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 may not only help worthwhile organizations reveal their type, but it may also help the fundraiser reduce the free-rider problem.

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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.[1] 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 fundraiser in the fundraising game.[2] The majority of the voluntary contribution literature assumes that donations are given simultaneously, yet the characteristics of many fundraisers suggest that the underlying game is a sequential move 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.[3]

The objective of this paper is to investigate the role of the fundraiser in the fundraising game, and to determine 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 is successful because it helps reveal otherwise unknown information about the quality of the public good. Indeed the paper

[1] See for example Andreoni (1988, 1990, 1995), Bergstrom, Blume, and Varian (1986), Cornes and Sandler (1984).

[2] 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 (1998).

[3] In Edle's book "Fundraising: Hands-on Tactics for Nonprofit Groups," he recommends that fundraisers inform future contributors of the number of donors and the total amount that they have contributed.

demonstrates that when there is imperfect information, then there exist equilibria where high quality charities strictly prefer to announce past contributions. 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 high quality charities by announcing contributions 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.

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. It is shown 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.

The 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 he is prevented from contributing more than once; however, if given the option he will increase his 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 his first donation. That is, following his initial donation, the first contributor can make an additional donation to the public good simultaneously with the second contributor.[4] 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.[5] 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 20-hour 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 contributions than when they were not announced.[6] In other words, verbal information about what other people are doing is in itself 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.[7] That is, the announcement effectively

[4] 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.

[5] Section 3.3.1. demonstrates this point.

[6] 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 minute intervals and total contributions were calculated for each interval. To the extent possible the telethon alternated between the three different treatments every fifteen minutes. However there are many deviations from this rule. The strongest evidence in support of announcing pledges may be that during the last three 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.

[7] Andreoni (1988, 1990), Harbaugh (1998), Glazer and Konrad (1996), Olson (1965), and Steinberg (1989).

adds a private benefit to the donation, thereby increasing it's 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 often are 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."[8] 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 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 (1998). 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.[9]

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

[8] The New York Times, February 2, 1997, p. 10. This article points out that there are two aspects to being an annonymous 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 annonymous 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.

[9] 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.

result is not sensitive to that 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.[10] 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) 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.[11] That is, rather than assuming that one contributor is informed

[10] 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.

[11] In contrast to Schiff's approach we incorporate the fact that contibutors have an incentive to convince others that a charity is of high quality.

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.[12] Indeed some contributors spend substantial resources investigating the quality of the proposed project. Large contributors often set up foundations which employ a whole team of experts to evaluate and investigate proposed projects.[13]

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 $U_j^H = \ln x_j + \ln G$, when the charity is of high type, and $U_j^L = \ln x_j$, when the charity is of low type.[14]

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

[12] 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.

[13] 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."

[14] It will soon become clear that it is difficult to solve the model when preferences do not have a specific functional form. However, we suspect that the type of equilibria that arise for the log linear preferences also arise for other utility functions of the form $U_j = f(x_j) + v_i h(G)$, where both $f()$ and $h()$ are monotonically increasing and concave, and v_i denotes the value of the public good i. In Section 3.5. we also show that the results are not sensitive to the assumption that individuals are identical.

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 type-H or a type-L 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.[15] We will first examine the case where 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. That is, 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 it's 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 are effectively making 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

[15] 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 heterogenous agents. The reason is that in this case there is an optimal solicitation ordering. Hence, all subsequent contributors will use the size of the initial donation to determine the quality of the public good.

contribution is made prior to the announcement. Having observed this initial contribution, B donates to 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 type-L charity, and a positive contribution would be made to the type-H 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.[16]

In order 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; sections 3.2 and 3.3, derive the relevant contribution levels. Examining the announcement scenario in section 3.3 reveals that when information is purchased, the initial contribution reveals the quality of the charity.

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 two 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 other type of equilibrium arises when the information cost is sufficiently

[16] If the belief is that only high-type fundraisers announce contributions, then low-type fundraisers will choose to announce. Similarly the low-type fundraiser will choose not to announce if the belief is that only high-type fundraisers choose this strategy. Of course such beliefs are not consistent with the fundraiser's strategy and as a result they do not constitute an equilibrium.

low. In this case 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 contribution. In this case 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. Hence these equilibria are semi-separating.

