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## Journal of Economic Behavior &amp; Organization

journal homepage: [www.elsevier.com/locate/jebo](http://www.elsevier.com/locate/jebo)

# The impact of burden sharing rules on the voluntary provision of public goods



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## ARTICLE INFO

### Article history:

Received 10 April 2013

Received in revised form 14 April 2014

Accepted 19 April 2014

Available online 6 May 2014

### JEL classification:

C72

C92

H41

### Keywords:

Public goods

Institutions

Minimum contribution rules

Cooperation

Heterogeneity

## ABSTRACT

We investigate how burden sharing rules impact the voluntary provision of a public good which generates heterogeneous benefits to agents. We compare different rule-based contribution schemes where agents can first suggest a minimum provision level of the public good, before the smallest common denominator is implemented. We find that rule-based contribution schemes significantly increase payoff levels relative to the VCM, while significant differences exist between the rules. Importantly, the equal-payoff rule maximizes payoffs for all player types. This also holds relative to a scheme where different types of players separately can determine their minimum contribution levels. Our results lend insights into the efficient institutional design for voluntary private provision of public goods, and how burden sharing rules interact with efficiency when agents are heterogeneous.

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## 1. Introduction

The provision of public goods often faces the problem that agents need to voluntarily decide on their own contributions or – alternatively – have to agree upon some desired provision level of the public good in combination with a specific burden sharing rule. This challenge is particularly demanding when interests differ among players due to heterogeneous preferences. Examples reach from international climate policy (e.g., Nordhaus, 2010) to the provision of local public goods like maintaining infrastructure for irrigation (e.g., Bardhan, 2000; Dayton-Johnson, 2000a,b). While strong free-riding incentives prevent a pure voluntary and uncoordinated solution, both the level of the provision of a public good and the distribution of the burden are mostly subject to intense debate.

In this paper, we investigate how burden sharing rules impact the provision level of a public good that all agents voluntarily accept. We focus on different rule-based contribution mechanisms that are based on the principle of the smallest common denominator: all agents can suggest a minimum provision level of the public good that is allocated across agents according

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to some predetermined rule. The minimum of all proposals, i.e. the smallest common denominator, then takes effect and creates a lower bound for the individual contribution levels.<sup>1</sup>

This approach reflects many real world institutional arrangements that involve either a simultaneous or a sequential choice of the provision goal and the burden sharing rule. For the climate policy example, a pre-negotiated rule, e.g. using uniform obligations among countries (Barrett, 2003), may be particularly beneficial in reducing negotiation costs when the total target changes over time. Since each participating country needs to sign and ratify the agreement, the player with the smallest proposal is pivotal. Countries can, however, voluntarily go beyond their obligations. Similar burden sharing rules can be applied to individual decisions on voluntary public good provision (Dayton-Johnson, 2000a,b). In the literature, the interaction of burden sharing has been discussed within the concept of Lindahl prices (Silvestre, 1984; Sato, 1987), where the outcome is given when no agent would desire reducing the public-good provision simultaneously with his own individual contribution to the public good (see van den Nouweland et al., 2002; Bilodeau and Gravel, 2004). We contribute to the literature by experimentally comparing the ability of different rule-based contribution schemes to overcome the inefficiency in public good provision.

Our paper relates to the vibrant literature on the voluntary provision of public goods. Orzen (2008) and Dannenberg et al. (2014) have shown the benefits from such a smallest common denominator rule when agents are homogeneous. It may not be surprising that these authors find this mechanism to allow groups to reach large provision levels, thereby generating substantial welfare gains relative to the voluntary contribution mechanism, as players have a weakly dominant strategy to suggest an efficient provision and the only fair burden sharing rule allocates the same burden to all players. However, cooperation in many settings faces the challenge of substantially differing interests, for example due to different wealth or costs and benefits from the public good. Our paper explores the performance of rule-based contribution schemes for heterogeneous agents. We focus on differences in the agents' benefits from the public good.

There is a significant literature on voluntary public good provision when players are heterogeneous. Many papers concentrate on endowment heterogeneity. Ledyard (1995) and Zelmer (2003) each review several experimental studies and find a negative impact of endowment heterogeneity on contributions.<sup>2</sup> Spraggon and Oxoby (2009) show endowment effects to be sensitive to the endowments' origin. Ledyard (1995) and Zelmer (2003) summarize findings that higher marginal per capita returns (MPCR) increase contributions. Relative to homogenous groups of identical MPCR, Fisher et al. (1995) report tendencies of low-type players (MPCR = 0.3) contributing more and high-type players (MPCR = 0.7) contributing less when combined in one heterogeneous group. Tan (2008) find that heterogeneity with respect to contributing costs lowers cooperation. Reuben and Riedl (2013) show that heterogeneities in endowments or benefits do not alter decision behavior if no punishment options exist, while with punishment contributions are proportional to endowments or respectively to the ratio of marginal benefits. Fellner et al. (2011) investigate the impact of productivity isolated from the costs of contribution. They report that information about heterogeneity increases cooperation but alters contribution norms. While less information leads to more equal contributions, subjects focus on group efficiency in case of full information. Considering an endogenous coalition formation setting, McGinty et al. (2012) focus on different distribution rules for coalition payoffs among heterogeneous players and find that efficiency substantially depends on the rule for division of coalitions' benefits.

In this paper, we introduce heterogeneity with respect to the benefits from a public good in a linear four-person game. Each group consists of two high-type players (MPCR = 0.7) and two low-type players (MPCR = 0.3). We compare the traditional VCM with four other treatments that are based on the smallest common denominator rule, but differ in the implemented burden sharing rule: (i) two variants of equal minimum contribution requirements for all players, (ii) separated minimum levels for low- and high-type players, and (iii) a burden sharing rule aiming at equalizing payoffs of all players. The first rule equally distributes the contribution obligation on all players. We thereby can study the performance of an equal contribution rule (Orzen, 2008; Dannenberg et al., 2014) to a heterogeneous player setting. Here, the different types of players can only implicitly differentiate their burden by voluntarily contributing more than required. The other two rules make this differentiation of burdens more explicit: The second rule allows both types of players to separately implement minimum contribution requirements that are only binding for players of their own type. This treatment is inspired by proposals in international climate policy negotiations to have small agreements among more homogeneous players rather than creating the problem of complicated discussion on burden sharing rules when all countries try to agree on a comprehensive treaty as in the Kyoto process (e.g., Olmstead and Stavins, 2006; Edenhofer et al., 2013). It also alludes to recent findings that public good provision may benefit from endogenously choosing institutional features (e.g., Kosfeld et al., 2009) as the differentiation of burdens based on the separate minimum requirements is endogenously determined. The last rule exogenously differentiates the burden with the goal of equalizing payoffs. This rule is inspired by recent findings that behavior by some individuals

<sup>1</sup> The implementation of the smallest common denominator bears similarities to "weakest link" games (e.g., Harrison and Hirshleifer, 1989; Cornes and Hartley, 2007). However, while in weakest link games, provision exceeding the implemented minimum (i.e., weakest link) is costly to agents, making a minimum proposal larger than the implemented smallest common denominator comes at no costs, as agents decide about the actual contribution level in the second stage.

<sup>2</sup> van Dijk et al. (2002) and Cherry et al. (2005) as well as Anderson et al. (2008) also confirm the negative endowment effect. In contrast, Chan et al. (1996, 1999) and Buckley and Croson (2006) show potential positive effects. Recent studies on this topic include Sadrieh and Verbon (2006), Koukoulis et al. (2010) and Georgantzis and Proestakis (2011).

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