Public Goods: Linear

Teaching Note | MobLab x Harvard Business Impact

Primary Topic:	Microeconomics, Public Economics, Behavioral Economics, Environmental Policy
Typical Duration:	Prep & Instructions: 5 min | Game play: 10-15 min | Debrief: 15-20 min
Group Size:	3-6 players per group; scales to any class size
Difficulty Level:	Introductory / Intermediate
Prerequisites:	Introductory understanding of individual vs. social incentives helpful, but not required. Works well as a first exposure to market failure and externalities.

1. Simulation Overview

In this simulation, students are placed in small groups and each member receives an equal endowment of money. In each round, every student simultaneously decides how much of their endowment to contribute to a shared water purification project and how much to keep for themselves. The total amount contributed by all group members is multiplied by the Rate of Return and shared equally among everyone in the group — including those who contributed nothing.

The core tension is precise and immediate: contributing $1 returns less than $1 to the individual contributor (since the Rate of Return is less than 100%), but the group as a whole gains more than $1 in total benefit (since the Rate of Return times the group size exceeds 1). Free riding — keeping your endowment while others contribute — is individually rational but collectively self-defeating. Across multiple rounds, students typically begin with moderate contributions that decay steadily as free riding takes hold, producing one of the clearest live demonstrations of market failure in the introductory economics curriculum.

The Payoff Formula

Each round, your payoff is calculated as follows:

Your Payoff	=	Endowment minus Your Contribution	+		Rate of Return x Total Group Contributions
Example: $18	=	($20 - $12)	+		(50% x $20 total contributions)

Key Insight: With a Rate of Return of 50% and a group of 3, contributing $1 costs you $1 but generates $1.50 in total group benefit (50 cents for each of the 3 members). The group gains more than it costs — but you personally only get back 50 cents, so keeping the dollar is individually optimal. This gap is the public goods problem.

Learning Objectives

By the end of this simulation, students will be able to:

- **Public Goods and Free Riding**: Explain why non-excludable, non-rival goods lead to under-provision when left to voluntary contributions, and identify free riding as the mechanism driving this outcome.
- **Private vs. Societal Benefits:** Distinguish between the private benefit an individual receives from contributing to a public good and the full societal benefit, and explain why this gap drives the wedge between individual incentives and collective optimum.
- **Voluntary Contribution Decay**: Describe the typical dynamic pattern of contributions across rounds — initial moderate giving followed by steady decline — and explain it in terms of best-response behavior and conditional cooperation.
- **Efficiency and Market Failure:** Define the socially efficient outcome (full contribution) and the Nash equilibrium (zero contribution), and explain why competitive markets fail to provide public goods at the efficient level.
- **Policy Interventions:** Evaluate mechanisms — including communication, norms, taxation, and regulation — that can improve voluntary contribution outcomes, connecting the experiment to real-world policy debates about environmental goods, public infrastructure, and collective action.

2. Classroom Setup

Configuration	Recommended Setting
Group Size	Default: 4 players per group. Larger groups increase societal benefit per contribution but also increase the free-rider problem. Consider varying this across sessions to illustrate the effect.
Endowment	Default: $20 per player per round.

Configuration	Recommended Setting
Rate of Return (%)	Default: 50%. At this rate, contribution is socially efficient when group size is 3 or more (50% x 3 = 150% > 100%). Increase to 70-80% to make cooperation easier; decrease toward 30-40% to intensify the free-rider tension.
Number of Rounds	5-10 rounds recommended. More rounds allow the decay pattern to become visible. Announce the number of rounds in advance to allow end-game reasoning to emerge.
Chat	Disabled for baseline game; enable for a second session to show how communication shifts contribution norms. A classic result from Ostrom et al. (1992): chat dramatically increases contributions even without enforcement.
Robot Players	Available if group sizes are uneven. Robots are conditional cooperators: they contribute randomly in round 1, then match the average contribution of other group members in each subsequent round.
Technology Required	Laptop or tablet with an up-to-date web browser

3. Pedagogical Instructions

Pre-Game Briefing

Before starting, ensure students understand the payoff structure clearly:

- Each round, you receive $20. You choose how much to contribute to the water purification project (from $0 to $20) using the slider, then click Contribute.
- Your private payoff from what you keep: you keep every dollar you do not contribute.
- Your share of the public benefit: the total contributions from all group members are multiplied by the Rate of Return (50%) and this amount is distributed equally to every group member — including those who contributed nothing.
- Walk through the payoff formula using the worked example: if you contribute $12 and total group contributions are $20, your payoff is ($20 - $12) + (50% x $20) = $8 + $10 = $18.
- Ask students: 'If everyone else is contributing, does it pay for you to contribute too?' Let them work through the math. Then: 'If no one else is contributing, does it pay for you to contribute?' This surfaces the dominant strategy before they play.