This type of equilibrium is particularly interesting because it shows the announcement strategy as being optimal, and because the announcement strategy enables the high-type fundraiser to achieve contribution levels that exceed those of the perfect information scenario. In order to signal that the charity is of high quality contributor A must make a donation which exceeds the contribution level she would have made had the quality of the charity been known. Relative to the perfect information case, 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 the perfect information scenario.

The next sections demonstrate that there only exist two types of equilibria. Characteristic of them is that in both equilibria a low-type fundraiser randomizes between announcing and not announcing. In contrast 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 always announces the first contribution. Thus any uncertainty about the cost of information will result in the high-type fundraiser always announcing the first contribution.

3.2. No Announcement Contributions

When no announcement is made, 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. With the cost of information being common knowledge, however, B can deduce whether information is purchased. 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. $t_A \in \{u, h, l\}$.

Let us first determine the contributions that result when A does not purchase information. Conditional on their posterior, $\rho_0 = \mu(H|z = 0)$, 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:

$$\begin{array}{ll} Max_{g_j,x_j} & lnx_j + \rho_0 lnG \\ s.t. & g_j + x_j = m \\ & g_j \geq 0. \end{array}$$

If we let $g_{-j}(0)$ denote the contribution by the other donor, then j's best response function is $g_j(0) = \max\{0, \frac{\rho_0 m - g_{-j}(0)}{1+\rho_0}\}$, and the total contribution to the public good is $G_i(0, I_A = 0) = \frac{2m\rho_0}{2+\rho_0}$ 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 $g_A(0, h) = \max\{0, \frac{m-c-g_B(0,I_A=1)}{2}\}$. 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

$$\begin{array}{ll} Max_{g_B,x_B} & lnx_B + \rho_0 ln\left(g_A(0,h) + g_B\right) \\ s.t. & g_B + x_B = m \\ & g_B \geq 0. \end{array}$$

Hence, $g_B(0, I_A = 1) = max\{0, \frac{\rho_0 m - g_A(0,h)}{1+\rho_0}\}$. This implies that B will make no donation when the posterior is sufficiently small, and will make a positive donation when it is sufficiently large. When $\rho_0 \leq \frac{m-c}{2m}$, then $G_H(0) = g_A(0, h)$, and $G_L(0) = 0$.[17] If $\rho_0 > \frac{m-c}{2m}$, 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 type when no information is purchased, a high-type charity receives a larger contribution when information is purchased.

Given these contributions levels A will only buy information if

$$\begin{aligned} (1) \quad & \ln(m - g_A(0, u)) + \rho_0 \ln G(0, I_A = 0) \\ & < \rho_0(\ln(m - c - g_A(0, h)) + \ln G^H(0, I_A = 1)) + (1 - \rho_0)\ln(m - c). \end{aligned}$$[18]

In order 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.

[17] Using the expression for $g_A(0, h)$ and assuming a positive contribution level we see that $g_B(0, I_A = 1) = \frac{(2\rho_0-1)m+c}{1+2\rho_0}$, i.e. B makes no contribution when $\rho_0 \leq \frac{m-c}{2m}$.

[18] See Appendix 1 for the specific conditions.

3.3. Announcement Contributions

Knowing that the fundraiser has chosen to announce the initial contribution, the donors update their beliefs that it is a high-type project. Denote this posterior $\rho_1 = \mu(H|z=1)$. Contributor A then decides whether to purchase information. Conditional on her type the first mover 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, $\mu_B(H|g_A^0) = \mu_B^h + \rho_1 \mu_B^u$.[19] B then makes her contribution, $g_B^1(1, g_A^0)$, simultaneously with a potential additional contribution from the first mover, $g_A^1(1, t_A)$.

If agent A receives a low signal then she knows with certainty that it is a low-type charity and will have no incentive to act as if she were someone who received a high signal.[20] Likewise, a contributor who receives a high signal has no incentive to mimic the behavior of a contributor who receives a low signal. However, given that the purchasing decision is unobserved, A may be better off not purchasing information, yet making a contribution that leads the second contributor to believe that she bought information and received a high signal.

