“A note on the design of experiments involving public goods”

AUTHORS	Philip E. Graves

ARTICLE INFO	Philip E. Graves (2010). A note on the design of experiments involving public goods. *Environmental Economics*, *1*(2)
RELEASED ON	Thursday, 03 February 2011
JOURNAL	"Environmental Economics"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
0	0	0

Philip E. Graves (USA)

A note on the design of experiments involving public goods

Abstract

Concern about potential free riding in the provision of public goods has a long history. More recently, experimental economists have turned their attention to the conditions under which free riding would be expected to occur. A model of free riding is provided here, which demonstrates that existing experimental approaches fail to explore a potentially important real-world dimension of free riding. In a cash-in-advance economy, free riding becomes a two-stage problem, while existing experiments only address the second stage. That is, one would expect households with high demands for public goods relative to private goods to generate less income than households, preferring ordinary private goods, because the former are unable to individually increment the public good and leisure is valuable. Existing experiments start with a given number of "tokens" for each decision-maker, effectively only addressing the second stage of the free riding problem, namely, under what conditions free riding becomes a problem out of a given income. A recommended solution to this problem is to incorporate the potential to generate income prior to (or simultaneously with) the decision of how to allocate that income between private and public goods.

Keywords: decision-making, choice behavior, public goods, experimental economics, altruism, fairness, conditional reciprocity.
JEL Classification: A10, C9, C92, D03, D12, D64, D81, H41, Q5.

Introduction

In an excellent recent review, Levitt and List (2007) ask: "What do laboratory experiments measuring social preferences reveal about the real world?" They focus on a wide range of experimental games (ultimatum, dictator, trust, gift exchange, and public goods) that have been used to try to understand the nature of preferences in social settings. Their general conclusions are that many real-world markets operate in ways that make pro-social behavior less likely than it seems from laboratory experiments. Although, there are situations, notably publicized dealings among friends and family, in which pro-social behavior might be more likely in the real world than in the laboratory.

The concern here is with public goods games. It is, frequently, observed that the extent of free riding from a given "token endowment", varies according to the nature of the experimental intervention, discussed more fully below. But, an additional free riding problem has not been recognized and, importantly, not been incorporated into experimental design. When incentives exist to free ride in output markets, those incentives also distort input market decisions.

In Section 1, a model of free riding is presented. This model demonstrates that free riding would generally be expected in both input and output markets. In Section 2, it is seen that existing experimental methods ignore half of the general problem, making extrapolation to real-world settings even more problematic than previously thought. The last Section concludes with research recommendations.

1. Rational public good free riding behavior: a simple model

For models of free riding behavior to be relevant to experimental analyses, they must incorporate two central observations that are really a generalization of the prisoner's dilemma. First, if an individual attempts to increment the public good, and others do not, private good losses are large relative to any gains from the public good. Second, if the other households do contribute to the public good provision, an individual household will be little damaged by failing to contribute. Both of these effects work to encourage free riding, but the extent of free riding in the laboratory or in the real world will depend on many things, including the numbers of people involved and whether decisions are "one-shot" or repeating.

Let the price of ordinary goods, X, be the numeraire good and let $(1-L_i)$ represent the share of total time (normalized to unity in equation 1) spent working at wage W_i, and G is the amount of public good consumed. A simple model capturing the essential nature[1] of free riding for household i is as follows:

Max $U(L_i, X_i, G)$ subject to the budget constraint

$$(1-L_i)\, W_i = X_i + pG_i, \qquad (1)$$

where $G = G_i + \Sigma G_j$, $j \neq i$.

That is, the quantity of the public good that each individual actually experiences equals what he and all other households collectively choose. Assuming

[1] Most models of free riding (e.g., those in Varian (1987) or Hanley, Shogren, and White (1997)) do not endogenize leisure, but start with a fixed money income. This explicitly omits the present concern with free riding in input markets.

a Nash equilibrium, we take ΣG_j as given, so the optimization of equation (1) reflects the sum of all individuals' choices.

While the marginal benefit of an increment to the private good is $\partial U(\bullet)/\partial X$, the marginal benefit of the public good is the sum of the benefits over all of the individuals, $\Sigma \partial U(\bullet)/\partial G, \vee i$. Hence, from society's perspective, setting the marginal rate of substitution between G and ordinary goods optimally to equal their price ratios results in $(\Sigma \partial U(\bullet)/\partial G)/(\partial U(\bullet)/\partial X) = p$.

Strictly rational optimizing individuals only equate their individual marginal value to the price: $(\partial U(\bullet)/\partial G)/(\partial U(\bullet)/\partial X) = p$. The marginal benefit level is set much too high[1] with total consumption of G correspondingly set much too low. If there were only two non-cooperating individuals in society with similar preferences, G would be provided at about half of the socially-optimal level, and as the number of individuals gets larger, the difference between the social optimum and the observed provision level progressively increases.

The critical observation, as we move into the next phase of the argument, is not merely that provision levels of the public good, G, are likely to be very far from socially-optimal levels. This may or may not be the case, depending on numbers of individuals in the experiments, their familiarity with each other, and their expectations regarding the number of times the game will be played. What is important is that any time the public good is non-optimally supplied, each individual household will have high marginal values of the public good, in terms of leisure and private goods that they would be willing to give up to increase the public good[2]. That is, each individual has an incentive to undergenerate income ("buying" too much leisure). This provides another avenue of free riding, an avenue that has not been explored, yet, in the public goods experiments in the literature (see Graves (2009) for further detail).

