# Public Goods and Collective Action

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**Cooperation and Competition in Markets and Organizations**

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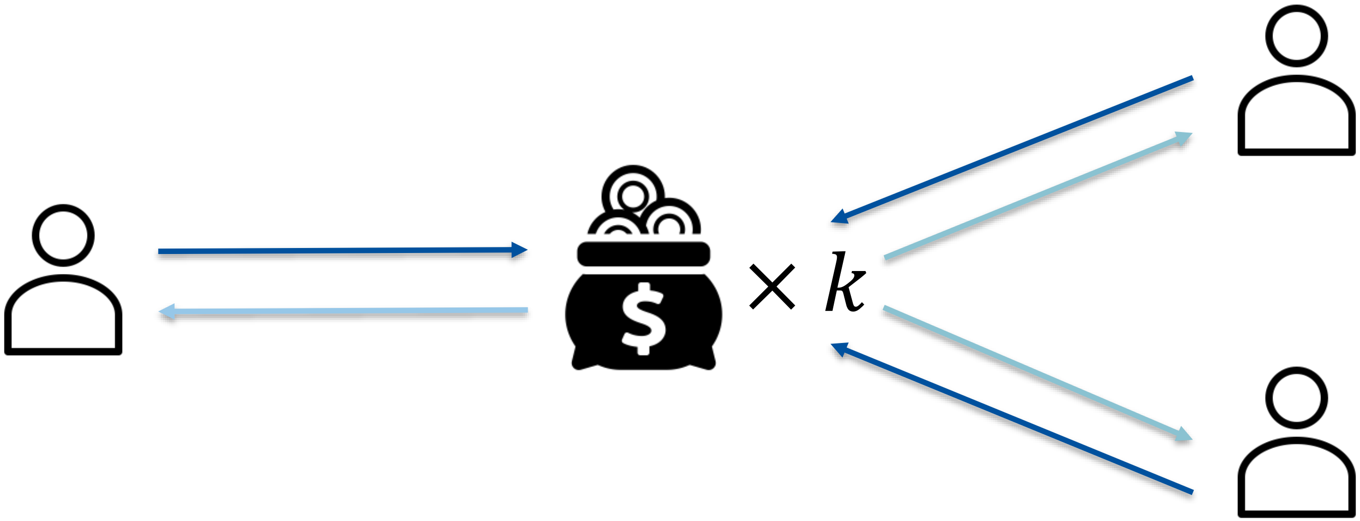
# Let‘s Play!

- You decide how many of your gummy bears you keep for yourself and how many you put in the group pot
- I double (!) the amount of gummy bears in the group pot
- The group pot is distributed equally among the participants