> **Instructor Tip:** Do not tell students the Nash equilibrium (zero contribution) or the efficient outcome (full contribution) before round 1. Let the tension emerge through play. Many students will start by contributing generously, discover they are being free-ridden on, and reduce contributions across rounds. This trajectory is the learning.

The Gameplay Experience

During play, watch for the following dynamics across rounds:

- Round 1 — High Initial Contributions: Most groups start with contributions around 40-60% of endowments. Some students contribute fully out of altruism or optimism; others contribute nothing from the start. This early variation sets up the debrief well.
- Middle Rounds — The Decay Sets In: As students see their payoffs and observe that some group members contribute little or nothing, contributions begin to fall. Conditional cooperators (those matching the group's average) drag the group contribution down; free riders pull it further. Note which groups decay fastest and which maintain higher levels — this heterogeneity is valuable discussion material.
- Final Rounds — Convergence Toward Zero: By the last rounds, most groups will have contribution levels significantly below round 1. A few groups may maintain partial cooperation throughout; others collapse to near-zero. Use the Go To menu in Results to pull up round-by-round comparisons during the debrief.

Instructor Tip: The box-and-whiskers chart in the Multi-Period Summary is the single most powerful visual for this game. The widening spread and falling mean across rounds tells the free-rider story at a glance. Pull this up at the start of the debrief before asking any questions — let students react to their own data first.

Facilitator Checklist

1. Configure group size, endowment, and Rate of Return before class. Test with Preview Activity.
2. Decide whether to announce the number of rounds in advance (produces end-game effects) or keep it hidden (produces more sustained cooperation).
3. Open the activity and wait for students to join before clicking Begin.
4. Monitor contributions in real time from the instructor console. Note any groups with unusually high or low contribution rates for use in the debrief.
5. If running a second session with chat, use Repeat > Random to reshuffle groups before enabling chat.
6. Before the debrief, navigate to Results > Multi-Period Summary and prepare the box-and-whiskers chart and group contribution trends.

4. Debriefing & Discussion

Plan for 15-20 minutes. Open with the results charts — let students react to the data before introducing theory. The decay pattern typically produces immediate recognition and strong reactions, which makes the theoretical framing land much harder.

Suggested Discussion Questions

- Look at the contribution chart across rounds. What happened to contributions over time? Did this surprise you — and if not, did you expect it to happen so quickly?
- Were you ever tempted to contribute nothing and let others carry the group? Did you act on that temptation? Why or why not?

- If you contributed generously in round 1 and then watched others contribute little, what did you do in round 2? Why? What does this tell us about cooperation under voluntary contribution schemes?
- In every round, the group as a whole would have been better off if everyone contributed their full $20. Yet contributions fell. How can something be individually rational and collectively destructive at the same time?
- The water purification project in this game is a public good: everyone benefits from it whether they pay for it or not. What real-world goods and services have this property? What do those examples have in common with what happened in your group today?
- In the chat-enabled version: did communication change your behavior? Why? What is it about being able to talk with your group that shifts contributions — and why did it not work perfectly?
- What mechanisms could fix the free-rider problem? For each one you propose, what are its limitations?

Theoretical Connections

This experiment grounds several foundational concepts in public economics and game theory:

