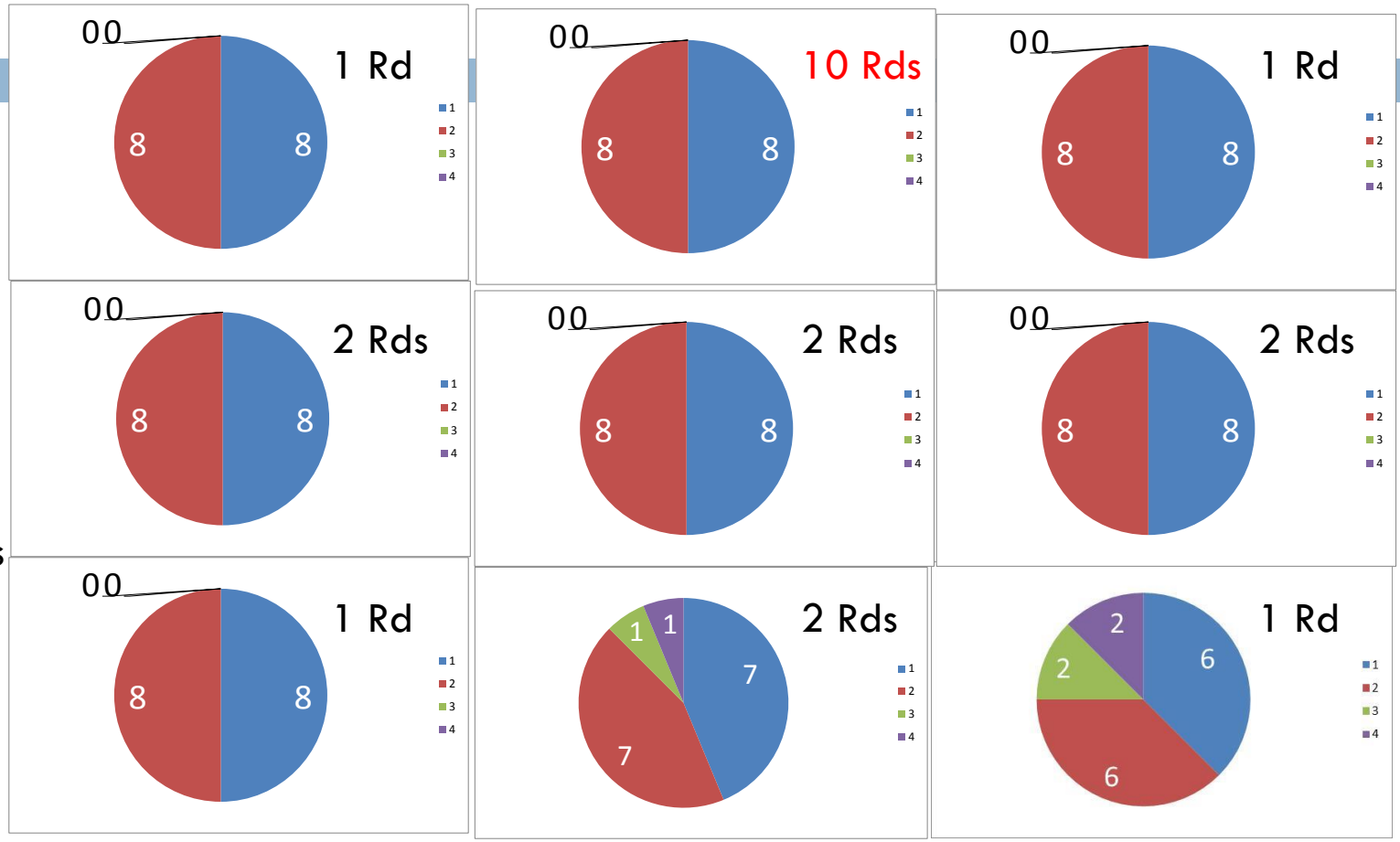
- Common practice in classical committee voting experiments (e.g. Fiorina & Plott, 1978):
  No side-payments!
- But Frohlich & Oppenheimer (1990) study voting on **redistribution principles**.

- Cabrales, Nagel & Mora (2012) find that a unanimous vote on whether or not to redistribute payoffs equally after playing a coordination game, **does not lead to efficient results**.

- Theoretically, Bös & Kolmar (2003) show difficulty of **sequential** decision about 1) allocation (by unanimous vote) and 2) voluntary redistribution via transfers.
  → "Constitution" needed to punish non-compliance.

