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## The informational value of sequential fundraising

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### Abstract

This paper examines a puzzling inconsistency between the theoretical prediction of private provisions to public goods and actual fundraising behavior. While fundraisers often choose to announce past contributions, economic theory predicts that contributions will be largest when donors are uninformed of the contributions made by others. This paper suggests that an announcement strategy may be optimal because it helps reveal the charity's quality. It is shown that when there is imperfect information about the value of the public good and contributors can purchase information regarding its quality, then there exist equilibria in which an announcement strategy is optimal. Interestingly, in equilibrium a high-quality charity receives contributions that exceed those that would result had the quality of the charity been common knowledge. Hence, an announcement strategy not only helps worthwhile organizations reveal their type, but it also helps the fundraiser reduce the free-rider problem. © 2002 Elsevier Science B.V. All rights reserved.

*Keywords:* Private provisions; Public goods; Fundraising behavior

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### 1. Introduction

The literature on charitable giving typically assumes that the fundraising game is exogenously determined, thereby ignoring the possibility that fundraisers may be able to design fundraising drives to maximize their objective functions.<sup>1</sup> If we are to understand charitable giving, then we must recognize the alternative strategies available to the fundraiser and better account for the role of the

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<sup>1</sup>See for example Andreoni (1988, 1990, 1995), Bergstrom et al. (1986), Cornes and Sandler (1984).

fundraiser in the contribution game.<sup>2</sup> Most of the literature on voluntary contributions assumes that donations are given simultaneously, yet the characteristics of many fundraisers suggest that the underlying game is a sequential game. For example, in practice, fundraisers often use a sequential solicitation strategy and announce contributions that are given during a fund drive. In addition, capital campaigns are typically launched by the announcement of a large ‘leadership’ donation, and new contributors and their pledged amounts are made public throughout the campaign. Also, recurring fundraising campaigns often inform contributors of previous donations made in the local community or at the latest charity event.<sup>3</sup>

This paper investigates the role of the fundraiser in the contribution game and examines why and when a fundraiser has an incentive to announce contributions. Current theory on private provision of public goods suggests that an announcement strategy is suboptimal. Varian (1994) shows that private contributions will be largest when contributors are uninformed of the donations made by others. However, this result relies on the assumption that the first contributor can commit to giving only once. When this assumption is relaxed it can be shown that the contribution levels with and without an announcement are identical. That is, a fundraiser will achieve no additional gain by announcing previous contributions.

Why then do many fundraisers appear to be far from indifferent between announcing and not announcing past contributions? The hypothesis of this paper is that an announcement strategy succeeds because it helps reveal otherwise unknown information about the quality of the public good. Indeed the paper demonstrates that when there is imperfect information, then there exist equilibria where charities, independent of quality, choose to announce past contributions, and high-quality charities strictly prefer this action. The reason is that the initial contributor acquires costly information about the charity’s quality, and the fundraiser is able to credibly make this information common knowledge by announcing the level of the first contribution. Hence, for high-quality charities, announcements generate contributions that exceed those that arise when past contributions are not announced.

Of particular interest is that by announcing contributions high-quality charities can secure a provision level which exceeds the level that would result had the charity’s quality been common knowledge. An announcement strategy not only helps high-quality projects to be recognized as being worthwhile, but it also enables them to reduce the traditional free-rider problem of private provision of public goods.

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<sup>2</sup>Examples of previous research on fundraising are Rose-Ackerman (1982), Steinberg (1985, 1986, 1991), Weisbrod (1988), Bilodeau and Slivinski (1996, 1997, 1998), Andreoni (1998), Slivinski and Steinberg (1998), and Romano and Yildirim (2001).

<sup>3</sup>Edles (1993) recommends that fundraisers inform future contributors of the number of donors and the total amount that they have contributed.

The next section of the paper provides a brief review of the work that motivates the present paper. The third section describes the model and examines the equilibria that arise. The last section concludes the paper.

## 2. Literature review

Varian (1994) examines a model in which two individuals make sequential or simultaneous donations to a public good. He shows that if donations are announced and the first contributor can commit to a one-time contribution, then the first contributor can effectively free ride on the second contributor by committing to a low initial donation. The implication of this result is that relative to a no-announcement fundraising strategy, less of the public good is provided when the first contribution is announced.

This result indicating the suboptimality of announcement strategies relies on the strong assumption that the first contributor can commit to giving only once. Clearly, the first contributor prefers a scenario in which she is prevented from contributing more than once; however, if given the option she will increase her contribution in the second round of the game. Unfortunately, it is difficult to imagine the mechanism that would give such commitment power to the first contributor. Assuming that the fundraiser's objective is to maximize the sum of the contributions, it is doubtful that the fundraiser would refuse an additional donation from the first contributor.

Suppose instead that the first contributor is unable to commit to her first donation. That is, following her initial donation, the first contributor can make an additional donation to the public good simultaneously with the second contributor.<sup>4</sup> The equilibrium contribution of this game is identical to the level that results when the first contribution is not announced and contributions are made simultaneously.<sup>5</sup> Hence, the contributed amount is independent of the announcement strategy, and there is no reason why the fundraiser should prefer to announce past contributions.

This prediction not only runs counter to common practices of the fundraising industry, but it is also inconsistent with one of the few empirical studies in this area. Silverman et al. (1984) examine data from a national telethon in which three different funding schemes were employed. They find that announcing the names of individuals pledging money and the amount of money pledged resulted in greater

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<sup>4</sup>There are many ways in which this game can be played in practice. Imagine for example that the fundraiser calls up the first contributor and asks for her contribution. Then the fundraiser calls all the other contributors, tells them what the first contribution was and asks them to contribute anonymously to the public good. In addition to asking for donations, the fundraiser also informs each donor that once all the donors have been called, the fundraiser will call the first contributor again to ask her if she wishes to increase her initial donation. Bilodeau and Slivinski (1998) also examine a sequential contribution game and show that the entrepreneur is unable to commit to a one-time contribution.

<sup>5</sup>Section 3.3.1 demonstrates this point.

contributions than when they were not announced.<sup>6</sup> In other words, verbal information about what other people are doing is sufficient to increase contributions.

One explanation for why contributors make larger donations when their contributions are announced might be that the announcement gives contributors prestige or the ability to signal their wealth.<sup>7</sup> That is, the announcement effectively adds a private benefit to the donation, thereby increasing its marginal benefit.

While these social factors may play a role, they do not sufficiently explain why contributions are announced during a fund drive. In particular, if announcements are made simply to generate an internal benefit to the contributor, then the donations might as well be announced after the fund drive is over. Furthermore, this explanation is not consistent with the fact that charities ask the contributor for permission to announce the contribution. Donors who want to make a contribution anonymously are often encouraged by the fundraiser to make the contribution publicly. For instance, the chairman of the trustees of Johns Hopkins explains that the reason that the university asks donors for permission to announce their gifts is that “fundamentally we are all followers. If I can get somebody to be the leader, others will follow. I can leverage that gift many times over.”<sup>8</sup> Therefore, an announcement will not only increase the donation of the leader, but in addition it is likely to have a positive effect on future contributions of others.

One reason why donations should be announced is provided by Andreoni (1998). He shows that if there is a fixed cost associated with provision of a public good, then there may be multiple equilibria of the provision game. In particular there will be an equilibrium where the public good fails to be provided and one

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<sup>6</sup>The average amount contributed per hour was \$771 during local time with announcements, \$412 with local talent without announcements, and \$312 with national talent and no announcements. One should evaluate these results, however, with a bit a caution. The 20 hour telethon was separated into 15-min intervals and total contributions were calculated for each interval. To the extent possible the telethon alternated between the three different treatments every 15 min. However there are many deviations from this rule. The strongest evidence in support of announcing pledges may be that during the last 3 hours of the telethon more time was spent reading pledges because it was clear by then “. . . that reading pledges increased them” (p. 308). The results do support announcements even when this latter period is not included in the data. The authors do not rule out that some contributors may simply have played a timing game, however they also argue that viewers may be less likely to watch television during the pledge readings.

<sup>7</sup>Andreoni (1988, 1990), Harbaugh (1998), Glazer and Konrad (1996), Olson (1965), and Steinberg (1989).

<sup>8</sup>The New York Times, 2 February 1997, p. 10. This article points out that there are two aspects to being an anonymous donor. While some prefer that neither their gift nor identity be announced, others don't mind that their donation be listed but prefer that they are listed as anonymous givers. The model that we develop in this paper requires that both of these facts are known. If the first contribution is to serve as a signal of the charity's type then the size of the donation as well as the identity of the donor must be known. To keep the model simple we assume, however, that the identity of the contributor is known, and limit ourselves to analyzing whether the donation should be announced in a model of imperfect information.

where it is provided. He demonstrates that the fundraiser by coordinating leadership contributions can guarantee a positive-provision outcome. In such a scenario the fundraiser strictly prefers to announce the leadership contributions.

An alternative explanation is provided by Romano and Yildirim (2001). They show that contributors may give more in a sequential game if the first contributor can commit to a one-time contribution and the second mover's best-response function is increasing in the contribution of the leader.<sup>9</sup>

Contrary to the approach taken in this paper, both of these models assume that the first contributor can commit to a one-time contribution, however Andreoni's result is not sensitive to this assumption, and Romano and Yildirim's result holds in the no-commitment case when all contributors have positively sloped best-response functions. Both of these explanations can be seen as complementary to the explanation presented here.

### **3. Fundraising when information is imperfect**

As proposed in the introduction, we argue that fundraisers may choose to announce past contributions because this announcement helps them reveal the value of the public good that they provide.<sup>10</sup> In the model examined here, it is therefore assumed that the contributors have imperfect information about the quality of the charity.

