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The provision point mechanism with refund bonuses

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ABSTRACT

We introduce refund bonuses into the provision point mechanism. If a total contribution is less than the provision point, each contributor receives not only his contribution refunded but also a refund bonus the size of which is proportional to the contribution made. However, because of competition for refund bonuses the provision point is reached in equilibrium. Furthermore, the mechanism can uniquely implement the public good project with Lindahl prices. The mechanism also has other applications.

1. Introduction

For private funding of discrete public goods, a frequently applied fund-raising method is the voluntary contribution mechanism with a provision point, commonly known as the provision point mechanism (Palfrey and Rosenthal, 1984; Bagnoli and Lipman, 1989; also see Andreoni, 1998). This method has a long history of applications, perhaps the most famous example of which is Joseph Pulitzer's fund-raising campaign for the construction of the pedestal for the Statue of Liberty in New York. Most recently, the mechanism has been successfully applied by Internet crowdfunding platforms such as Kickstarter and Indiegogo for funding numerous public projects ranging from open-air art exhibitions, skateboarding parks, preservation of archaeological sites to the launch of the first public space telescope.[1] The provision point mechanism owes its popularity to its simple structure in spite of the implementability concerns that this structure raises. Indeed, the mechanism is fraught with multiple equilibria, both efficient and inefficient, and particularly with free riding.[2] This paper offers a simple modification that significantly improves the mechanism's properties up to strict implementation.

As an illustration, consider a group of people that can benefit from a public good project, say, a $1000 drinking fountain. Under the provision point mechanism with refunds, the drinking fountain is provided when at least $1000 is raised in contributions, which are refunded otherwise. Obviously, the zero-contribution outcome is equilibrium as is any other combination of individually rational contributions that sum up to the provision point. Now imagine that one group member contributes $100 and announces that if others contribute less than $900 in total, then he will divide his contribution among others in the proportion of their individual contribution to the total contribution. Namely, in the event of insufficient contributions, each contributor gets his contribution back plus a share of $100 as refund bonus. But with this modification, the only equilibrium outcome is the provision of the public good.

To see this, first observe that the zero-contribution outcome is not equilibrium. By just contributing a penny, any member could get the entire $100 as refund bonus. With the refund bonus increasing in own contribution, no outcome with total contributions less than $900 can make an equilibrium. The only possible equilibrium outcome is when total contributions exactly reach the provision point of $900, the necessary condition for which is that the promised bonus money of $100 does not exceed the net value of the public good. Thus, in equilibrium the public good is provided without the distribution of refund bonuses. The same outcome can also be achieved when the mechanism designer does not make any contribution, but sets the provision point at $1000 and promises an amount of bonus money in the case of non-provision. In the paper, we analyze the latter version of the mechanism and also discuss its other variants.

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[1] For more on crowdfunding, see Young (2013).

[2] In laboratory experiments, the success rate of the provision point mechanism is about 50% (see Isaac et al., 1989; Cadsby and Maynes, 1999; for reviews, see Ledyard, 1995; Chen, 2008). In the field, it is significantly lower (Rose et al., 2002). In 2013, Kickstarter reported the success rate of 44% for all of its initially pre-screened crowdfunding campaigns, which also included projects other than for public goods.

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Under the proposed mechanism, every consumer obtains an equilibrium payoff from the public good at least as high as that from the highest refund bonus assigned to him if he deviates. Therefore, the effect of refund bonuses is the reduction of the set of strategies that can be supported in equilibrium. More generous refund bonuses imply a smaller set of equilibrium strategies as deviations become more profitable. With bonus money set at the net value of the project, the mechanism not only uniquely implements the public good project but does so with Lindahl pricing: Consumers contribute the same proportion of their valuations for the public good.

The introduction of refund bonuses into the provision point mechanism resolves the equilibrium coordination problem. For the same reason, a similar mechanism can be applied to other problems with multiple Pareto-ranked equilibria such as the collective action problem or markets with adverse selection (Akerlof, 1970). In these problems, schemes with bonus money can be designed so that they eliminate undesirable equilibria leaving only the efficient ones, which, by design, do not lead to the distribution of refund bonuses. From this more general perspective, our mechanism can be viewed as a practical application of the augmented revelation principle of Mookherjee and Reichelstein (1990), where side payments are designed to eliminate non-truthful equilibria.

In the next section, we discuss related literature. In Section 3, we introduce the provision point mechanism with bonus money and analyze its performance under complete information. In Section 4, we discuss sources of bonus money, different informational environments, present a class of equivalent mechanisms, and also discuss other applications of the mechanism. The last section concludes the study.