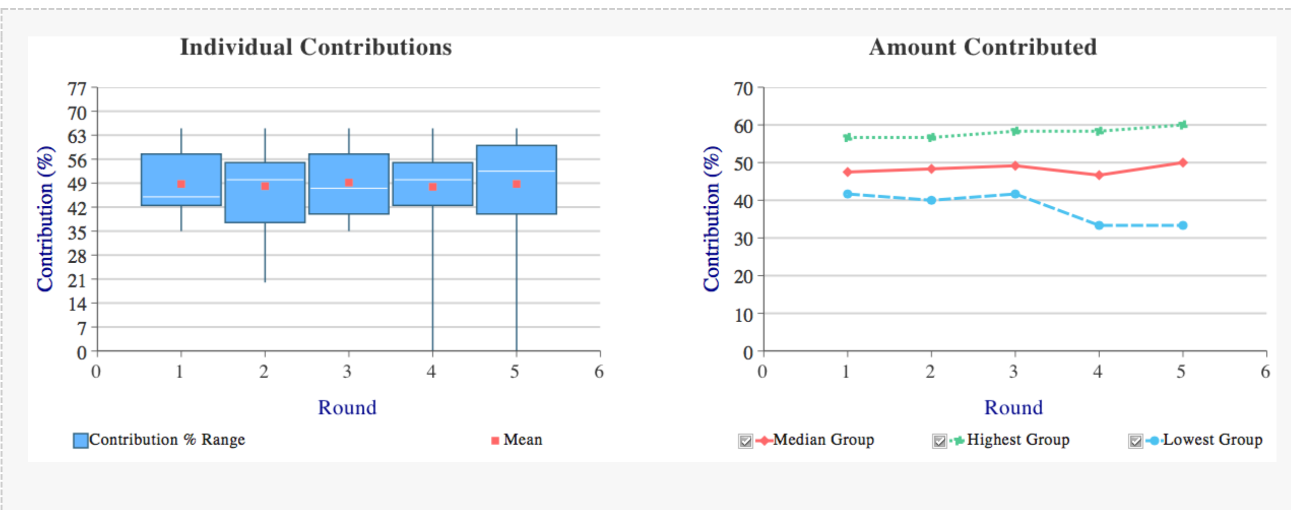
- Public Goods — Non-rivalry and Non-excludability: The water project is non-rival (one person's benefit does not reduce another's) and non-excludable (group members benefit regardless of contribution). These two properties are what make voluntary provision systematically insufficient.
- Free Riding and Nash Equilibrium: Contributing zero is the dominant strategy in a one-shot version of this game, making zero contribution the Nash equilibrium. The experiment makes this logic vivid: students who contribute generously and watch others free-ride learn the equilibrium prediction through direct experience.
- The Efficiency Gap: The socially efficient outcome (everyone contributes their full endowment) and the Nash equilibrium (no one contributes) are polar opposites. The gap between them is the core of the market failure argument for government provision of public goods.
- Conditional Cooperation: Experimental research consistently finds that many people are conditional cooperators — they contribute if others do, and reduce contributions when others free-ride. The decay pattern across rounds is driven by this behavioral regularity, not just pure self-interest. This connects the experiment to behavioral economics and the limits of the homo economicus model.
- Ostrom's Insights on Communication: Elinor Ostrom's Nobel Prize-winning research showed that communication — even without enforcement — dramatically increases voluntary contributions by enabling norm-setting and mutual commitment. The chat-enabled session demonstrates this directly.
- Policy Solutions: The public goods problem motivates taxation, regulation, and Pigouvian solutions. The experiment gives students an intuitive stake in these debates: after experiencing free-riding firsthand, the case for collective action mechanisms is immediately understandable.

5. Results & Data Interpretation

Reading the Results Dashboard

Use the Go To menu to switch between round-specific views and the Multi-Period Summary. Three views are most useful for the debrief:

- Group Outcomes Table (per round): Shows each group's total contributions, average payoffs, and the equilibrium and efficient benchmarks side by side. Sort by the contribution column to quickly identify the highest and lowest contributing groups. Higher-contributing groups consistently show higher average payoffs — a point worth emphasizing in discussion.
- Distribution of Contributions (per round): A histogram showing how individual contribution amounts are distributed in a given round. In round 1, the distribution is typically wide and roughly symmetric. By round 5+, it shifts sharply toward zero, with most players clustered at low or zero contribution levels. Showing this shift round by round is one of the most effective debrief visuals.
- Multi-Period Summary — Box-and-Whiskers Chart: The primary chart for showing the full arc of the experiment. The box plots the interquartile range of individual contributions per round; the whiskers show the full range; the red marker shows the mean. The steady fall of the mean and the widening spread tell the free-rider story at a glance.
- Multi-Period Summary — Group Contribution Chart: Plots the highest, lowest, and median contributing group as a percentage of group endowment across rounds. This reveals the heterogeneity: some groups maintain high contributions throughout while others collapse early. Use this to motivate discussion about what sustained cooperation in the high-contributing groups.



