

Aggregating Citizen Preferences for Public Projects Through Civic Crowdfunding*

Extended Abstract

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ABSTRACT

We focus on the aggregation of citizen preferences for public projects through civic crowdfunding. Existing civic crowdfunding mechanisms consider only agents with positive valuation towards the public project. Moreover, these mechanisms assume that each agent has a symmetric belief about the project getting provisioned. As public projects aim to cater to the majority, they should be provisioned only if the majority prefers it. To incorporate negative valuations, we propose a methodology to convert existing civic crowdfunding mechanisms for positive preferences to cater to markets having both types of agents. Specifically, we adapt existing PPR and PPS mechanisms to design PPRN and PPSN, that incentivize agents to contribute towards or against the project's provision: based on their preference. Besides, to address asymmetric beliefs, we propose a novel reward scheme, Belief Based Reward (BBR) based on Robust Bayesian Truth Serum (RBTS) mechanism. BBR rewards agents based on their belief towards the project's provision. Using this reward scheme, we introduce a general mechanism for civic crowdfunding which allows for agents having asymmetric beliefs towards the project getting provisioned and incentivizes them to contribute towards the project's provision. We illustrate the general mechanism by designing two novel mechanisms, namely PPRx and PPSx, adapting PPR and PPS respectively, and prove that in both the mechanisms the project is provisioned at equilibrium.

KEYWORDS

Mechanism Design; Civic Crowdfunding; Preference Aggregation; Nash Equilibrium; Sub-game Perfect Equilibrium

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1 INTRODUCTION

With the advent of modern technology, citizens all over the world are more involved in their government's decision making than ever before. These modern technologies have served as a platform for citizens to voice their opinions, allowing for increased democratic participation by continuously raising awareness towards current affairs and government projects. For instance, consider the construction of a garbage dump yard in a locality. Here, a certain set of citizens may wish to relocate the project from its current location to another. In other words, these citizens may be against the construction of the dump yard – in the locality proposed. In such a scenario, the construction of the dump yard (as well as the locality in which it is constructed) must depend on the majority's opinion of it. Since such *public* projects aim to cater to the majority, they should only be provisioned if a majority *prefers* them. To determine whether the provision of a public project benefits the majority, we need a mechanism to *aggregate* citizens' preferences.

Crowdfunding is a process of raising funds from a large pool of interested agents and is an active area of research [1, 2, 6, 9, 10]. The process, when applied for the provision of public projects, is called *civic crowdfunding*. In the last decade, civic crowdfunding has grown to be instrumental in providing a platform through which citizens can collectively finance social initiatives such as libraries, public parks, etc. A consequence of this "pooling" of resources, through civic crowdfunding, is that it leads to aggregation of agents' private valuation of the public project. Thus, civic crowdfunding provides a natural way for *preference aggregation*.

In the standard approach for civic crowdfunding, the social planner uses the voluntary contribution mechanism with a provision point (h^0), the *provision point mechanism* (Bagnoli and Lipman [3]). The social planner sets up a target amount, referred to as the provision point, to be raised. If the contributions, $x_i \forall i \in \mathbb{A}$, exceed the provision point, social planner provisions the project; otherwise, returns the contributions. The mechanism, however, has been shown to have several inefficient equilibria [3, 4, 8].

Provision Point mechanism with Refund bonus (PPR) by Zubrickas [12] introduces an additional *refund bonus* (B) to be paid to each contributing Agent i (along with their contribution x_i) in case the project is not provisioned. Chandra et al. [5] showed that in *sequential setting*, wherein the history of contributions is known to the agents, PPR collapses to a simultaneous move game, among the contributing agents. Towards this, they proposed Provision Point

Equilibrium Contribution	PPRN		PPSN	
	Market 1 (PPR1)	Market 2 (PPR2)	Market 1 (PPS1)	Market 2 (PPS2)
Agent $i \in \mathbb{P}$	$< \left(\frac{h^1 + h^2}{B + h^1 + h^2} \right) \theta_i $	0	$\leq C_0(\theta_i + Q^{a_i})$ $-C_0(Q^{a_i})$	0
Agent $i \in \mathbb{N}$	0	$< \left(\frac{h^1 + h^2}{B + h^1 + h^2} \right) \theta_i $	0	$\leq C_0(\theta_i + Q^{a_i})$ $-C_0(Q^{a_i})$

Table 1: PPRN and PPSN Mechanisms.

mechanism with Securities (PPS) with refunds based on complex prediction markets governed by a *cost function* C_0 and depending on the total issued securities at time t , q^t . They showed that it induces a sequential game, in which the project is provisioned at equilibrium and each Agent i contributes as soon as it arrives in the market, i.e., at time a_i . Thus in this paper, for a sequential game, we focus on PPS while focusing on PPR for a simultaneous game. We leave it for future work to explore other provision point mechanisms with refunds [7].

Note that in all these mechanisms only those agents with a positive valuation, i.e., $\theta_i \geq 0 \forall i \in \mathbb{A}$, towards the project contribute to its provision. Thus, the civic crowdfunding literature does not address such negative valuation, i.e., $\exists i$ s.t. $\theta_i < 0$. The mechanisms also assume that apart from knowing the history of contributions, each Agent i has *symmetric* belief towards or against the project's provision, i.e., $k_i^1 = 1/2; k_i^2 + k_i^3 = 1$. Motivated to break these barriers on an agent's information structure in existing literature for civic crowdfunding, in this paper, we address these two limitations by (i) handling symmetric agents with negative preference and (ii) handling positive agents with *asymmetric* belief towards the project's provision, independently.