Considering that currently there are more than 600 000 charities and another 30 000 joining their ranks every year, it seems plausible that contributors do not have perfect information about the quality of the organizations. While contributors may be informed about the quality of some organizations, charities continually introduce 'new products' and it may be difficult prior to the provision of a specific public good to evaluate how useful that good will be.

Although the standard assumption in the voluntary contribution literature has been one of perfect information, there are a few exceptions. Rose-Ackerman (1980, 1981) and Handy (1995) argue that for most agents the quality of charities is uncertain, and suggest that the presence of government grants, united funds or prominent individuals, will help resolve the informational problem. Schiff (1990)

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<sup>9</sup>An individual's contribution may be increasing in that of others if he is sufficiently concerned about the private benefit that he derives from his own contribution.

<sup>10</sup>The idea examined here is related to that of Hermalin (1998). He examines a team production problem in which one team member, the leader, is exogenously informed about the marginal return to effort. The leader commits to an effort level, and this level serves as a signal of the marginal return to effort. Hermalin shows that this sequence of moves increases the overall effort level. The primary difference from the private provision of public goods problem is that there is no crowding out in the team production model. This negative correlation has important consequences if one is to extend Hermalin's model to a public goods model. Indeed if the leader can commit to a one-time contribution, then it is often the case that the charity strictly prefers not to announce past contributions.

suggests that the informational problem may be resolved when potential contributors choose to volunteer for an organization. Similarly to Schiff we argue that the quality of the charity can be revealed after some sort of costly inspection by the contributors.<sup>11</sup> That is, rather than assuming that one contributor is informed we endogenize the contributor's information-acquisition decision. While charities certainly try to convince contributors of their merits, it is reasonable to assume that truthful information is costly.<sup>12</sup> Indeed some contributors spend substantial resources investigating the quality of the proposed project and may even set up foundations which employ a whole team of experts to evaluate and investigate proposed projects.<sup>13</sup>

In summary the model that we propose extends the standard model of private provision of public goods in four directions. First, the value of the provided public good is uncertain; second, contributors can buy information about the true value of the public good; third, the fundraiser is viewed as an actual player in the game; and fourth, contributors cannot commit to one-time contributions.

### 3.1. Model

Although it is of interest to explain why fundraisers continue to announce contributions, this paper focuses solely on why fundraisers choose to announce the first contribution. The following section describes the model and the underlying assumptions.

The fundraiser is working either for a high-type charity,  $H$ , or for a low-type charity,  $L$ . A high-type charity provides a beneficial public good, while a low-type charity provides a useless public good. Let  $x_j$  denote  $j$ 's private consumption and let  $G$  denote the public good. Assume that each individual has income  $m$ , and individual preferences of the form  $x_j^{0.5} + v_i G^{0.5}$ , where  $v_i$  denotes the value of the public good  $i$ .<sup>14</sup> When the charity is of high type it provides a public good where

<sup>11</sup>In contrast to Schiff's approach we incorporate the fact that contributors have an incentive to convince others that a charity is of high quality.

<sup>12</sup>At the very least contributors have to spend time determining the charity's quality. In contrast Hermalin (1998) does not model this choice and assumes that the leader always is given a signal prior to exerting effort but only after the contracts have been fixed. The followers in Hermalin's model are always uninformed.

<sup>13</sup>In an interview with John Stossel, Ted Turner stated that "Giving a lot of money away is almost as difficult and complicated as making it. You have to hire people to do it. They've got to analyze things real carefully."

<sup>14</sup>It will soon become clear that it is difficult to solve the model when preferences do not have a specific functional form. However, it is easily shown that similar equilibria arise when preferences are of the form  $U_j = x_j^\alpha + v_i G^\alpha$ , where  $\alpha \in (0, 1)$ . We suspect that the same will hold for utility functions of the form  $U_j = f(x_j) + v_i h(G)$ , where both  $f()$  and  $h()$  are monotonically increasing and concave. In Section 3.5 we describe in more detail how preferences may affect the class of equilibria, and we also show that our results are not sensitive to the assumption that individuals are identical.

$v_H = 1$ , and when it is of low type it provides a public good where  $v_L = 0$ .<sup>15</sup>

The charity's type is known to the fundraiser, who, conditional on type, chooses either to announce the first contribution,  $z_i = 1$ , or not to announce the first contribution,  $z_i = 0$ , where  $i = H, L$ . The fundraiser's goal is to choose  $z_i$  such that it maximizes the total contribution  $G_i$ . Assume that the price of the public good is one, and that it takes one unit of the private good to provide one unit of the public good.

Contrary to the fundraiser, the potential donors do not know the charity's type. Each donor's prior is that a charity has an equal probability of being a high-type or a low-type charity. Conditional on whether an announcement is made, contributors form beliefs  $\mu(H|z)$  about the charity's type.

Assume that there are two identical contributors,  $j = A, B$ , and that contributor  $A$  is the first to make a donation.<sup>16</sup> We first characterize the equilibria when only  $A$  can buy information about the charity. Later in Section 3.5 we examine the case where both contributors can purchase information, and we show that this assumption does not alter the equilibrium predictions.

By paying a cost,  $c$ , contributor  $A$  will receive a perfectly informative signal,  $s \in \{L, H\}$ , indicating the charity's type. Let  $I_A(z) \in \{0, 1\}$  denote  $A$ 's decision to purchase information when the fundraiser uses fundraising strategy  $z$ , such that  $I_A(z) = 1$  when she buys information. This implies that  $A$  can be one of three different types. Denote an uninformed  $A$  as type  $t_A = u$ , an informed contributor who receives a high signal as type  $h$ , and an informed contributor who receives a low signal as type  $l$ . While the cost of information is common knowledge,  $A$ 's purchasing decision and the signal are known only to  $A$ . Thus  $A$ 's type,  $t_A$ , is not common knowledge.

The structure of the game is the following. First, nature reveals to the fundraiser which type of charity it is representing. Contingent on its type, the fundraiser decides whether to announce or not to announce the first contribution. This decision is common knowledge. Prior to donating, contributor  $A$  has the option of buying information about the public good. If a no-announcement action is chosen by the fundraiser, the two contributors effectively make simultaneous donations to the public good.

In the case where the first contribution is announced, contributor  $A$  first decides whether to buy information and then makes an initial contribution of  $g_A^0(z = 1, t_A)$  to the public good, where the '0' superscript denotes that the contribution is made prior to the announcement. Having observed this initial contribution,  $B$  donates to

<sup>15</sup>The primary conclusions of this paper are not driven by this assumption. When the low-type charity produces a valuable good, i.e.,  $0 < v_L < v_G$ , there still exists fully revealing equilibria where both charities are using an announcement strategy (see Section 3.5 for a discussion).

<sup>16</sup>This is common knowledge, hence it is not possible that the fundraiser can solicit announcement level contributions from anyone other than  $A$ . In Section 4, we argue that this is a more reasonable assumption in a model with heterogeneous agents. The reason is that in this case the high-type fundraiser has an optimal solicitation ordering. Hence, all subsequent contributors will use the size of the initial donation to determine the quality of the public good.

the public good, and finally without knowing  $B$ 's contribution,  $A$  is given an option to increase her initial contribution.

In summary the structure of the game is as follows:

1. Nature selects  $i = L$  or  $H$ .
2. Fundraiser observes  $i$ , and selects  $z_i \in \{0, 1\}$ .
3.  $A$  and  $B$  observe  $z$ .
4.  $A$  chooses  $I_A(z) \in \{0, 1\}$ ; if  $I_A(z) = 1$ ,  $A$  pays  $c$  and observes  $s \in \{L, H\}$ .
5. If  $z = 0$ ,  $A$  chooses donation  $g_A(z = 0, t_A) \in [0, m - I_A \cdot c]$ , simultaneously with  $B$ 's choice of  $g_B(z = 0) \in [0, m]$ .
6. If  $z = 1$ ,  $A$  chooses donation  $g_A^0(z = 1, t_A) \in [0, m - I_A \cdot c]$ .  $B$  observes  $g_A^0$  and chose  $g_B^1(z = 1, g_A^0) \in [0, m]$ , simultaneously with  $A$ 's choice of  $g_A^1(1, t_A) \in [0, m - I_A \cdot c - g_A^0(1, t_A)]$ .

If contributors knew the charity's type then no donations would be made to a low-type charity, and a positive contribution would be made to the high-type charity. Therefore there does not exist an equilibrium where the fundraiser's announcement choice reveals that a charity is of high type. The reason is that the low-type fundraiser will mimic any action that generates high-type donations.<sup>17</sup>

To determine the equilibria of this game we first need to find the contributions that result when the first contribution is not announced and when it is announced. The relevant contribution levels are determined in Sections 3.2 and 3.3. Examining the announcement scenario in Section 3.3 reveals that there exist initial contributions which fully reveal the initial contributor's type.<sup>18</sup>

Given the contribution levels, the fundraiser's optimal strategy can be determined, and equilibria that constitute sequentially rational strategies and consistent beliefs can be found. Section 3.4 derives the set of equilibria and demonstrates that there exist three types of perfect Bayesian equilibria.

The first type arises when the cost of information is so high that no information is purchased. In this case the fundraiser, independent of type, is indifferent between announcing and not announcing the first contribution, and a pooling equilibrium arises.

The second type of equilibria arises when the information cost is sufficiently low. Contributor  $A$  buys information when an announcement strategy is used, and she makes the value of the public good common knowledge through a large initial

<sup>17</sup>Consider for example the case where the high-type fundraiser uses announcements, and the low type does not. This case cannot be sustained as an equilibrium because when contributors, consistent with this proposed equilibrium, believe that only high types announce, then the low type when using announcements will be perceived as being of high type. Thus the low type has an incentive to deviate and use announcements. Similarly there is no equilibrium where the low-type fundraiser always announces contributions and the high type does not.