# Linear Public Goods Game




Assumption: $1 < k < n$

Payoff function: $y_i(x) = \frac{k}{n}\sum_{j=1}^{n} x_j + (b - x_i)$

Contributions: $x = (x_1, \dots, x_n)$ with $0 \le x_j \le b$

Budget: $b > 0$

# Linear Public Goods Game

$$y_i(x) = \frac{k}{n}\sum_{j=1}^{n} x_j + (b - x_i)$$

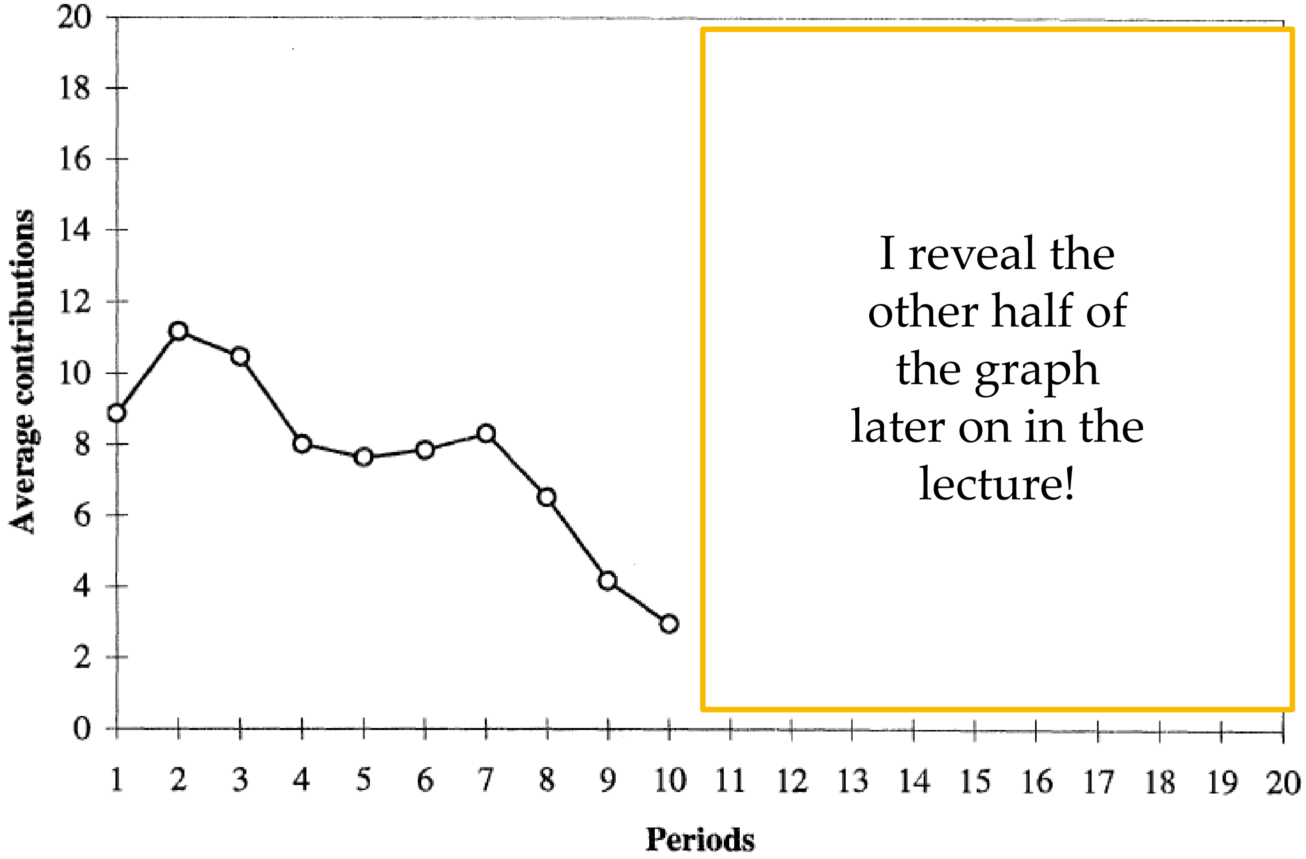
**Game-Theoretical Analysis**

- Private cost of a marginal contribution: 1
- Private benefit of a marginal contribution: $\frac{k}{n} < 1$
- Social benefit of a marginal contribution: $k > 1$

There is a unique Nash-equilibrium, in which nobody contributes and this equilibrium is not Pareto-efficient!

*The voluntary provision of public goods is inefficient due to problems of free-riding!*

# Experimental Findings




Source: Fehr & Gächter (2000)

# Why You Should Care

From the micro to the macro spheres of society and in both the private as well the public sector, problems of *team work* and *group tasks* can be described as problems of producing public goods and collective action. Some examples:

- Founding a business,
- Oligopolistic industries,
- Lobbying for economic policies,
- Raising children,
- Restricting climate change.

*Identifying problems of collective action and analyzing their subtle nuances is key in applying well-established insights from the social sciences to overcome the problem of inefficiency!*

# This Lecture

1. Motivation
2. Basic Concepts: Excludability, Rivalization, and Technology
3. Overcoming the Problem of Inefficiency
4. Application: Open Source Software
5. Summary

# *Basic Concepts*

# Types of Goods

Goods vary along the dimensions of *non-excludability* and *non-rivalization*

- Non-excludability: Once the good is provided, nobody can be excluded from its consumption (irrespective of whether she contributes towards its provision or not)

- Non-rivalization: Adding an additional consumer does not decrease the utility (or marginal utility) obtained by other consumers