2 PREFERENCE AGGREGATION

For preference aggregation through civic crowdfunding, we require mechanisms that also incorporate negative agents. For this, we set up two parallel markets, with two different targets – one for the provision, i.e., *provision point* (h^1) and one against the provision, i.e., *rejection point* (h^2), for the project. The project is provisioned (not provisioned) if the provision (rejection) point is reached first. A strategic agent may choose to contribute in a market, against its preference, if its *expected utility* for contributing in that market is more than if it contributes in the market based on its true preference. Thus, the challenge in such a setting remains to ingeniously design a refund scheme such that the agents are incentivized to contribute based on their preference, thus allowing for aggregation of agents' exact preferences. For this, we propose a methodology through which existing mechanisms for positive preferences can allow for preference aggregation, by catering to both type of agents, such that agents contribute to the market based on their actual preference.

Towards this, we introduce novel mechanisms, namely, PPRN by leveraging PPR; and PPSN by leveraging PPS such that at equilibrium either the provision or the rejection point holds. For these mechanisms, let $\mathbb{P} (\mathbb{N})$ denote the set of all positive (negative) agents, such that $\mathbb{A} = \mathbb{P} \cup \mathbb{N}$. Further, let $\vartheta^1 = \sum_i \theta_i \forall i \in \mathbb{P}$ and $\vartheta^2 = \sum_i (-\theta_i) \forall i \in \mathbb{N}$, i.e., $\vartheta = \vartheta^1 - \vartheta^2$. For PPSN, we have $Q^t = \min(q_{PPS1}^t, q_{PPS2}^t)$. Table 1 summarizes these mechanisms.

For both mechanisms, the project is always provisioned if $\vartheta^1 > h^1$ and $\vartheta \geq 0$ or is never provisioned if $\vartheta^2 > h^2$ and $\vartheta < 0$. Thus,

these mechanisms allow for truthful aggregation of private preferences of each agent with respect to public projects.

3 MECHANISMS FOR ASYMMETRIC AGENTS

In civic crowdfunding for agents with *asymmetric* beliefs, a strategic agent with significant belief towards the project's provision may not contribute towards the project as it believes that the project would be provisioned regardless of its contribution – thereby increasing its utility by free-riding. Thus, such asymmetric agents need to be *further* incentivized to contribute towards the project's provision. For this, we propose a novel reward scheme *Belief Based Reward* (BBR) that rewards agents based on their belief towards the project's provision. The reward for an Agent i is proportional to a score \mathbb{M}_i , calculated through a *peer prediction* mechanism (eg., [11]) and depends on its belief k_i^1 reported at time t_i . Eq. 1 presents BBR $\forall i$ with B^B as the budget. Here, $\mathbb{A}^+ = \{i | \forall i \in \mathbb{A} : k_i^1 > 1/2\}$ and $\mathbb{A}^- = \{i | \forall i \in \mathbb{A} : k_i^1 < 1/2\}$.

$$b_i = \begin{cases} \frac{w_i}{\sum_j w_j} \times B^B & \forall j \in \mathbb{A}^+; \forall i \in \mathbb{A}^+ \\ \frac{w_i}{\sum_j w_j} \times B^B & \forall j \in \mathbb{A}^-; \forall i \in \mathbb{A}^- \end{cases} \quad (1)$$

for $w_i = \frac{\mathbb{M}_i}{\sum_j \mathbb{M}_j} \forall j \in S^{t_i}$ where S^{t_i} consists of all the agents that have reported their belief till t_i .

With BBR, we propose a *general* mechanism for civic crowdfunding which incentivizes agents with asymmetric beliefs to contribute towards the provision. The general mechanism consists of two phases, (i) *Belief Phase* (BP), where each Agent i arrives at time a_i^1 and reports its belief k_i^1 ; and (ii) *Contribution Phase* (CP), where each Agent i arrives at time a_i^2 and contributes x_i . The budget allocated to BP is B^B and to CP is B^C . We show that in this mechanism the contributions are such that the project is provisioned at equilibrium. To illustrate the general mechanism, we present novel mechanisms, namely, PPRx and PPSx, by plugin PPR and PPS in CP. Table 2 summarizes these mechanisms. Trivially, in PPRx and PPSx, the equilibrium contributions are such that agents with greater belief to contribute *more* than agents with lesser belief.

Mechanism	Equilibrium Contribution	
	Agent $i \in \mathbb{A}^+$	Agent $i \in \mathbb{A}^-$
PPRx	$\leq \left(\frac{k_i^1 \theta_i + k_i^1 b_i}{k_i^2 B^C + k_i^1 h^0} \right) h^0$	$\leq \left(\frac{k_i^2 \theta_i - k_i^1 b_i}{k_i^1 B^C + k_i^2 h^0} \right) h^0$
PPSx	$\leq C_0(\theta_i + b_i + q^{a_i}) - C_0(q^{a_i})$	$\leq C_0(\theta_i - b_i + q^{a_i}) - C_0(q^{a_i})$

Table 2: PPRx and PPSx Mechanisms.

Trivially, from Table 2, the equilibrium contribution $\forall i \in \mathbb{A}^+$ is *greater* than $\forall i \in \mathbb{A}^-$ for the same valuation and belief. Thus, PPRx and PPSx provide a *natural* way for civic crowdfunding with asymmetric agents such that the project is provisioned at equilibrium. **Discussion.** Preference aggregation for asymmetric agents, provides an extra dimension for the agents to manipulate the mechanism. For instance, an Agent $i \in \mathbb{A}^+$ with $\theta_i \geq 0$, will *always* contribute towards the project not getting provisioned, as it believes that the project will be provisioned anyways, making it eligible for the additional refund bonus. This "general setting" can be further explored in future work.

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