<sup>18</sup>When beliefs off the equilibrium path are required to satisfy the intuitive criterion the individual's total contribution is uniquely determined.

contribution. Thus, a high-type fundraiser strictly prefers announcing the first contribution, while a low-type fundraiser is indifferent between announcing and not announcing the first contribution. These equilibria are semi-separating, and since both fundraiser types use announcements we refer to them as announcement equilibria.

A third type of equilibria is sustainable for a range of even smaller information costs. Here contributor *A* buys information when no announcement is made. Interestingly, contributor *B* free-rides off *A*'s information and does not contribute to the public good. Opposite of the announcement equilibria both types of fundraiser choose not to announce, and only the low type chooses to announce contributions. We refer to this type of equilibria as no-announcement equilibria.

The paper pays particular attention to the announcement equilibria. First, announcement equilibria are supported for the same and even larger costs than that of the no-announcement equilibria, and they result in larger contributions to the high-type charity. Thus we argue that announcement equilibria are the more likely of the two types. Second, announcement equilibria are interesting because the high-type charity, by using announcements, will receive contribution levels that exceed those of the perfect information environment. The explanation is that if the first contributor wants to signal when the charity is of high quality then she must make a donation large enough that an uninformed first contributor does not want to mimic the donation, even when doing so falsely would convince future contributors that the charity is of high quality.<sup>19</sup> To separate herself from the uninformed type, an initial contributor who knows the charity is of high quality will therefore make a contribution which may be substantially larger than the contribution level she would have made had the quality of the charity been common knowledge.<sup>20</sup> This increase in contributions decreases the donation of the second contributor, however since the crowding out is incomplete the resulting contribution level exceeds that of a perfect information environment.

The next sections demonstrate the existence of the three types of equilibria. Characteristic of them is that a low-type fundraiser randomizes between announcing and not announcing, and that the strategy of the high-type fundraiser depends on the cost of information. For prohibitively high information cost, a high-type fundraiser randomizes between announcing and not announcing, and for a sufficiently low cost a high-type fundraiser chooses either to announce or not to announce the first contribution. Interestingly announcement equilibria are supported for a range of higher costs than that of the no-announcement equilibria.

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<sup>19</sup>Uninformed first contributors value the public good, and thus have an incentive to convince others to increase contributions to the charity. In particular they have an incentive to increase their donations so as to appear as if they know that the charity is of high type. See Section 3.3.2, Eq. (2) for the incentive constraint.

<sup>20</sup>The contribution necessary to separate herself depends on the mixed strategy played by the low-type fundraiser. See Fig. 1 for the exact contributions required as a function of  $\rho_1$ .

### 3.2. No announcement contributions

When a fundraiser has chosen not to announce the initial contribution donors update their beliefs that the fundraiser is of high type,  $\rho_0 = \mu(H|z = 0)$ . In the absence of announcements, each contributor's donation is unobserved by the other contributor. As a result if *A* buys information to determine the true value of the public good, then that signal cannot be credibly revealed to contributor *B*. Recall that *A*'s purchasing decision implies that *A* can be one of three types: uninformed, informed with a high signal, or informed with a low signal, i.e.,  $t_A \in \{u, h, l\}$ . With the cost of information being common knowledge, however, *B* can deduce whether information is purchased, and thus whether *A* is informed or uninformed.

Let us first determine the contributions that result when *A* does not purchase information. Conditional on their posterior,  $\rho_0$ , contributors allocate their income,  $m$ , between private consumption  $x_j(z = 0)$  and contribution  $g_j(z = 0)$  such that they maximize their expected utility subject to the following constraints:

$$\begin{aligned} \text{Max}_{g_j, x_j} \quad & x_j^{0.5} + \rho_0 G_H^{0.5} \\ \text{s.t.} \quad & g_j + x_j = m \\ & g_j \geq 0. \end{aligned}$$

If we let  $g_{-j}(0)$  denote the contribution by the other donor, then  $j$ 's best response function is  $g_j(0) = \max\{0, (\rho_0^2 m - g_{-j}(0))/(1 + \rho_0^2)\}$ , and the total contribution to the public good is  $G_i(0, I_A = 0) = (2m\rho_0^2)/(2 + \rho_0^2)$  for  $i = H, L$ .

Now examine the contributions that result when *A* buys information. If *A* receives a low signal, then her optimal contribution is zero,  $g_A(z = 0, t_A = l) = 0$ . If she instead receives a high signal, then her best-response function equals  $g_A(0, h) = \max\{0, (m - c - g_B(0, I_A = 1))/2\}$ . *B* takes these contribution levels into account when determining her donation. Particularly valuable to *B* is the fact that *A* contributes  $g_A(0, h)$  whenever it is a high-type charity. This enables *B* to free ride off *A*'s information and her maximization problem is

$$\begin{aligned} \text{Max}_{g_B, x_B} \quad & x_B^{0.5} + \rho_0 (g_A(0, h) + g_B)^{0.5} \\ \text{s.t.} \quad & g_B + x_B = m \\ & g_B \geq 0. \end{aligned}$$

Hence,  $g_B(0, I_A = 1) = \max\{0, (\rho_0^2 m - g_A(0, h))/(1 + \rho_0^2)\}$ . This implies that *B* makes no donation when the posterior is sufficiently small, and makes a positive donation when it is sufficiently large. When  $\rho_0 \leq \sqrt{(m - c)/(2m)}$ , then  $G_H(0) = g_A(0, h)$ , and  $G_L(0) = 0$ .<sup>21</sup> If  $\rho_0 > \sqrt{(m - c)/(2m)}$ , then  $G_L(0) = g_B(0)$ , and  $G_H(0) = g_A(0, h) + g_B(0)$ . While the contribution to the charity is independent of

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<sup>21</sup>Using the expression for  $g_A(0, h)$  and assuming a positive contribution level we see that  $g_B(0, I_A = 1) = ((2\rho_0^2 - 1)m + c)/(1 + 2\rho_0^2)$ , i.e., *B* makes no contribution when  $\rho_0 \leq \sqrt{(m - c)/(2m)}$ .

type when no information is purchased, a high-type charity receives a larger contribution when information is purchased.

Given these contribution levels  $A$  purchases information if <sup>22</sup>

$$(m - g_A(0, u))^{0.5} + \rho_0 G_H(0, I_A = 0)^{0.5} < \rho_0 [(m - c - g_A(0, h))^{0.5} + G_H(0, I_A = 1)^{0.5}] + (1 - \rho_0)(m - c)^{0.5}. \quad (1)$$

To predict the contributions and information purchasing decision, we need to know the cost of information and the consistent posterior of the no-announcement strategy.

### 3.3. Announcement contributions

Next we examine the contributions that arise when the first contribution is announced. We first provide an overview of how contributions are derived, and subsequently we determine the actual contributions.

Knowing that the fundraiser has chosen this strategy, the donors update their beliefs that the fundraiser represents a high-type project. Denote this posterior  $\rho_1 = \mu(H|z = 1)$ . Recall that when announcements are made the structure of the game is as follows: contributor  $A$  decides whether to purchase information. Conditional on her type  $A$  chooses a contribution  $g_A^0(z = 1, t_A)$  which is announced. Having observed  $g_A^0$ ,  $B$  updates her belief about  $A$ 's type and consequentially the value of the public good.<sup>23</sup>  $B$  then makes her contribution,  $g_B^1(1, g_A^0)$ , simultaneously with a potential additional contribution from the first mover,  $g_A^1(1, t_A)$ .

The crucial difference from the no-announcement case is that  $B$  may use  $A$ 's initial contribution to infer whether  $A$  is uninformed or informed with a high or a low signal. All else equal  $B$  increases her contribution if she thinks it is more likely that the charity is of high quality. When  $A$  is informed with the low signal, she knows that the charity is worthless, and independent of  $B$ 's response she makes no contribution to the public good.<sup>24</sup> If  $A$  is informed that it is a high-quality charity she has no incentive to pretend otherwise. What complicates  $B$ 's ability to infer  $A$ 's type is the fact that  $A$ 's purchasing decision is unobserved, and if possible  $A$  may prefer to not purchase information, yet making a contribution that leads  $B$  to believe that  $A$  bought information and received a high signal. Common for both the uninformed and the type- $h$  contributor is that they prefer that  $B$  makes the largest contribution possible, thus both will attempt to convince  $B$  that it is a high-quality charity. The question of interest is whether

<sup>22</sup>See Appendix B for the specific conditions.

<sup>23</sup> $B$ 's prior is  $\mu_B(H|g_A^0) = \mu_B^h + \rho_1 \mu_B^u$ , where  $\mu_B(t_A = h|g_A^0) = \mu_B^h$ ,  $\mu_B(t_A = l|g_A^0) = \mu_B^l$ ,  $\mu_B(t_A = u|g_A^0) = \mu_B^u$ , and  $\mu_B^h + \mu_B^l + \mu_B^u = 1$ .

<sup>24</sup>In Section 3.5 we discuss the case where the low-type public good is of value, i.e.,  $v_L > 0$ .

there is a sufficiently large initial contribution that the type- $h$  contributor can make to separate herself from the uninformed type. The answer is yes. While it is costly for the donors to increase their contributions beyond their best response level, the marginal cost of a particular contribution is always larger for the uninformed type than it is for the type- $h$  contributor. The reason is that the public good is worth relatively more to the type- $h$  contributor than it is to the uninformed type, and thus the marginal cost of increasing her contribution is larger for the uninformed.<sup>25</sup> This implies that the type- $h$  contributor is willing to make an initial contribution which exceeds the maximum contribution that an uninformed type is willing to make to convince  $B$  that she is a type- $h$  contributor.