Contributions & Voting Rounds VTR

- Player L1
- Player L2
- Player H1
- Player H2 (contributions in CU)



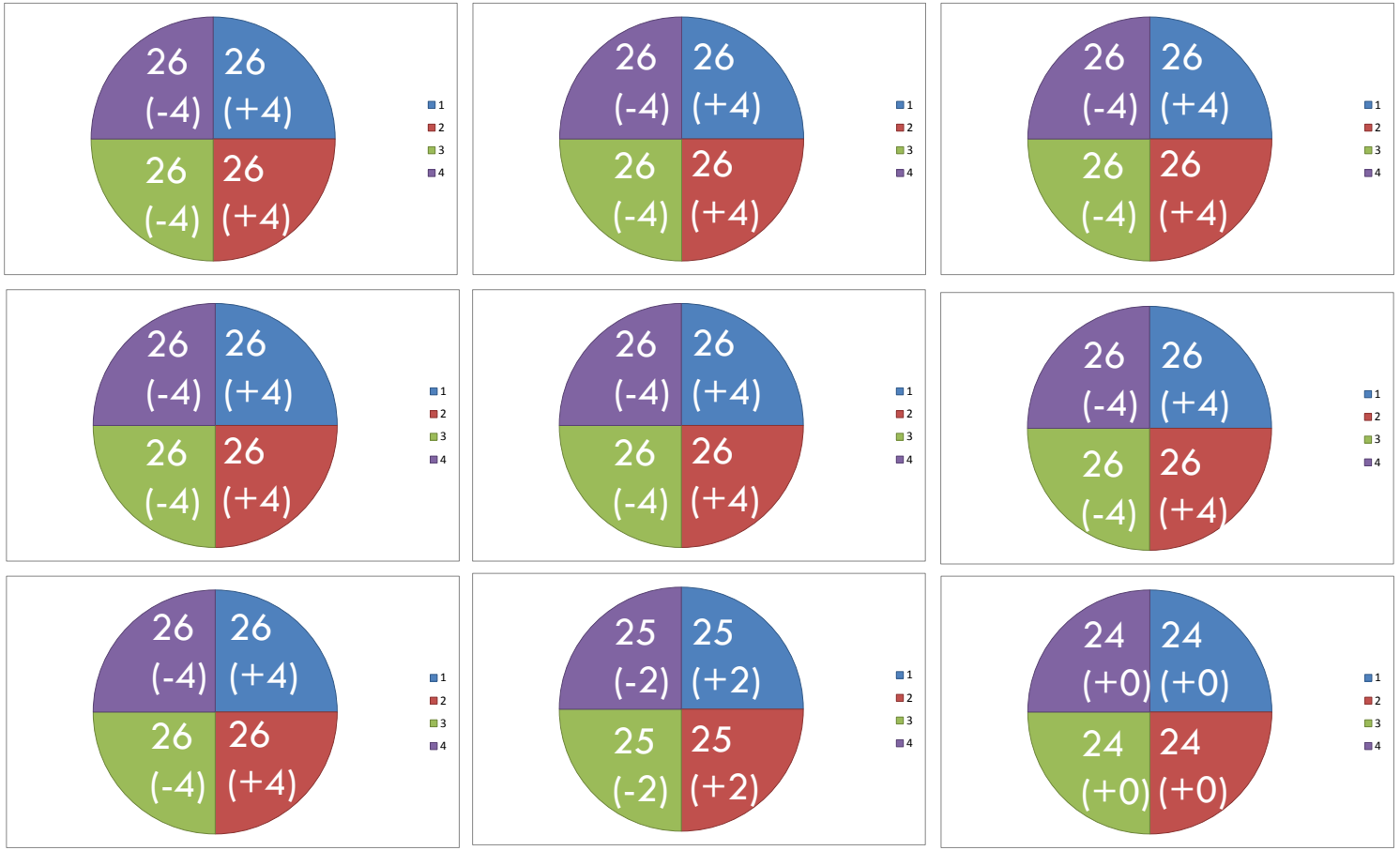
Only one group agrees on eqpay contributions.

Seven groups maximize welfare. One more group agrees on (7, 7, 1, 1).

Agreement is usually reached after 1 or 2 rounds.

Payoffs & Transfers VTR

- Player L1
- Player L2
- Player H1
- Player H2 (payoffs and transfers in ExCU)



- All groups agree on an equal (re-)distribution of payoffs.