2. Related literature

In social cooperation dilemmas, rewards play an important role in inducing higher levels of cooperation. For funding public goods, a well known example of a mechanism with rewards is a lottery.[3] Morgan (2000) studies a lottery mechanism where a fixed amount from ticket revenues is used for lottery prizes with the rest of the revenues spent on public goods. He demonstrates efficiency gains of the lottery mechanism over the voluntary contribution mechanism. Off the equilibrium path, there is a close connection between the lottery mechanism studied in Morgan (2000) and the mechanism with refund bonuses proposed here. The lottery mechanism also has inefficient equilibria of low contributions unless the lottery organizer has a budget to fill the difference between the ticket revenues and the promised lottery prize so that the lottery is not recalled. This clause eliminates low-contribution equilibria as do refund bonuses in our mechanism. However, even though in the lottery mechanism rewards increase allocative efficiency, they may impair distributional efficiency as poorer people, motivated by lottery prizes, end up contributing disproportionately too much.

In the event of insufficient contributions, the idea to reward contributors also appears in Tabarrok (1998).[4] In his model, agents have a binary choice of making or not making a pre-determined contribution toward a public good, which is provided conditional on a sufficient number of contributors. He proposes an “assurance contract” that specifies a reward that each contributor receives in case the number of contributors misses the target needed for implementation. With such a reward, like in the present paper, the mechanism designer can effectively and at no cost eliminate inefficient outcomes. The present paper is a generalization of this idea both in terms of strategy spaces and other applications. The main advantage of our mechanism with continuous contributions lies in its superior properties of distributional efficiency. For a similar reason, our mechanism can also achieve allocative efficiency in environments with very uneven distributions of private valuations, where an assurance contract with pre-determined contributions may be restrictive in raising sufficient funds.

Another strand of literature emphasizes the role of punishments for inducing contributions toward public goods. In environments where agents are perfectly informed about each other, Varian (1994) proposes a mechanism with punishments that are imposed on agents if their reported own Lindahl price differs from what other agents report as their Lindahl price. The punishment structure ensures truthful reports and, consequently, the implementation of the Lindahl allocation. Even though Andreoni and Varian, (1999) demonstrate the effectiveness of the mechanism in laboratory experiments, the problem with the mechanism is that it requires the authority to punish and is rather complex. Our proposed mechanism achieves the same outcome but through an incentive structure in reverse of that in Varian (1994). Namely, each agent reports his own Lindahl price and is rewarded if someone else shades his own, but no authority is required for implementation.

3. The provision point mechanism with bonus money

There are a set $N = \{1, \ldots, n\}$ of consumers and a discrete public good, which costs C to provide. A consumer i's willingness to pay for the public good is given by $v_i \geq 0$, $i \in N$, to which we also refer as his valuation. Until further notice, we assume that individual valuations are publicly known. Let V denote the sum of consumers' valuations.

A mechanism designer solicits voluntary contributions toward the public good. Let g_i denote consumer i's contribution and G the sum of contributions. If $G \geq C$, the public good is financed out of the contributions collected, with the excess amount G–C wasted (assumed for the ease of exposition). If $G < C$, the public good is not provided, the contributions are refunded, but also each contributor receives a refund bonus $\frac{g_i}{G}R$, where R is the amount of bonus money promised by the mechanism designer from own budget in the beginning of the campaign. The payoff to consumer i is given by

$$\pi_i(g_i, G) = \begin{cases} \mathcal{I}(G \geq C)[v_i - g_i] + \mathcal{I}(G < C)\left[\frac{g_i}{G}R\right] & \text{if} \quad G > 0 \\ 0 & \text{if} \quad G = 0, \end{cases} \tag{1}$$

where $\mathcal{I}(.)$ is an index function.

We assume that consumers choose contributions (without randomizing) that constitute a Nash equilibrium of the game induced by mechanism R, which is short for a mechanism with promised bonus money R. Letting G_{-i} denote the sum of all contributions of consumers other than i, we define

Definition 1. *A vector of contributions* (g_i^*), $i = 1, \ldots, n$, *is a Nash equilibrium if for each i,* g_i^* *maximizes* $\pi_i(g_i, G_{-i}^* + g_i)$.

The next proposition characterizes the set of pure-strategy Nash equilibria, which we denote by $\Gamma(R)$.

Proposition 1. *Let* $V > C$ *and* $R > 0$. $\Gamma(R) = \left\{ \left(g_i^*\right) : \forall i, g_i^* \leq \frac{C}{R+C} v_i, G^* = C \right\}$ *if* $R \leq V - C$. *Otherwise,* $\Gamma(R) = \{\varnothing\}$.

Proof. In equilibrium, $G^* < C$ cannot hold as any consumer could obtain a higher refund bonus by marginally increasing his contribution because of $R > 0$. Likewise, any consumer with a positive contribution could gain in utility by marginally decreasing his contribution if $G^* > C$. Thus, the equilibrium candidates need to have $G^* = C$. A vector (g_i^*) is an equilibrium if for each consumer i the net utility from the public good, $v_i - g_i^*$, exceeds the highest possible refund bonus, $\frac{g_i^*}{C}R$, or after transformations

$$g_i^* \leq \frac{C}{R + C} v_i. \tag{2}$$

[3] For other examples, see Falkinger (1996) who proposes a mechanism that rewards contributors with above-average contributions. Goeree et al. (2005) demonstrate the advantages of the all-pay auction design in soliciting contributions.

[4] I thank Ted Bergstrom for bringing my attention to this work.