For a particular contribution profile to be an equilibrium of this game,  $B$ 's beliefs must be consistent with  $A$ 's strategy. Unfortunately this imposes no restrictions on beliefs off the equilibrium path, and as a result there will generally be multiple equilibria: some where  $B$  cannot distinguish the uninformed and the type- $h$  contributor and others where the two types are separated by their initial contributions. Riley (1979) argues that the most reasonable of these equilibria is one where conditional on types being revealed the uninformed type chooses a donation that maximizes her utility, and the type- $h$  contributor chooses a donation that maximizes her utility subject to the constraint that the uninformed type has no incentive to mimic her choice. Thus the so-called Riley outcome is the separating equilibrium which in the standard signaling model has the least amount of inefficient signaling. Cho and Kreps (1987) show that when there are only two types, the Riley outcome is the unique equilibrium which satisfy the intuitive criterion. The intuitive criterion imposes restrictions on  $B$ 's off-the-equilibrium-path beliefs, in particular it requires that the probability of deviation is allocated only to types that have an incentive to deviate. When  $B$  is trying to determine if a contribution is made by an uninformed or a type- $h$  contributor,  $B$  should believe that deviations are made only by the type that benefits from deviating. Thus if independent of  $B$ 's beliefs the uninformed type prefers her fully revealing equilibrium contribution to donating above a certain level, then  $B$  should attach zero probability to donations above this level being made by the uninformed type.

Applying the intuitive criterion to the contribution game that follows announcements therefore reduces the set of equilibrium contribution profiles to that of the Riley outcome. Next we determine these contributions, that is we determine the contributions of a fully revealing equilibrium where the set of strategies and beliefs are such that the first contribution reveals whether the first contributor bought information, and if she bought information, the true value of the public

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<sup>25</sup>This is the standard single crossing argument, i.e., the indifference curve of an uninformed type is steeper than that of a type- $h$  contributor. The only problem in showing that the single crossing property holds is that the uninformed type does not purchase information and thus has more resources available. Fortunately, as shown in Appendix A, the single crossing property holds as long as  $A$  is willing to purchase information.

good. At any stage of the game, strategies are optimal given the beliefs, and the beliefs are obtained from equilibrium strategies and observed actions using Bayes' rule.

### 3.3.1. Uninformed first contributor

Let us start by determining the contributions that result when the first contributor is uninformed and is recognized as such. First *A* makes a contribution  $g_A^0 = g_A^0(1, u) > 0$ , which is announced and observed by *B* who correctly infers that *A* is uninformed, i.e., her consistent belief is  $\mu_B(H|g_A^0) = \rho_1$ . The corresponding best-response function of *B* is  $g_B^1(1, g_A^0) = (\rho_1^2 m - g_A^1(1, u) - g_A^0(1, u))/(1 + \rho_1^2)$ . Characteristic of the Riley outcome is that the uninformed type selects the contribution that maximizes her utility. Thus, *A*'s optimal contribution following the initial announcement is  $g_A^1$ , where

$$\begin{aligned} \text{Max}_{g_A^1, x_A} \quad & x_A^{0.5} + \rho_1 G_H^{0.5} \\ \text{s.t.} \quad & g_A^0 + g_A^1 + x_A = m \\ & g_A^1 \geq 0. \end{aligned}$$

Contributor *A*'s best-response function is  $g_A^1(1, u) = (\rho_1^2 m - (1 + \rho_1^2)g_A^0(1, u) - g_B^1(1, g_A^0))/(1 + \rho_1^2)$ . Simultaneously solving the two best-response functions reveals that  $g_B^1(1, g_A^0) = (\rho_1^2 m)/(2 + \rho_1^2)$ , and  $g_A^1(1) = (-g_A^0(1) + \rho_1^2 m)/(2 + \rho_1^2)$ . While it is possible to determine *A*'s overall contribution,  $g_A^1(1, u) + g_A^0(1, u) = (\rho_1^2 m)/(2 + \rho_1^2)$ , it is not possible to identify  $g_A^0(1, u)$  and  $g_A^1(1, u)$  separately. Let  $g_A(1, t_A) = g_A^0(1, t_A) + g_A^1(1, t_A)$ . Note however that  $g_A^0(1)$  does affect *B*'s posterior, which implies that it may be in *A*'s best interest to give everything prior to the announcement and nothing after the announcement.

When no information is bought the resulting contributions are  $g_A(1, u) = (\rho_1^2 m)/(2 + \rho_1^2)$ , and a consistent belief is  $\mu_B(H|g_A^0) = \rho_1$ , for  $g_A^0 \in (0, (\rho_1^2 m)/(2 + \rho_1^2)]$ . Given these beliefs, *B*'s contribution is  $g_B^1(1, g_A^0) = (\rho_1^2 m)/(2 + \rho_1^2)$ .

### 3.3.2. Informed first contributor

Next we determine the contributions that result when the first contributor buys information about the value of the public good. If *A* buys information and receives a low signal then no contribution is made to the public good, and *B*'s consistent belief and contribution are,  $\mu_B(H|g_A^0 = 0) = 0$  and  $g_B^1(1, g_A^0 = 0) = 0$ , respectively.

In the case where *A* receives a high signal, she contributes an amount that is sufficiently large to distinguish herself from an uninformed contributor. In particular the initial contribution,  $g_A^0(1, h)$ , needs to be large enough that an agent who does not buy information prefers contributing  $g_A(1, u) = (\rho_1^2 m)/(2 + \rho_1^2)$  rather than mimicking and pretending to be someone who bought information and received a high signal. If *B* believes that the charity is high type, her best response is  $g_B^1(g_A^0) = (m - g_A(1, h))/2$ , and the overall contribution to the public good is

$G_H(1) = (m + g_A(1, h))/2$ . Hence,  $g_A^0(1, h)$  must be set such that the following constraint is satisfied:<sup>26</sup>

$$\left(\frac{2m}{2 + \rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2 m}{2 + \rho_1^2}\right)^{0.5} \geq (m - g_A^0(1, h))^{0.5} + \rho_1 \left(\frac{m + g_A^0(1, h)}{2}\right)^{0.5}. \tag{2}$$

In a separating equilibrium with an equilibrium contribution of,  $g_A^0(1, h)$ , consistent beliefs are  $\mu_B(t_A = h | g_A^0 = g_A^0(1, h)) = 1$ . Let  $g^H = g_A^0(1, h)$  be the contribution that results from letting (2) exactly bind, i.e., it is type- $h$  contribution suggested by Riley (1979).

Note, that this contribution level can only be sustained as a separating equilibrium if a first-mover who receives a high signal has no incentive to mimic an uninformed contributor. Contrary to most signaling games the mimicker is not constrained to choosing a contribution which is identical to that of the uninformed donor. The reason is that only  $A$ 's first contribution serves as a signal. If  $B$  believes that  $A$  is uninformed then  $g_B^1(g_A^0) = (\rho_1^2 m)/(2 + \rho_1^2)$ , and it can be shown that the mimicking type- $h$  first-mover will make an additional donation  $g_A^1(1, h) = -g_A^0(1, h) + (2m - (2 + \rho_1^2)c)/(4 + 2\rho_1^2)$  after the announcement. Thus, type- $h$ 's indifference curve when pretending to be uninformed reaches its minimum at  $(g_A, g_B) = ((2m - (2 + \rho_1^2)c)/(4 + 2\rho_1^2), (\rho_1^2 m)/(2 + \rho_1^2))$ . For a separating equilibrium to exist this indifference curve must lie below that of a type- $h$  contributor who reveals that the charity is of high type, specifically the equilibrium contribution  $g_A^0(1, h)$  must satisfy the condition

$$\begin{aligned} & (m - c - g_A^0(1, h) - g_A^1(1, h))^{0.5} + \left(\frac{m + g_A^0(1, h) + g_A^1(1, h)}{2}\right)^{0.5} \\ & \geq 2 \left(\frac{2(m - c) + \rho_1^2(2m - c)}{2(2 + \rho_1^2)}\right)^{0.5}. \end{aligned} \tag{3}$$

The question is whether there exist contributions which satisfy (2) and not (3). Clearly if the solution to (2) is such that  $g_A^0(1, h) \leq (2m - (2 + \rho_1^2)c)/(4 + 2\rho_1^2)$ , then (3) is satisfied as well. The reason is that in this case the type- $h$  contributor can by making a smaller donation reveal her type and cause  $B$  to increase her donation. If we can show that the indifference curve of the uninformed and a type- $h$  contributor satisfy the single crossing property, then the same result holds when  $g_A^0(1, h) > (2m - (2 + \rho_1^2)c)/(4 + 2\rho_1^2)$ . The reason is that in this case any separating contribution along the uninformed's indifference curve will lie strictly above the indifference curve for the type- $h$  contributor pretending to be uninformed. Fortunately, as demonstrated in Appendix A we can show that if the

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<sup>26</sup>Note that in trying to mimic someone with a high signal, the uninformed agent is willing to set  $g_A^1(1, u) = 0$  and contribute everything in the first period.

single-crossing property does not hold then contributor *A* has no incentive to buy information, that is, the single crossing property holds whenever it is relevant for *B* to determine whether *A* is an uninformed or a type-*h* contributor.<sup>27</sup> Thus we know that any contribution satisfying (2) also satisfies (3).