2. The public goods experiments

In typical public goods experiments, a group of n members decide simultaneously how much to invest in the public good, where the payoff for the ith person is given as:

$$P_i = e - g_i + \beta \Sigma_n g_j, \quad (2)$$

where e is initial endowment in "tokens", not varying across subjects; g_i is tokens subject i contributes to the group public good account; β is marginal payoff to each individual from the public good; and $\Sigma_n g_j$ is the sum of the n individual contributions to the public good.

As noted by Levitt and List (2007), by making $0 < \beta < 1 < n\beta$, a prisoner's dilemma situation is created in which every individual has an incentive to engage in free riding behavior that is against their collective best interest. As the cost of the public good, g_i, becomes smaller and as the marginal payoff, β, becomes larger, the extent of free riding would be expected to fall.

Typical findings, per Levitt and List, are that: "Players contribution to public good is roughly 50% of endowment in one-shot games. Many players' contributions unravel to approach 0% in latter rounds of multi-period games". The Nash equilibrium for this game is, frequently, argued to be zero, but from the preceding Section it is clear that if marginal values are high enough, homogeneous individuals will contribute some small amount, resulting is small, but positive, quantities of public goods provided. With heterogeneous subjects, actual contribution levels vary widely (see Jannsen and Ahn, 2003), and a number of variants to the game have been concocted.

Of particular interest for present purposes is the ubiquitous finding that for a given level of average contribution in a round, there is a substantial variance in the level of contribution at the individual level. And this is despite each subject receiving identical initial endowments, which in the real-world would not be the case, as seen in Section 1. Those who desire predominantly public goods would generate less income than those, caring primarily for ordinary private goods.

The equimarginal principle would suggest, ceteris paribus, that those exhibiting high pro-social values out of a fixed endowment would also generate more income by giving up leisure in real world settings. However, as public goods experiments are currently conducted, this possibility is not allowed. An alternative payoff for the ith person could be created as:

$$P_i = e_0 + e_i(t) - g_i + \beta \Sigma_n g_j, \quad (3)$$

where e_0 is an initial "token endowment" independent of work effort, $e_i(t)$ is the amount of "tokens", earned in some time-using activity (where e_i would correspond to a subject's normal after tax wage), and the other variables are as previously defined. This modified experimental approach allows a

[1] For the Cobb-Douglass and similar utility functions that lack a "choke-price", there would be some small amount demanded by each individual, hence, there would be some initial provision. In many realistic experiments with large numbers of anonymous individuals, the optimal quantity of the public good for each individual might be fairly close to zero.

[2] To my knowledge, there are no public good experiments that address the income generation free riding behavior of particular interest here. The experiments start with some fixed number of tokens that can be allocated between the private and public good, ignoring how much individuals might wish to increment work effort to increase the number of tokens available to buy the public good.

richer and potentially more realistic set of behaviors to be observed than does the restriction in existing studies to identical initial "token" income.

Conclusions

Economic experiments in public goods provision are currently conducted by giving all subjects the same initial endowment and observing how contributions to the public good of interest change under varying circumstances. In the real-world, one would expect that those caring the most about public goods would generate the least income, so the imposition of initial endowment equality renders extrapolation of these experiments to an understanding of the real world problematic.

A recommendation would be to have a two-stage procedure in which subjects could earn "tokens" in a first stage to be used to contribute to the public good in a second stage. One might also design an experiment in which the decision of how many "tokens" to earn and how much to consume on the private and public good were simultaneously undertaken. With one of these modifications, a very pro-social individual would be expected to both earn more tokens in the first stage (or simultaneously) and contribute more tokens at the second stage (or simultaneously). A rational free rider might generate little or no additional token income and might offer little of his or her non-earned endowment income for the public good.

It would be particularly interesting to examine how various subjects' work effort would change if they were told explicitly: (a) that working more at stage one would enable greater payments for the public good at stage two; versus (b) that they could keep accumulated tokens as income available for private goods at the conclusion of the experiment regardless of their public good contribution.

Acknowledgements

I would like to acknowledge the comments on related papers of those attending seminars at the University of British Columbia, George Mason University, Colorado State University, Georgia State University, North Carolina State University, Rochester Institute of Technology, University of Chicago, University of Colorado, University of Louisville and the University of Missouri on earlier variants of this paper. I would like, specifically, to thank Ron Cummings, Nick Flores, Rick Freeman, Don Fullerton, John Horowitz, John List, Keith Maskus, Ted McConnell, Peter Mueser, Jack Robles, Kerry Smith, Laura Taylor, George Tolley, Donald Waldman, and Randy Walsh. Additionally, I would like to acknowledge the support of CESifo in Munich where I revised this paper. I retain responsibility for any remaining errors.

References

1. Graves, P.E. (2009). A note on the valuation of collective goods: overlooked input market free riding for non-individually incrementable goods, *The B.E. Journal of Economic Analysis and Policy*, Vol. 9, Iss. 1 (Topics).
2. Hanley, N., J.F. Shogren, and B. White (1997). Environmental economics in theory and practice, Oxford University Press: New York.
3. Jannsen, M.A. and T.K. Ahn (2006). Learning, signaling, and social preferences in public-good games, *Ecology and Society*, 11(2): 21.
4. Levitt, S.D. and J.A. List (2007). What do laboratory experiments measuring social preferences reveal about the real world? *Journal of Economic Perspectives*, 21 (2).
5. Varian, H.R. (1987). Intermediate microeconomics: a modern approach, W.W. Norton & Company: New York.