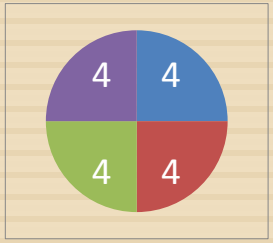
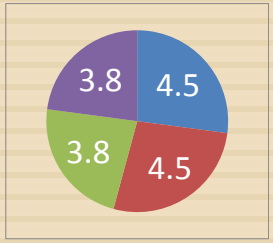
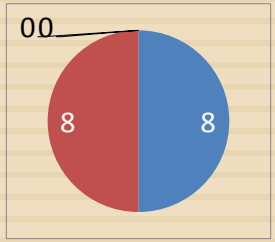
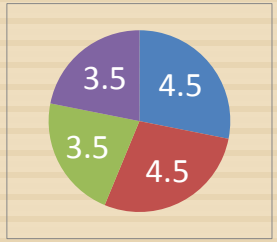
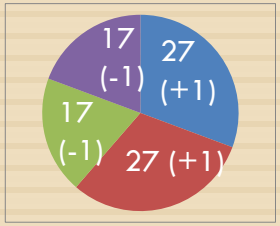
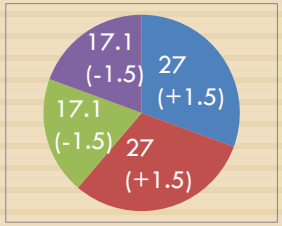
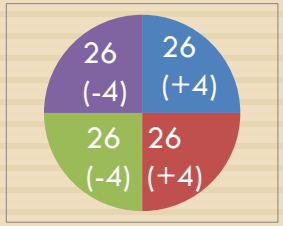
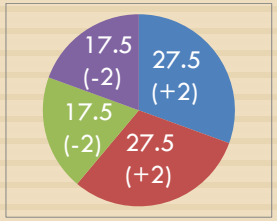
Statistical comparison of treatments

Treatment	Avg. total payoffs
VNOTR (n = 9)	96.00 ExCU
VTR (n = 9)	102.67 ExCU

Comparison of total payoffs with Wilcoxon rank-sum: z = -3.618, p < 0.001

Player type	Avg. individual payoffs (cluster-robust SEs) VNOTR	VTR
both	24.00 ExCU (0.00)	25.67 ExCU (0.23)
$c_L = 1$	24.00 ExCU (0.00)	25.67 ExCU (0.23)
$c_H = 3$	24.00 ExCU (0.00)	25.67 ExCU (0.23)

Example of voting behavior during VTR treatment (Round 1)

	Proposal L1	Proposal L2	Proposal H1	Proposal H2
Contributions (in CU)				
Payoffs (transfers) (in ExCU)				

- Player L1
- Player L2
- Player H1
- Player H2

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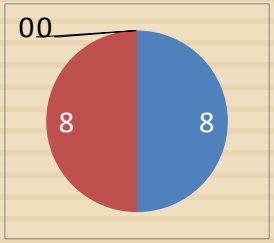
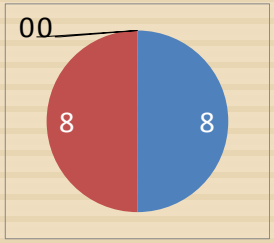
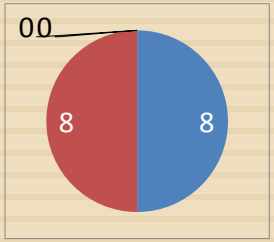
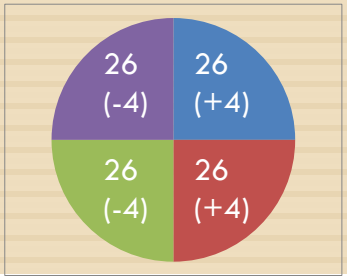
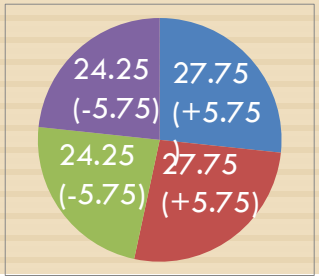
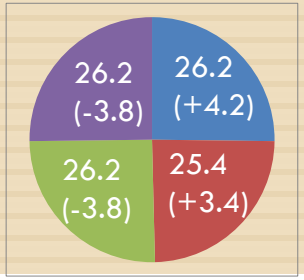
Votes	L2, H1, H2	L1

Proposed contributions and payoffs (incl. transfers) for each of the 4 players in one group. The group quickly realizes how to maximize welfare, but some players hope to earn more than an equal share.

Example of voting behavior during VTR treatment (Round 6)

	Proposal L1, H2	Proposal L2	Proposal H1
Contributions (in CU)			
Payoffs (transfers) (in ExCU)			
Votes	L1, H1, H2	L2	

- Player L1
- Player L2
- Player H1
- Player H2

In later rounds, most proposals do not differ with respect to contributions.

H1's proposal is a subtle hint to L2 that his bargaining position is weak.

Final agreement in round 10: WM with equal payoffs.

Additional results

- Ex-post transfer payments and individual voluntary contributions:
  - Similar welfare increase, but less efficient than voting
  - But: requires repeated game (cf. Bös & Kolmar (2003) (and possibly refund of contributions if threshold is missed)

- Lab-in-the-field experiment with classEx (so far only pilot):
  - Simplified procedure (proposal and voting stages combined)
  - One larger group (~30 students)
  - Initial disagreement between eqpay and welfmax&eqpay
  - Then movement towards welfmax&eqpay

Summary

- Redistribution by means of transfer payments significantly increases total payoffs in threshold public goods games with heterogeneous marginal costs.
- Both player types (high-cost and low-cost) benefit from this increase.
- The result is robust with respect to the decision rule (unanimous vote vs. voluntary individual contributions).

Thanks for your attention!

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