Finally, the question that remains is whether, given these constraints, the first contributor has an incentive to buy information. Contributor *A* will purchase information if and only if

$$\left(\frac{2m}{2 + \rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2 m}{2 + \rho_1^2}\right)^{0.5} \leq \rho_1 \left[ (m - c - g_A(1, h))^{0.5} + \left(\frac{m + g_A(1, h)}{2}\right)^{0.5} \right] + (1 - \rho_1)(m - c)^{0.5}. \quad (4)$$

As is common in signaling models, there generally exist a continuum of contributions  $g_A^0(1, h)$  that satisfy Eq. (2). However, as argued earlier, this set of contributions is reduced to the Riley outcome when we require that beliefs off the equilibrium path satisfy the intuitive criterion. Specifically, since an uninformed contributor has no incentive to contribute more than  $g^H$ , the second contributor should attach zero probability to observing an uninformed contributor giving more than  $g^H$ , that is  $\mu_B(H | g_A^0 \geq g^H) = 1$ . Likewise, the second contributor believes that any donation  $g_A^0 \in (0, g^H)$  is made by an uninformed contributor, i.e.,  $\mu_B(H | 0 < g_A^0 < g^H) = \rho_1$ . These beliefs imply that if  $g^H > (m - 2c)/3$ , then a separating equilibrium exists if the first contributor is willing to purchase information when she contributes  $g_A^0(1, h) = g^H$  and  $g_A^1(1, h) = 0$ , resulting in  $g_B^1(1, g^H) = (m - g^H)/2$  and  $G^H = (m + g^H)/2$ . Similarly for  $g^H \leq (m - 2c)/3$  where  $G^H = (2m - c)/3$ .<sup>28</sup>

### 3.4. Equilibria

Using the optimal contributions developed in the previous two sections, this section determines the types of equilibria that arise in the examined game. The fundraiser's payoffs that result from announcing or not announcing the first contribution are summarized in Table 1.

Note that the only way in which the fundraiser can affect the contributors' choice is through the choice of *z*. Since  $I_A(z) \in \{0, 1\}$  there are four potential types of equilibria: (1) information is never purchased, i.e.,  $I_A(0) = I_A(1) = 0$ ; (2) information is purchased only when an announcement is made, i.e.,  $I_A(0) = 1$  and  $I_A(1) = 0$ ; (3) information is purchased only when no announcement is made, i.e.,  $I_A(0) = 0$  and  $I_A(1) = 1$ ; (4) information is purchased independent of the fundraiser's action, i.e.,  $I_A(0) = I_A(1) = 1$ . Given the contributions in Table 1, we will show that while (4) is not an equilibrium of the game the three other types can, for

<sup>27</sup>Since *B* knows *A*'s cost, she also knows that *A* is uninformed.

<sup>28</sup>If  $g^H \leq (m - 2c)/3$ , then  $g_A^0(1, h) + g_A^1(1, h) = (m - 2c)/3$  where  $g_A^0(1, h) \geq g^H$ , and  $g_A^1(1, h) = (m + c)/3$ , such that the overall contribution is  $G^H = (2m - c)/3$ .

Table 1  
Total contributions to the fundraiser

		Contribution to high-type charity, $G_H$	Contribution to low-type charity, $G_L$
$z = 1$	$I_A = 0$	$\frac{2m\rho_1^2}{2 + \rho_1^2}$	$\frac{2m\rho_1^2}{2 + \rho_1^2}$
	$I_A = 1$	$\geq \frac{2m - c}{3}$	0
$z = 0$	$I_A = 0$	$\frac{2m\rho_0^2}{2 + \rho_0^2}$	$\frac{2m\rho_0^2}{2 + \rho_0^2}$
	$I_A = 1, \rho_0 \leq \sqrt{\frac{m - c}{2m}}$	$\frac{m - c}{2}$	0
	$I_A = 1, \rho_0 > \sqrt{\frac{m - c}{2m}}$	$\frac{\rho_0^2(2m - c)}{1 + 2\rho_0^2}$	$\frac{m(2\rho_0^2 - 1) + c}{1 + 2\rho_0^2}$

certain costs, be supported as equilibria of the game. Specifically, (1) results in pooling equilibria while (2) and (3) result in hybrid equilibria. Next we show these results.

**Proposition 1.** *There does not exist a perfect Bayesian equilibrium where information is purchased independent of the fundraiser’s action, i.e.,  $[I_A(z = 1)] \cdot [I_A(z = 0)] \neq 1$ .*

**Proof.** A will only acquire information if the quality of the charity is not already known. Therefore, if A always purchases information then both types of fundraisers must have a positive probability of announcing and not announcing the initial contribution. Implying that both  $\rho_0$  and  $\rho_1$  are bounded away from 0 and 1. However with information always being purchased, a high-type fundraiser strictly prefers to announce the first contribution, and a low-type fundraiser either prefers not to announce the first contribution or is indifferent between announcing and not announcing. Therefore the consistent belief must be that a fundraiser that does not announce the first contribution is of low type. Given this belief it is not optimal for A to buy information about the public good when no announcement is made.<sup>29</sup>  $\square$

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<sup>29</sup>As an illustration let us consider the case where the high and low-type charity play identically mixed strategies. This implies that independent of the announcement the consistent prior is one half, and we can show that A will choose to always purchase information if the cost  $c < 0.05m$ . This is not an equilibrium because a high-type fundraiser in this environment will choose to always announce past contributions. When an announcement is made total contributions to the high-type charity equals  $0.7m$ , and when no announcement is made total contributions equal  $(m - c)/2$ . Given the high-type fundraiser’s incentive to announce, only low-type fundraisers will choose not to announce, and thus it is not optimal for A to purchase information when no announcement is made.

Taking account of Proposition 1 we are left with three potential types of equilibria: one where, independent of the announcement decision, no information is purchased, and two others where information is bought only when the first contribution either is or is not announced.

### 3.4.1. Equilibria I: no information is purchased

Let us begin by demonstrating the existence of a perfect Bayesian equilibrium where no information is bought in either the announcement or the no-announcement game. In this no-information case both fundraisers receive the same contributions:  $G_H(z) = G_L(z) = (2\rho_z^2 m)/(2 + \rho_z^2)$ , where  $z = 0, 1$ . If  $\rho_0 > \rho_1$  then both fundraiser types choose the no-announcement game and the consistent belief is  $\rho_0 = 0.5$ . Since  $z = 1$  is off the equilibrium path, perfect Bayesian equilibrium imposes no restrictions on  $\rho_1$ . However, since both fundraiser types experience the same loss from a deviation away from  $z = 0$ , a reasonable belief off the equilibrium path is  $\rho_1 = 0.5$ . Clearly for mixed strategy equilibria to exist, it must be that  $\rho_0 = \rho_1 = 0.5$ .

To sustain these equilibria  $A$  must not have an incentive to purchase information. When no announcement is made and  $\rho_0 = 0.5$ ,  $A$  will not buy information when the cost  $c > 0.05m$ .

Next let us determine the conditions under which information is not purchased when the first contribution is announced. First, we need to determine what the optimal contributions are when information is bought. In particular  $g_A^0(1, h)$  must be set such that an uninformed contributor does not mimic someone who received a high signal. To signal that it is a high-type charity,  $A$  must contribute  $g_A^0(1, h) \geq g^H$ , where  $g^H$  makes (2) a binding constraint. Evaluated at  $\rho_1 = 0.5$  it is seen that  $g^H = 0.43m$ . Since  $g^H > (m - 2c)/3$  for all  $c$ , the incentive constraint is binding, i.e.,  $g_A^0(1, h) = g^H$  and  $g_A^1(1, h) = 0$ .

Given  $A$ 's contribution her willingness to pay for information can be determined. Denote the threshold cost  $c_{z=1}$  such that a contributor in the announcement game buys information if the cost  $c < c_{z=1}$ . Evaluated at  $\rho_1 = 0.5$  and  $g^H = 0.43m$ , condition (4) is a binding constraint at  $c_{z=1} = 0.19m$ . Therefore, if the cost of information is higher than  $0.19m$ , then  $A$  will not buy information when  $z = 1$ .

In summary, if  $c \geq 0.19m$  no information is purchased and the two donors each contribute  $(\rho_z^2 m)/(2 + \rho_z^2)$ . Given consistent beliefs of  $\rho_0 = \rho_1 = 0.5$  the best response by the fundraiser is to announce with probability  $\gamma$  and not to announce with probability  $1 - \gamma$ , where  $\gamma \in [0, 1]$ . Note that these are pooling equilibria since, independent of type, the fundraiser plays the same strategy. See Appendix B for a complete description of the equilibrium.

### 3.4.2. Equilibria II: announcement equilibria

Next we show that the existence of announcement equilibria where information is bought when the first contribution is announced, but not when it is not

announced. Given the announcement of the first contribution both contributors will know when it is a low-type charity, and as a result  $G_L(z = 1) = 0$ .

If the information-purchasing strategy is sequentially rational, then it must be that  $\rho_1 \in (0, 1)$ , otherwise there is no reason to buy information. This requirement implies that a low-type fundraiser must be willing to announce the first contribution with some positive probability. Therefore a consistent belief must be  $\rho_0 = 0$ , such that  $G_L(z = 0) = 0$ . This in turn requires that sequentially rational strategies for the fundraisers are  $z_H = 1$  with probability 1,  $z_L = 1$  with probability  $\gamma$ , and  $z_L = 0$  with probability  $1 - \gamma$ , where  $\gamma \in (0, 1]$ , generating consistent beliefs  $\rho_0 = 0$  and  $\rho_1 = 1/(1 + \gamma) \in [0.5, 1)$ .