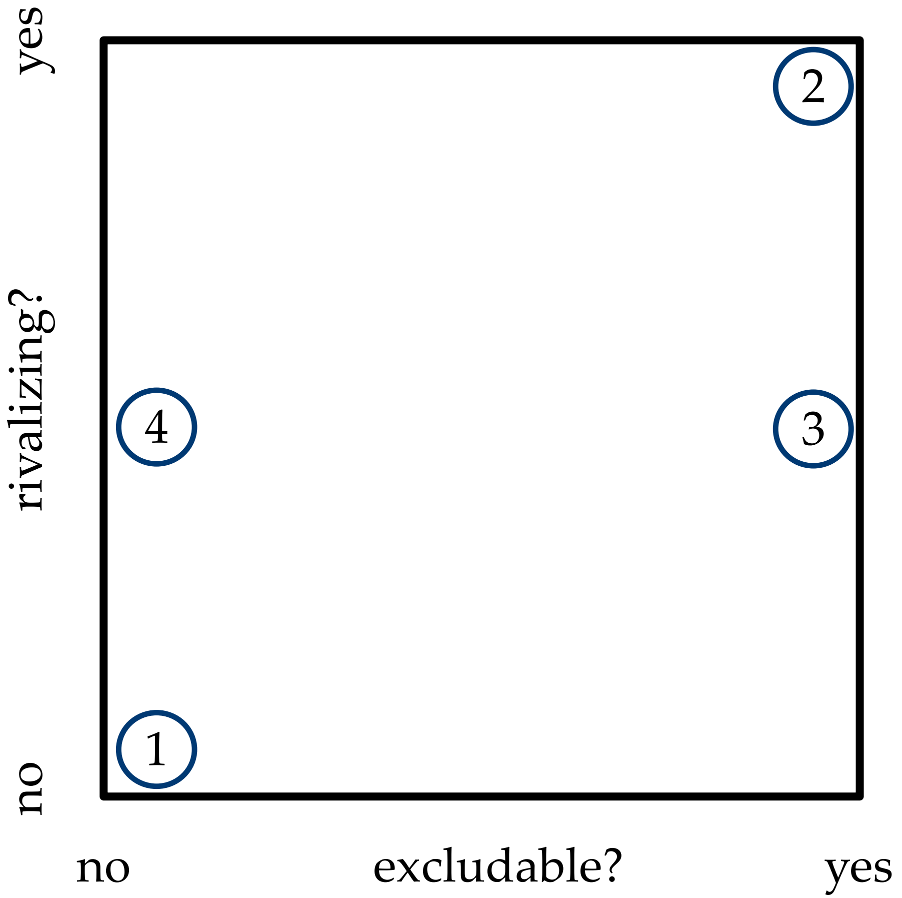
# Types of Goods

1: Pure public goods
(e.g. climatic condition)

2: Pure private goods
(e.g. iPhones)

3: Club goods
(e.g. fitness studios)

4: Common-pool resources
(e.g. fishing grounds)



# Types of Goods

**Excercise**

Considering our game of gummy bears, does the group pot qualify as a pure public good? Is there non-excludability and non-rivalization?

$$y_i(x) = \frac{k}{n}\sum_{j=1}^{n} x_j + (b - x_i)$$

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$$y_i(x) = \frac{k}{n}\sum_{j=1}^{n} x_j + (b - x_i)$$

Non-rivalization does not obtain because each additional player diminishes the individual share of the pie

Non-excludability holds because irrespective of whether a player contributes, she gets her share of the pie

# Production Technologies

**Plethora of Technologies – Details Matter!**

- Linear: $$y_i(x) = \frac{k}{n}\sum_{j=1}^{n} x_j + (b - x_i)$$
- Weakest-link: $$y_i(x) = \frac{k}{n}\min\{x_1, \dots, x_n\} + (b - x_i)$$
- Threshold: $$y_i(x) = \frac{k}{n} I\left(\sum_{j=1}^{n} x_j > t\right) + (b - x_i)$$

# Production Technologies

**Excercise**

Assuming the weakest-link technology as well as $k = 4, n = 2$ and $b = 1$ and only considering the two strategies $x_j = 0$ (defect) and $x_j = 1$ (cooperate) for each player, write down the game in strategic form and solve for all Nash-equilibria!

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| | Cooperate | Defect |
|---|---|---|
| Cooperate | (2,2) | (0,1) |
| Defect | (1,0) | (1,1) |

# Production Technologies

| | Cooperate | Defect |
| --- | --- | --- |
| Cooperate | (R,R) | (S,T) |
| Defect | (T,S) | (P,P) |

- Linear PT: *Prisoners Dilemma* $(T > R > P > S)$
- Weakest-link PT: *Assurance Game* $(R > T > P > S)$
- Threshold PT: *Chicken Game* $(T > R > S > P)$

*Linear technology leads to most severe problem of collective action, which cannot be overcome by coordination alone!*

Adapted from: Sandler (2004)

# Overcoming the Problem of Inefficiency

# Various Mechanisms

**Institutions** (Olson 1965; Ostrom 1990)

Changing the rules and/or the payoff structure of the game

- Selective incentives (private costs and benefits)
- Exogenous sanctions (institutionalized power)
- Endogenous sanctions
- Repeated interaction (reputation, social norms)
- Leadership

**Dispositions and Mental States of Agents**

- Selecting for dispositions and social preferences
- Priming & Framing
- Manipulating beliefs and expectations

# Social Preferences

**Basic Idea**

Players do not care solely about their material payoffs but also about properties of the distribution of payoffs and/or properties of the strategy profiles

**Example**

Consider a linear public goods game with $k = 2, n = 4$ and $b = 20$. Assume that players a *pure altruists*, i.e. player i's utility is given by

$$u_i(x) = y_i(x) + \alpha \sum_{j \neq i} y_j(x).$$

Determine the smallest $\alpha$ such that there exists a Nash-equilibrium, in which all players contribute their full endowment!