Common Outcome Patterns

- Contribution Decay (expected): The signature result. Mean contributions start at 40-60% of endowments in round 1 and decline to 20% or below by the final rounds. This pattern is highly robust across classes and parameter settings. If decay is slow, it typically reflects conditional cooperators holding each other up — still a useful teaching point.
- Group Heterogeneity (common): Even under identical parameters, some groups maintain cooperation while others collapse quickly. Ask high-contributing groups to explain their norms and low-contributing groups to explain their reasoning. The contrast typically surfaces the role of group composition, communication, and trust.

- High Cooperation with Chat (expected): Enabling chat in a second session typically produces contribution levels 20-40 percentage points higher than the no-chat baseline, especially in early rounds. End-game unraveling may still occur, but the overall level is meaningfully higher. Use the Compare button to show this difference directly.
- Payoff Dominance of High-Contributing Groups: The Group Outcomes table will almost always show that groups with higher contributions have higher average payoffs. This result — that cooperation pays off at the group level even while free riding is individually rational — is one of the most important and discussable findings of the experiment.

6. Extensions & Variations

Parameter Adjustments

- Vary the Rate of Return: Lowering the Rate of Return (e.g., to 30%) intensifies the free-rider problem and produces faster decay. Raising it (e.g., to 70-80%) makes cooperation easier and can sustain higher contributions for longer. Running both in sequence shows students that the incentive structure matters, not just preferences.
- Vary Group Size: Larger groups increase total societal benefit per dollar contributed but also dilute individual impact and increase anonymity, typically accelerating free riding. Comparing a 3-person and a 6-person group session is a clean treatment that connects to real-world debates about the optimal scale of collective action institutions.
- Announce vs. Conceal Round Count: Announcing the number of rounds in advance produces cleaner end-game effects (a sharp drop in the final round). Concealing the endpoint suppresses backward induction and sustains higher cooperation, mirroring indefinitely repeated game dynamics from the Prisoner's Dilemma.
- Enable Chat: The most impactful single variation. Even without enforcement, communication allows groups to establish contribution norms and express disapproval of free riding. This is the experimental version of Ostrom's communal management insight.

Cross-Disciplinary Connections

- Environmental Economics — Carbon Emissions and Climate Change: Nations deciding whether to reduce emissions face a global public goods problem: the benefits of clean air are non-excludable and non-rival, but abatement is costly for each individual country. The experiment makes visceral why international climate agreements are so difficult to enforce.
- Public Finance — Taxation and Government Provision: The free-rider problem is the primary economic justification for government taxation and provision of public goods. Students who have just experienced free riding firsthand have immediate intuition for why markets under-provide roads, national defense, basic research, and public health infrastructure.
- Organizational Behavior — Team Shirking: Teams in firms face a public goods problem when individual effort is not perfectly observable. Each team member benefits from the team's output but has an incentive to let others carry the workload. The experiment motivates discussions of monitoring, incentive design, and team culture as solutions.
- Political Science — Collective Action: Olson's logic of collective action — that large groups struggle to provide public goods voluntarily because individual incentives favor free riding — is directly visible in the results. The experiment is a natural bridge between economics and political science treatments of collective action problems.

7. References & Further Reading

The following resources pair well with this experiment:

- Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press. Ostrom's foundational work on how communities self-organize to manage public goods — directly relevant to the chat-enabled sessions.
- Ledyard, J.O. (1995). Public Goods: A Survey of Experimental Research. In J. Kagel & A. Roth (Eds.), Handbook of Experimental Economics. Princeton University Press. The definitive survey of public goods experiments; a useful reference for instructors wanting the empirical backdrop.
- Olson, M. (1965). The Logic of Collective Action. Harvard University Press. The theoretical foundation for understanding why large groups fail to provide public goods voluntarily.
- Mankiw, N.G. (current edition). Principles of Economics. Cengage. Chapter on Public Goods and Common Resources maps directly onto the experiment's learning objectives.
- Fischbacher, U., Gaechter, S., & Fehr, E. (2001). Are People Conditionally Cooperative? Evidence from a Public Goods Experiment. Economics Letters, 71(3), 397-404. The key paper on conditional cooperation — explains the decay pattern students observe in their own data.