Given this set of beliefs the uninformed's incentive constraint (2) is always binding. Hence,  $g_A^0(1, h) = y(\rho_1)m$ , where  $y(\rho_1)$  must satisfy

$$\left(\frac{2m}{2 + \rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2 m}{2 + \rho_1^2}\right)^{0.5} = (m - ym)^{0.5} + \rho_1 \left(\frac{m + ym}{2}\right)^{0.5}.$$

Fig. 1 illustrates the solution  $y(\rho_1)$ . Note that an increase in the posterior  $\rho_1$  on one hand makes the uninformed contributor care more about the public good and gives her a larger incentive to mimic a type- $h$  contributor, hence  $y$  increases. On the other hand an increase in  $\rho_1$  improves the uninformed's utility of telling the truth, and thus she has less of an incentive to mimic a type- $h$  contributor, i.e., the separating  $y(\rho_1)$  decreases. Depending on which of these factors dominate,  $y(\rho_1)$  may either increase or decrease with  $\rho_1$ . Clearly as  $\rho_1$  approaches 1,  $A$ 's

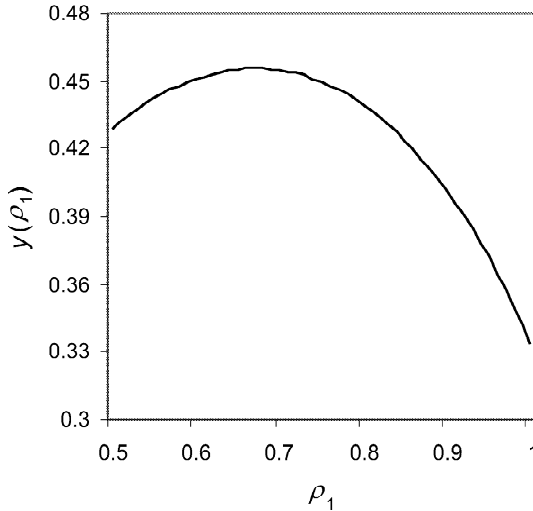


Fig. 1.  $A$ 's contribution to the high quality charity,  $y(\rho_1)$ .

contribution  $y(\rho_1)$  approaches  $m/3$ . Since  $g_A^0(1, h) > (m - 2c)/3$  contributor  $A$  will never make a contribution after the announcement, that is  $g_A^1(1, h) = 0$ .

Given  $y(\rho_1)$  we can determine the maximum cost  $c(z = 1) = mx(\rho_1)$  that contributor  $A$  is willing to pay for information, where  $x(\rho_1)$  is such that

$$\left(\frac{2m}{2 + \rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2 m}{2 + \rho_1^2}\right)^{0.5} = \rho_1 \left[ (m(1 - x - y))^{0.5} + \left(\frac{m(1 + y)}{2}\right)^{0.5} \right] + (1 - \rho_1)(m(1 - x))^{0.5}.$$

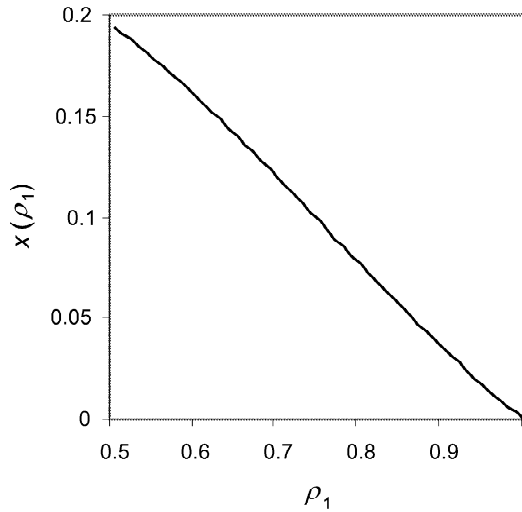


Fig. 2. Maximum willingness to pay for information,  $x(\rho_1)$ .

For all  $c < mx(\rho_1)$ , contributor  $A$  purchases information about the charity. Fig. 2 illustrates the contributor's maximum willingness to pay,  $c(z = 1)/m$ , conditional on  $\rho_1$ .

Not surprisingly contributor  $A$ 's willingness to pay for information decreases with the posterior  $\rho_1$ , and in particular  $A$  is not willing to pay for information when she knows that the public good is of high quality.

Fig. 3 illustrates the overall contribution made to a high-type charity conditional on  $\rho_1$ . Although there is a cost associated with determining the charity's quality, the contribution to the high-type fund is actually larger than it would be in a perfect information case where contributors can immediately distinguish a high-type charity from a low-type charity.<sup>30</sup> If the contributors are able to distinguish a

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<sup>30</sup>For  $\rho_1 \geq 1/2$  the incentive constraint is never satisfied when evaluated at the perfect information contribution level ( $g_A^0 = m/3$ ).

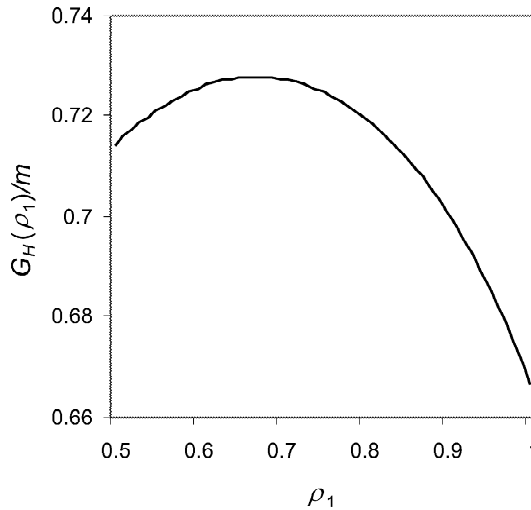


Fig. 3. Total contribution to high quality charity,  $G_H(\rho_1)$ .

high-type charity, the overall contribution is  $2m/3$ , which is strictly less than the equilibrium contributions just derived. See Appendix B for a complete description of the equilibrium strategies.

### 3.4.3. Equilibria III: no-announcement equilibria

Finally, we show that for a range of even smaller costs we can also support equilibria where information is bought only when there are no announcements. Given that information is purchased when no announcement is made, a high-type fundraiser receives a higher contribution from not announcing than does a low-type fundraiser. In contrast both types of fundraisers receive the same contribution when announcing the first contribution. Hence, for both fundraisers to be playing  $z = 0$  with positive probability, the low type must either prefer  $z = 0$  or be indifferent between  $z = 0$  and  $z = 1$ . To sustain the equilibrium the high-type fundraiser must strictly prefer  $z = 0$ , and thus the consistent belief is  $\rho_1 = 0$ . This in turn implies that sequentially rational strategies for the fundraisers are  $z_H = 0$  with probability 1,  $z_L = 0$  with probability  $1 - \gamma$ , and  $z_L = 1$  with probability  $\gamma$ , where  $\gamma \in [0,1]$ , generating consistent beliefs  $\rho_1 = 0$  and  $\rho_0 = 1/(2 - \gamma)$ . Let us first consider the case where  $\rho_0 > \sqrt{(m - c)/2m}$ , in this case there is no positive cost that  $A$  is willing to pay for information. Thus we cannot sustain no-announcement equilibria when  $\rho_0 > \sqrt{(m - c)/2m}$ . In contrast  $A$  is willing to purchase sufficiently cheap information for certain posteriors when  $\rho_0 \leq \sqrt{(m - c)/2m}$ . In this case  $B$  never contributes and  $A$  contributes  $(m - c)/2$  when it is a high-type fundraiser. We can therefore determine the maximum cost

$c(z = 0) = mx(\rho_0)$  that contributor *A* is willing to pay for information, where  $x(\rho_0)$  is such that

$$\left(\frac{2m}{2 + \rho_0^2}\right)^{0.5} + \rho_0 \left(\frac{2\rho_0^2 m}{2 + \rho_0^2}\right)^{0.5} = 2\rho_0 \left(\frac{m(1-x)}{2}\right)^{0.5} + (1 - \rho_0)(m(1-x))^{0.5}.$$

For all  $c < mx(\rho_0)$ , contributor *A* purchases information about the charity. Fig. 4 illustrates the contributor's maximum willingness to pay,  $c(z = 0)/m$ , conditional on  $\rho_0$ .

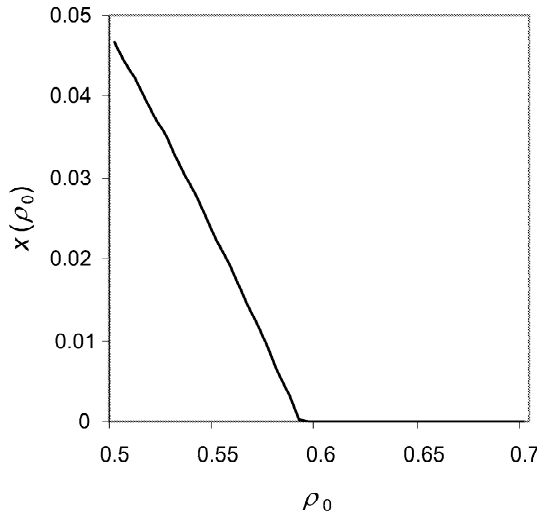


Fig. 4. Maximum willingness to pay for information,  $x(\rho_0)$ .

### 3.5. Discussion

The analysis presented here has demonstrated that when the cost of information is prohibitively high,  $c \geq 0.19m$ , the fundraiser, independent of type, is indifferent between announcing and not announcing the first contribution. In this case the contributions to the low-type and high-type charity are  $G_i(z) = 2m/9$ , independent of  $z$ , and an equilibrium exists only if the two types of fundraisers play identical strategies. Hence, for sufficiently high information costs pooling equilibria arise and the contribution level is uncorrelated with the announcement strategy.

When the information cost  $c \in (0, 0.19m)$  we can support announcement equilibria. Characteristic of these hybrid equilibria is that the high-type fundraiser always announces the first contribution, while the low-type fundraiser mixes between announcing and not announcing the first contribution. Independent of her

strategy, the low-type charity receives no contributions. Whereas the high-type charity receives contributions  $G_H(z = 1) > 2m/3$ .