# Social Preferences

$$u_i(x) = y_i(x) + \alpha \sum_{j \neq i} y_j(x)$$

$$= \frac{k}{n} \sum_{j=1}^{n} x_j + (b - x_i) + \alpha \sum_{j \neq i} \left( \frac{k}{n} \sum_{l=1}^{n} x_l + (b - x_j) \right)$$

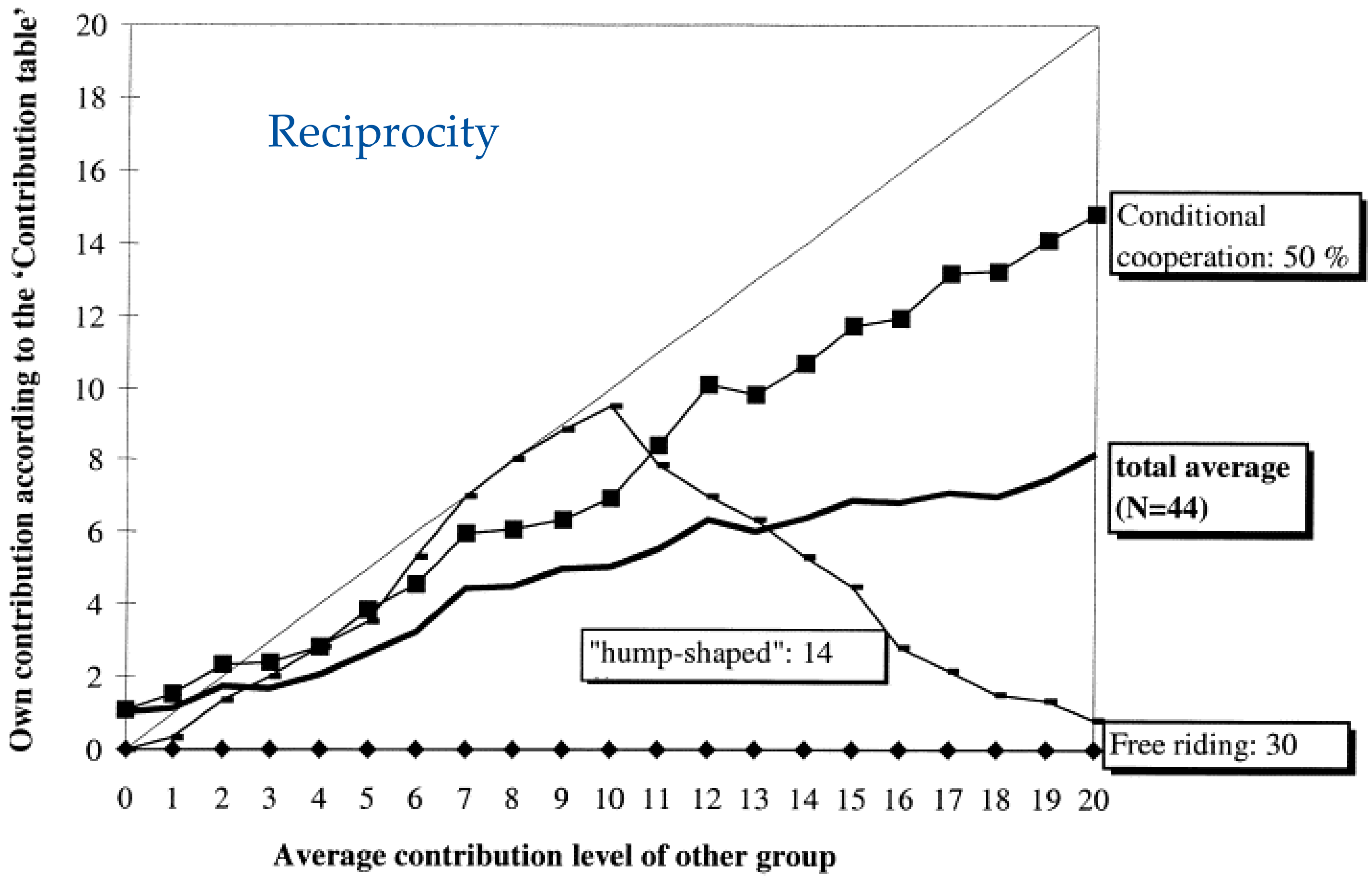
$$\frac{du_i}{dx_i} = \frac{k}{n} - 1 + \alpha(n-1)\frac{k}{n} \geq 0$$