Finally, when the information cost  $c \in (0, 0.05m)$  we can support no-announcement equilibria. These too are hybrid equilibria, in that the high-type fundraiser never announces the first contribution, and the low-type fundraiser mixes between announcing and not announcing the first contribution. While the high-type charity receives contributions of  $(m - c)/2$  when not announcing, the low-type charity receives no contributions independent of her strategy.<sup>31</sup>

Although we cannot rule out the no-announcement equilibrium, it is interesting to note that the set of costs that sustain a no-announcement equilibrium also sustain an announcement equilibrium. Given that the high-type fundraiser receives larger contributions ( $G_H(z = 1) > 2m/3$ ) when it announces, this appears to be the more reasonable equilibrium strategy.

An interesting aspect of the announcement equilibria is that in signaling that the charity is of high type, the first contributor donates so much to the charity that the total donation exceeds that of a perfect information scenario. Whereas the contribution to the high-type charity is  $2m/3$  when information is perfect, contributions in the imperfect information scenario depend on the mixed strategy employed by the low-type fundraiser. However, despite the fact that resources are spent purchasing information the overall contribution to the high-type charity exceeds that of a perfect information environment.

Thus, for a fundraiser who represents a high-type charity, it is indeed in her best interest to announce the first contribution that she receives. Not only does this announcement help reveal the true value of the public good, but it also helps reduce the free-rider problem that arises in a perfect information scenario.

To get a simple solution to this problem we have had to make a number of simplifying assumptions. However it is important to note that the characteristics of the equilibria in many instances will be unaffected when these assumptions are relaxed. For example, one may wonder whether the general results will change when the low-type charity is producing a public good of some value, i.e.,  $0 < v_L < v_G$ . Equilibria with similar characteristics can be sustained if we once again find that contributions to the high-type charity that result from announcements exceed those of a perfect information environment. So let us consider the contributions that result when announcements are used. Relative to the previous analysis we now see that a contributor with a low signal will have an incentive to mimic the behavior of the higher types. Thus we have three types of contributors who all wish to convince  $B$  to make the largest contribution possible. In this case the Riley outcome is the fully revealing equilibrium where the type- $l$  contributor selects her utility maximizing contribution, the uninformed type selects a contribution sufficiently large to separate her from the type- $l$  contributor, and the type- $h$  contributor donates an amount large enough to separate herself from the un-

<sup>31</sup>The same types of equilibria arise in the case where  $U_j = x_j^\alpha + v_j G^\alpha$  and  $\alpha \in (0, 1)$ .

informed type.<sup>32</sup> Note that once again the type-*h* contributor will be forced to make a large enough contribution to separate herself from the uninformed contributor, and thus the high-type charity will when revealed as the high type receive larger contributions than it would receive when no announcement is made.

Another question is whether the set of equilibria changes when both contributors can buy information? Surprisingly the set of equilibria are unaffected by this extension. First, when the cost of information is sufficiently high there will still be pooling equilibria where no information is purchased and the two fundraisers play identically mixed strategies between announcing and not announcing past contributions. Second, assuming that information is purchased prior to making a contribution, there will not exist equilibria where the second contributor purchases information following an announcement. Thus, we can still sustain the announcement equilibria where only the first contributor buys information. The intuition is as follows: the second contributor only buys information if she thinks that the first contributor is uninformed. However, if the second contributor buys information, the first contributor strictly prefers to buy information, and to pretend as if she were uninformed when it is a high-type charity. Hence, the second contributor can deduce that the first contributor is informed. Therefore, following an announcement the second contributor never buys information, and the announcement equilibria from Section 3.4.2. survive. For the set of costs depicted in Fig. 2, there exists equilibria where the high-type fundraiser always announces and the low-type fundraiser is indifferent between announcing and not announcing. Third, let us consider the no announcement equilibria, these arise when  $\rho_0 < \sqrt{(m-c)/2m}$ , and resulted in the second contributor making no contribution to the charity. In this case the second contributor is strictly better off not acquiring information, and hence there will still exist equilibria where only one contributor is informed in the no announcement case.<sup>33</sup>

One might also worry that the result is sensitive to the assumption that both contributors care equally about the public good. Fortunately this is not a very restrictive assumption. Suppose for example that the second contributor cares less

<sup>32</sup>Since there are three type *A* players the intuitive criterion is not sufficient to rule out the other equilibria, however stronger belief refinements will yield the Riley outcome in the case of the different charity types all having some value (see Fudenberg and Tirole, 1992).

<sup>33</sup>Similarly we see all three types of equilibria being sustained for the case where  $U = x^\alpha + G^\alpha$ ,  $\alpha \in (0, 1)$ . The only difference is that for low values of  $\alpha$  yet another type of equilibrium may arise. In particular there will for very low cost exist equilibria where both contributors buy information when there are no announcements. The fundraiser's strategy is to never announce if she is high type, and she will mix between the two if she is low type. Thus a high-type charity receives contributions of  $G_H(z=0) = (2(m-c))/3$ , while the low-type charity receives no contribution independent of its announcement strategy. The consistent posteriors are  $\rho_1 = 0$  and  $\rho_0 = 1/(2-\gamma)$ . Once again we see that the set of costs that sustain a no-announcement equilibrium also sustain an announcement equilibrium, and that the high-type fundraiser receives larger contributions in the announcement equilibria ( $G_H(z=1) > 2m/3$ ).

about the public good from a high-type charity and has preferences of the form  $U_B^H = x_B^{0.5} + \beta G_H^{0.5}$ , where  $\beta < 1$ . If we limit attention to the cases where  $\beta$  is not too small, and  $A$  does not crowd out  $B$ 's contribution, then one finds that there exist announcement equilibria which have the exact same characteristics as those that result when preferences are identical. In particular we still get the result that the contribution to the high-type charity exceeds the level that would result when there is perfect information. The reason, once again, is that evaluated at the perfect information contribution level the incentive constraint does not hold, hence total contributions to the high-type charity will be larger than under perfect information. If instead the first contributor cares less about the public good, then the characteristics of the equilibria remain the same, but the contributions to the high-type charity will be smaller than when the person who cares most about the public good is first to give.

An assumption which is of critical importance is that the charity truthfully reports the contribution level of the first donor. We consider this assumption to be reasonable. First, the contribution level is verifiable, and, second, we are not familiar with cases where a charity incorrectly reported past contribution levels. One might also wonder whether it is reasonable to assume that contributions are announced independent of their level. Since the model is one of complete information contributors know whether a high-type fundraiser has an incentive to announce past contributions. Therefore subsequent contributions will only arise if the initial donation is positive, hence it should not affect the results whether a zero initial contribution is or is not announced.

#### 4. Conclusion

The purpose of this paper was to investigate the extent to which fundraisers have an incentive to announce first contributions when there is imperfect information about the quality of the public good. It is demonstrated that for sufficiently low cost of information, there exist equilibria where a high-quality fundraiser strictly prefers to announce first contributions. In this case announcements help high-quality charities to be recognized as such, and they result in contributions that exceed those that would result had the quality of the charity been common knowledge. Hence, an announcement strategy, may not only help good organizations reveal their type, but may also help the charity overcome the free-rider problem.

An interesting extension of this paper is to allow the agents to have different incomes or preferences. This extension is likely to make several of the current assumptions more plausible; specifically, it will be possible to relax the assumptions regarding the exogenous contribution ordering and information purchasing ability.

The reason is that contributions to the high-type charity are largest when the

first contributor is either the wealthiest or the one who cares most for the public good. Hence the high-type fundraiser will have an optimal solicitation strategy. Given the strict preference by the high-type fundraiser, a low-type fundraiser will reveal her type by not soliciting the wealthiest donor first. Thus both the high and the low-type fundraiser will choose to first ask the largest potential donor, since asking any other donor will reveal that the charity is of low type. Once the optimal solicitation ordering is known, the donor with the largest potential gift will have an incentive to be the first to donate.

While a heterogeneous population will lead to an optimal solicitation ordering it may also be of interest to determine whether it could generate a volunteer ordering, where contributors order themselves and provide their contribution when it is optimal. In particular it may be that contributions arise endogenously once a potential donor has given a sufficiently large initial contribution to signal that she is informed that the charity is worthwhile.

One of the interesting results of this paper is that when both contributors have the option to buy information, the first contributor is the only one who will do so. That is, we have been able to endogenously derive an asymmetry between the information held by the initial contributor and those who follow. Future work will determine whether this asymmetry remains when individuals have private information regarding the project's quality and the quality of this information differs across individuals. Specifically, we will determine whether contributors with more precise information are likely to be first contributors.

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### Appendix A

First, we show the conditions under which *A* will purchase information when contributions are not announced. When  $\rho_0 \leq \sqrt{(m-c)/2m}$ , contributor *A* purchases information if and only if

$$\left(\frac{2m}{2+\rho_0^2}\right)^{0.5} + \rho_0 \left(\frac{2m\rho_0^2}{2+\rho_0^2}\right)^{0.5} < 2\rho_0 \left(\frac{m-c}{2}\right)^{0.5} + (1-\rho_0)(m-c)^{0.5}, \quad (\text{A.1})$$

and when  $\rho_0 > \sqrt{(m-c)/2m}$ , contributor A purchases information if and only if

$$\left(\frac{2m}{2+\rho_0^2}\right)^{0.5} + \rho_0 \left(\frac{2m\rho_0^2}{2+\rho_0^2}\right)^{0.5} < 2\rho_0 \left(\frac{\rho_0^2(2m-c)}{1+2\rho_0^2}\right)^{0.5} + (1-\rho_0)(m-c)^{0.5}. \tag{A.2}$$

Second, we demonstrate that when the single crossing property does not hold, the cost of information is so high that the first contributor is unwilling to buy information. That is, the second contributor knows that the first contributor is uninformed, and the incentive constraint becomes irrelevant.

**Proposition 2.** *If c satisfies Eq. (4) then the single crossing property holds.*

**Proof.** The utility function for an informed first contributor who has received a high signal is  $U_h = (m - c - g_A)^{0.5} + (g_A + g_B)^{0.5}$ , and the slope of an indifference curve is  $dg_B/dg_A = ((g_A + g_B)/(m - c - g_A))^{0.5} - 1$ . The utility function for an uninformed contributor is  $U_u = (m - g_A)^{0.5} + \rho_1(g_A + g_B)^{0.5}$ , and the slope of her indifference curve is  $dg_B/dg_A = ((g_A + g_B)/\rho_1^2(m - g_A))^{0.5} - 1$ . The single crossing property holds if  $c < (m - g_A)(1 - \rho_1^2)$ . Note however that the first contributor is unwilling to buy information when  $c \geq (m - g_A)(1 - \rho_1^2)$ . Recall that the condition for buying information is that Eq. (4) holds, i.e.,

$$\left(\frac{2m}{2+\rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2 m}{2+\rho_1^2}\right)^{0.5} \leq \rho_1 \left[ (m - c - g_A)^{0.5} + \left(\frac{m + g_A}{2}\right)^{0.5} \right] + (1 - \rho_1)(m - c)^{0.5}.$$

To signal that it is a high-type charity  $g_A > (\rho_1^2 m)/(2 + \rho_1^2)$ . Evaluated at  $c = (m - g_A)(1 - \rho_1^2)$ , it is seen that the right-hand side of the inequality is decreasing for  $g_A > (\rho_1^2 m)/(2 + \rho_1^2)$ , thus we can evaluate the constraint at  $g_A = (\rho_1^2 m)/(2 + \rho_1^2)$  and  $c = (m - g_A)(1 - \rho_1^2)$ . This reveals that the information purchasing constraint is not satisfied when  $c$  is so high that the single crossing property does not hold.  $\square$

## Appendix B

$$\rho_0 = \rho_1 = 0.5$$

$$z_H = 1 \text{ with probability } \gamma \quad z_H = 0 \text{ with probability } 1 - \gamma, \text{ where } \gamma \in [0, 1]$$

$$z_L = 1 \text{ with probability } \gamma \quad z_L = 0 \text{ with probability } 1 - \gamma, \text{ where } \gamma \in [0, 1]$$

### No announcement strategy

$$\begin{aligned}
 I_A(z = 0) &= 0 && \text{if } c \geq 0.047 \\
 I_A(z = 0) &= 1 && \text{if } c < 0.047 \\
 g_A(0, l) &= 0 \\
 g_A(0, h) &= (m - c)/2 \\
 g_A(0, u) &= (\rho_0^2 m)/(2 + \rho_0^2) \\
 g_B(0, I_A = 0) &= (\rho_0^2 m)/(2 + \rho_0^2) \\
 g_B(0, I_A = 1) &= 0
 \end{aligned}$$

### One announcement strategy

$$\begin{aligned}
 I_A(z = 1) &= 0 && \text{if } c \geq 0.194m \\
 I_A(z = 1) &= 1 && \text{if } c < 0.194m \\
 g_A^0(1, l) &= g_A^1(1, l) = 0 \\
 g_A^0(1, h) &= 0.429m, \quad g_A^1(1, h) = 0 \\
 g_A^0(1, u) + g_A^1(1, u) &= (\rho_1^2 m)/(2 + \rho_1^2) \\
 \mu_B(t_A = l | g_A^0 = 0) &= 1 \\
 \mu_B(t_A = u | 0 < g_A^0 < 0.429m) &= 1 \\
 \mu_B(t_A = h | g_A^0 \geq 0.429m) &= 1 \\
 \mu_B(H | g_A^0 = 0) &= 0 \\
 \mu_B(H | 0 < g_A^0 < 0.429m) &= \rho_1 \\
 \mu_B(g_A^0 \geq 0.429m) &= 1 \\
 g_B^1(1, g_A^0 = 0) &= 0 \\
 g_B^1(1, 0 < g_A^0 \leq (\rho_1^2 m)/(2 + \rho_1^2)) &= (\rho_1^2 m)/(2 + \rho_1^2) \\
 g_B^1(1, (\rho_1^2 m)/(2 + \rho_1^2) < g_A^0 < 0.429m) &= (\rho_1^2 m - g_A^0)/(1 + \rho_1^2) \\
 g_B^1(1, g_A^0 \geq 0.429m) &= \max\{(m - g_A^0)/2, 0\}
 \end{aligned}$$

### Equilibria II: Announcement equilibria

An equilibrium where *A* buys information when the first contribution is announced and not when the first contribution is not announced is supportable for any cost  $c < x(\rho_1)m$ , where  $x(\rho_1)$  is s.t.

$$\begin{aligned}
 \left(\frac{2}{2 + \rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2}{2 + \rho_1^2}\right)^{0.5} &= \rho_1 \left[ (1 - x - y(\rho_1))^{0.5} \right. \\
 &\quad \left. + \left(\frac{1 + y(\rho_1)}{2}\right)^{0.5} \right] + (1 - \rho_1)(1 - x)^{0.5}.
 \end{aligned}$$

The sequentially rational strategies and consistent beliefs are:

$$\begin{aligned} \rho_0 &= 0, \rho_1 = \frac{1}{1 + \gamma} \\ z_H &= 1 \text{ with probability } 1 \quad z_H = 0 \text{ with probability } 0 \\ z_L &= 1 \text{ with probability } \gamma \quad z_L = 0 \text{ with probability } 1 - \gamma, \text{ where } \gamma \in (0, 1] \end{aligned}$$

No announcement strategy

$$\begin{aligned} I_A(z = 0) &= 0 \quad \text{if } c \geq 0 \\ g_A(0, u) &= g_B(0, I_A = 0) = 0 \end{aligned}$$

One announcement strategy

$$\begin{aligned} I_A(z = 1) &= 0 \quad \text{if } c \geq x(\rho_1)m \\ I_A(z = 1) &= 1 \quad \text{if } c < x(\rho_1)m \\ g_A^0(1, l) &= g_A^1(1, l) = 0 \\ g_A^0(1, h) &= my(\rho_1), \text{ where } y(\rho_1) \text{ is s.t. } \left(\frac{2}{2 + \rho_1^2}\right)^{0.5} + \rho_1 \left(\frac{2\rho_1^2}{2 + \rho_1^2}\right)^{0.5} \\ &= (1 - y)^{0.5} + \rho_1 \left(\frac{1 + y}{2}\right)^{0.5} \\ g_A^1(1, h) &= 0 \\ g_A^0(1, u) + g_A^1(1, u) &= \frac{\rho_1^2 m}{2 + \rho_1^2}, \text{ where } g_A^0(1, u) > 0 \\ \mu_B(t_A = l | g_A^0 = 0) &= 1 \\ \mu_B(t_A = u | 0 < g_A^0 < y(\rho_1)m) &= 1 \\ \mu_B(t_A = h | g_A^0 \geq y(\rho_1)m) &= 1 \\ \mu_B(H | g_A^0 = 0) &= 0 \\ \mu_B(H | 0 < g_A^0 < y(\rho_1)m) &= \rho_1 \\ \mu_B(g_A^0 \geq y(\rho_1)m) &= 1 \\ g_B^1(1, g_A^0 = 0) &= 0 \\ g_B^1\left(1, 0 < g_A^0 \leq \frac{\rho_1^2 m}{2 + \rho_1^2}\right) &= \frac{\rho_1^2 m}{2 + \rho_1^2} \\ g_B^1\left(1, \frac{\rho_1^2 m}{2 + \rho_1^2} < g_A^0 < y(\rho_1)m\right) &= \frac{\rho_1^2 m - g_A^0}{1 + \rho_1^2} \\ g_B^1(1, g_A^0 \geq y(\rho_1)m) &= \max\left\{\frac{m - g_A^0}{2}, 0\right\} \end{aligned}$$

### *Equilibria III: No-announcement equilibria*

An equilibrium where A buys information when there are no announcements and not when the first contribution is not announced is supportable for any cost  $c < x(\rho_0)m$ , where for  $\rho_0 \leq \sqrt{m - c/2m}$ ,  $x(\rho_0)$  satisfies

$$\left(\frac{2}{2 + \rho_0^2}\right)^{0.5} + \rho_0 \left(\frac{2\rho_0^2}{2 + \rho_0^2}\right)^{0.5} = 2\rho_0 \left(\frac{1 - x(\rho_0)}{2}\right)^{0.5} + (1 - \rho_0)(1 - x(\rho_0))^{0.5},$$

The sequentially rational strategies and consistent beliefs are:

$$\begin{aligned} \rho_0 &= \frac{1}{2 - \gamma}, \rho_1 = 0 \\ z_H &= 1 \text{ with probability } 0 \quad z_H = 0 \text{ with probability } 1 \\ z_L &= 1 \text{ with probability } \gamma \quad z_L = 0 \text{ with probability } 1 - \gamma, \text{ where } \gamma \in (0, 0.305] \end{aligned}$$

#### No announcement strategy

$$\begin{aligned} I_A(z = 0) &= 0 \quad \text{if } c \geq x(\rho_0)m \\ I_A(z = 0) &= 1 \quad \text{if } c < x(\rho_0)m \\ g_A^0(0, l) &= 0 \\ g_A^0(0, h) &= \frac{m - c}{2} \\ g_A^0(0, u) &= \frac{\rho_1^2 m}{2 + \rho_1^2} \\ g_B^1(0, I_A = 0) &= \frac{\rho_1^2 m}{2 + \rho_1^2} \\ g_B^1(0, I_A = 1) &= 0 \end{aligned}$$

#### One announcement strategy

$$\begin{aligned} I_A(z = 1) &= 0 \quad \text{if } c \geq 0 \\ g_A^0(1, u) + g_A^1(1, u) &= 0 \\ g_B^1(1, g_A^0 = 0) &= 0 \end{aligned}$$

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