Private benefit

Private costs

Internalized social benefit

# Social Preferences




Source: Fischbacher et al. (2001)

# Endogenous Sanctioning

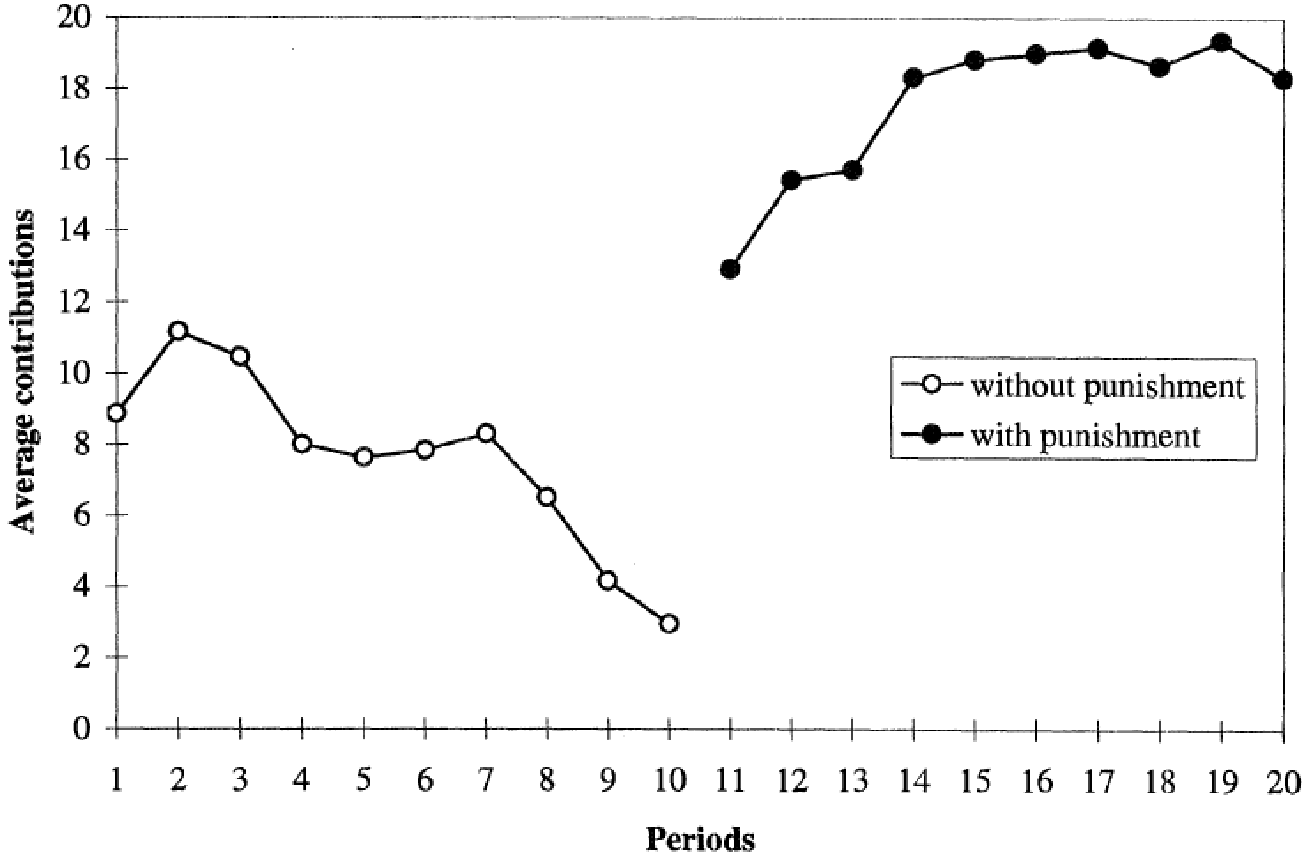
**Basic Idea (i.e. Norm Game)**

After completing a round of the linear public goods game, players can invest material resources in punishing other players

**Game-Theoretical Analysis** (Assuming Material Egoism)

- Irrespective of the outcome of the linear public goods game, nobody punishes, because punishment involves costs without any benefits
- Unique subgame perfect outcome: All players defect and nobody punishes
- Conclusion also holds for finite (!) repititions of the norm game

# Endogenous Sanctioning




Source: Fehr & Gächter (2000)

# Leadership

**Basic Idea**

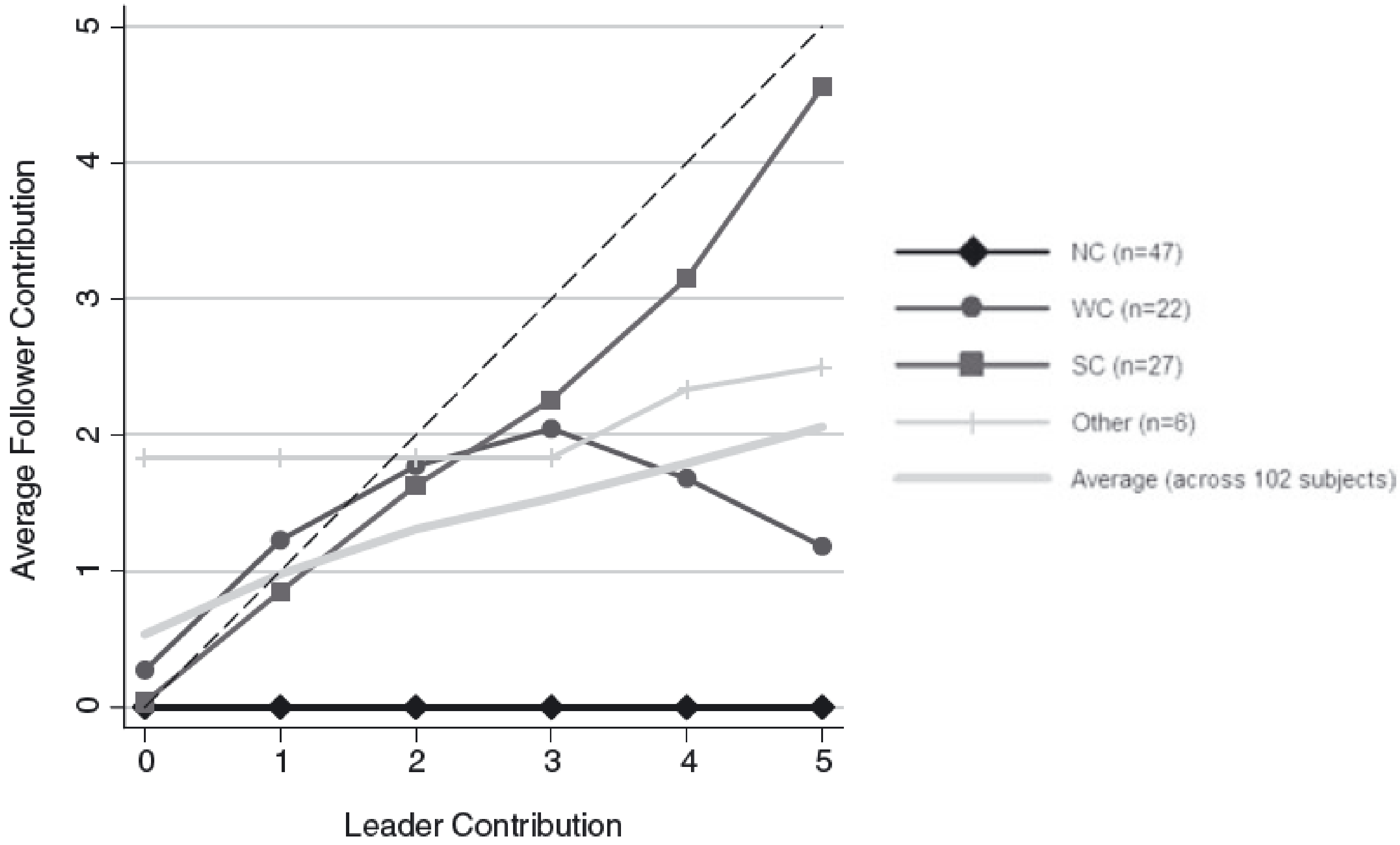
One player goes first in contributing in the linear public goods game. Other players observe her contribution and decide upon their own contribution level

**Game-Theoretical Analysis** (Assuming Material Egoism)

Nobody contributes

*However, given the tendency towards reciprocity, generous contributions by the leader might trigger greater contributions by the followers!*

# Leadership




Source: Gächter et al. (2012)

# Leadership

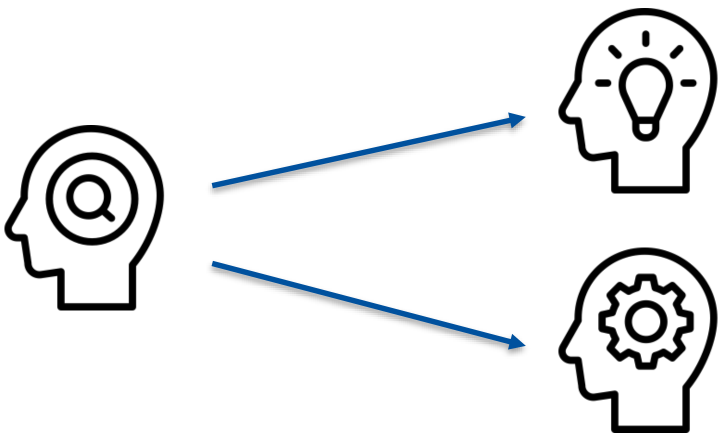
Total Contributions by Cooperation Types

| Type of Leader | Type of Follower NC ($n = 47$) | WC ($n = 22$) | SC ($n = 27$) | Expected* |
|---|---|---|---|---|
| NC | 0.63 | 1.24 | 1.17 | 0.92 |
| WC | 2.05 | 3.66 | 3.70 | 2.87 |
| SC | 2.85 | 4.40 | 5.32 | 3.89 |

Source: Gächter et al. (2012)

# Priming & Framing

**Dual-Process-Perspective**

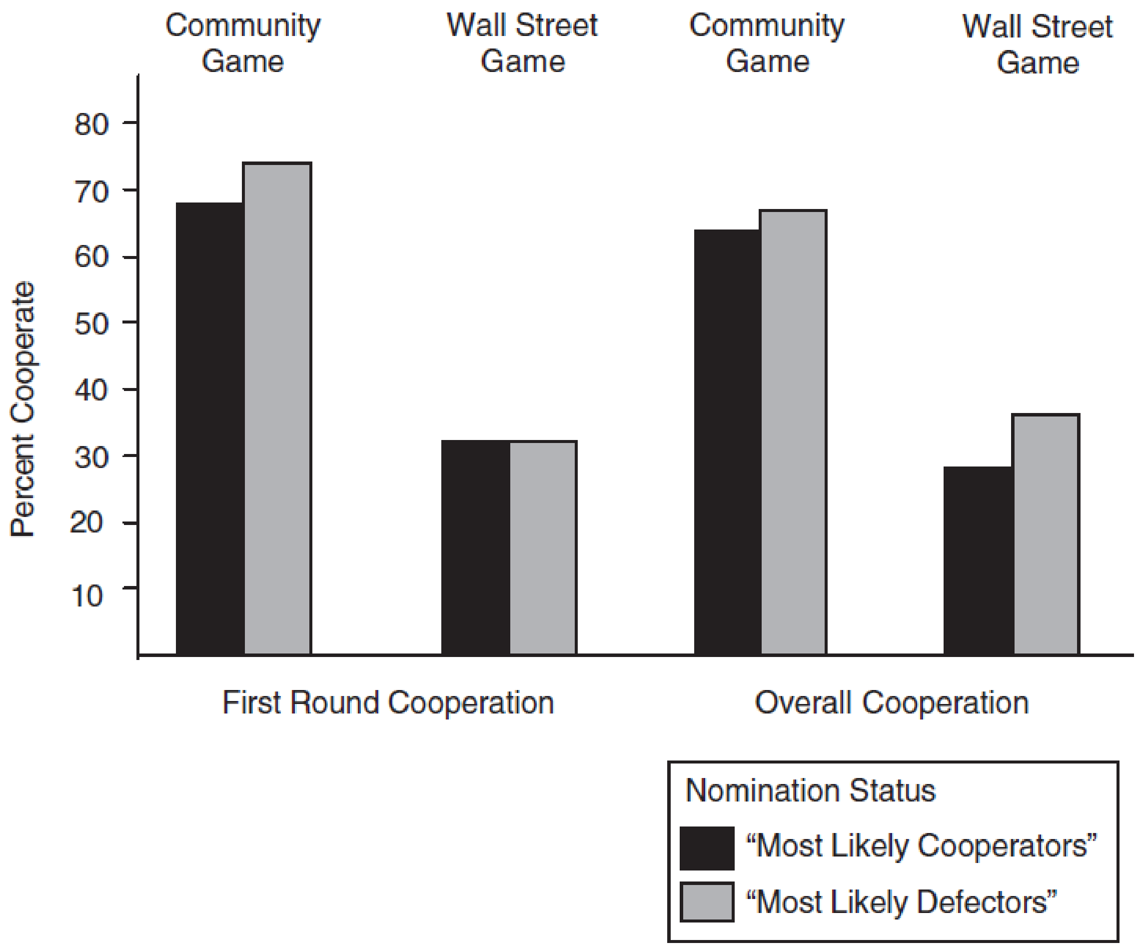


System 1 — automatic, fast, associative

System 2 — deliberate, slow, rule processing

- Definition of the situation (i.e. framing) impacts the interaction between the two selves
- Significant symbols signify the adequacy of frames

# Priming & Framing




Source: Liberman et al. (2004)

# *Application: Open Source Software*

# Open Source Software


*"Why should thousands of top-notch programmers contribute freely to the provision of a public good?"* (Lerner & Tirole 2000)

## Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science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### Abstract

Currently, two models of innovation are prevalent in organization science. The "private investment" model assumes returns to the innovator result from private goods and efficient regimes of intellectual property protection. The "collective action" model assumes that under conditions of market failure, innovators collaborate in order to produce a public good. The phenomenon of open source software development shows that users program to solve their own as well as shared technical problems, and freely reveal their innovations without appropriating private returns from selling the software. In this paper, we propose that open source software development is an exemplar of a compound "private-collective" model of innovation that contains elements of both the private investment and the collective action models and can offer society the "best of both worlds" under many conditions. We describe a new set of research questions this model raises for scholars in organization science. We offer some details regarding the types of data available for open source projects in order to ease access for researchers who are unfamiliar with these, and also offer some advice on conducting empirical studies on open source software development processes.

(*Open Source Software; Innovation; Incentives; User Innovation, Users, Collective Action*)


### 1. History and Characteristics of Open Source Software Development Projects

Open source software is software that is made freely available to all. Open source software development projects are Internet-based communities of software developers who voluntarily collaborate to develop software that they or their organizations need. Open source projects are becoming a significant economic and social phenomenon. Thousands exist today, with the number of developers participating in each ranging from a few to many thousands. The number of users of the software produced by open source software development projects ranges from few to many millions. Well-known examples of open source software having many users are the GNU/Linux computer operating system, Apache server software, and the Perl programming language.

To set a context for exploring the interest that the open source software phenomenon can hold for organization science researchers, we begin by briefly explaining the history and nature of open source software itself (the product). Next we outline key characteristics of the open source software development projects typically used to create and maintain such software (the development process).

#### Open Source Software

In the early days of computer programming commercial "packaged" software was a rarity—if you wanted a particular program for a particular purpose, you typically wrote the code yourself or hired it done. Much of the software development in the 1960s and 1970s was carried out in academic and corporate laboratories by scientists and engineers. These individuals found it a normal part of their research culture to freely give and exchange software they had written, to modify and build upon each other's software both individually and collaboratively, and to freely give out their modifications in turn. This communal behavior became a central feature of "hacker culture." (In communities of open source programmers, "hacker" is a very positive term that is applied to very talented and dedicated programmers.)[1]

In 1969 the U.S. Defense Advanced Research Project Agency (ARPA) established the ARPANET, the first transcontinental, high-speed computer network. This network eventually grew to link hundreds of universities, defense contractors, and research laboratories. Later succeeded by the Internet, it also allowed hackers to

# Open Source Software

- Source code is released under a license (e.g. GPL, Apache license) which grants users the right to use, change, and distribute the software for any purpose and free of charge
- More than 180,000 open source projects; by 2008, more than $60 billion savings by consumers of open source software per year (Source: Wikipedia)
- Typical structure of an open source project:
  - Initiated by a founder/maintainer
  - Source code is made freely available on website (e.g. Sourceforge.net)
  - Mailing lists for the community
  - Gate keepers for the authorized code recruited from the community

# Open Source Software

**Private Investment Innovation Model**

Incentive to innovate comes from monopolistic control by patents and copyrights

**Private-Collective Innovation Model**

- *Technology:* Software is typically non-rivalizing
- *Selective incentives*: Reputation
- *Idiosyncratic and prosocial preferences*: Intrinsic enjoyment of programming, hacker culture
- *Framing*: **Open** software not **free** software (since 1998)
- *Leadership*: Non-authoritarian style, stimulating voluntary contributions by example

# Summary

- Collective action and the voluntary provision of public goods are ubiquitous features of social life as well as economic and business transactions

- Typically there is a problem of inefficiency due to individual underinvestment in the public good

- Empirically the problem of inefficiency is not as severe as predicted by standard economic theory

- Theoretical as well as empirical research has worked out various institutional and organizational features that help to overcome the problem of inefficiency

# Literature


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