When comparing the indifference curve of an uninformed A contributor with that of an informed A contributor with a high signal, it is seen that they cross only once and that the uninformed's indifference curve is steeper than that of the informed A with a high signal.[21] Given that the single crossing property holds, we know from Cho and Kreps (1987) that the only equilibrium which survives the Intuitive Criterion is the Riley outcome, i.e. the separating equilibrium with the least amount of inefficient signaling.[22] Hence, we will determine a set of strategies and beliefs such that the first contribution reveals whether the first contributor bought information, and if she bought information, the true value of the public 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'

[19] Let $\mu_B(t_A = h|g_A^0) = \mu_B^h$, $\mu_B(t_A = l|g_A^0) = \mu_B^l$, and $\mu_B(t_A = u|g_A^0) = \mu_B^u$, where $\mu_B^h + \mu_B^l + \mu_B^u = 1$.

[20] Note that this result depends on the assumption that the contributors get no utility from the public good provided by the low-type charity. If they do get a positive benefit, then a contributor with a low signal will have an incentive to mimic.

[21] See Appendix I.

[22] The Intuitive Criterion is a reasonable belief refinement. It allows us to eliminate equilibria where a type has a deviation which is assured of yielding a payoff above the equilibrium payoff as long as there is not a positive probability assigned to the deviation having been made by any type for whom this action is equilibrium dominated. See Cho and Kreps (1987) for a complete definition.

rule.

3.3.1. Uninformed First Contributor

Let us first determine the contributions that result when the first contributor is uninformed. In a separating equilibrium a contributor who did not buy information is recognized as such. That is, when B observes $g_A^0 = g_A^0(1,u)$, her consistent belief is $\mu_B(H|g_A^0) = \rho_1$.

The best-response function of B is similar to the response function that results when all contributions are made simultaneously, that is $g_B^1(1, g_A^0) = \frac{\rho_1 m - g_A^1(1,u) - g_A^0(1,u)}{1+\rho_1}$. Now let us determine A's optimal contribution following the initial announcement:

$$\begin{array}{cc} Max_{g_A^1, x_A} & \ln x_A + \rho_1 \ln G \\ s.t. & g_A^0 + g_A^1 + x_A = m \\ & g_A^1 \geq 0. \end{array}$$

Contributor A's best-response function is $g_A^1(1,u) = \frac{\rho_1 m - (1+\rho_1) g_A^0(1,u) - g_B^1(1, g_A^0)}{1+\rho_1}$. Simultaneously solving the two best-response functions reveals that $g_B^1(1, g_A^0) = \frac{\rho_1 m}{2+\rho_1}$, and $g_A^1(1) = -g_A^0(1) + \frac{\rho_1 m}{2+\rho_1}$. While it is possible to determine A's overall contribution, $g_A^1(1,u) + g_A^0(1,u) = \frac{\rho_1 m}{2+\rho_1}$, 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 $g_A(1,u) = \frac{\rho_1 m}{2+\rho_1}$, and a consistent belief is $\mu_B(H|g_A^0) = \rho_1$, for $g_A^0 \in (0, \frac{\rho_1 m}{2+\rho_1}]$. Given these beliefs, B's best response is $g_B^1(1, g_A^0) = \frac{\rho_1 m}{2+\rho_1}$.

3.3.2. Informed First Contributor

Now let us 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, respectively, $\mu_B(H|g_A^0 = 0) = 0$, and $g_B^1(1, g_A^0 = 0) = 0$.

In the case where A receives a high signal, she will contribute an amount that is sufficiently large to distinguish herself from an uninformed contributor.

Having observed a sufficiently large first contribution, the second contributor's best response is $g_B^1(g_A^0) = \frac{m - g_A(1,h)}{2}$, and the overall contribution to the public good is $G_H(1) = \frac{m + g_A(1,h)}{2}$. In order to support this separating equilibrium, the initial contribution needs to be large enough that an agent who does not buy information prefers contributing $g_A(1,u) = \frac{\rho_1 m}{2+\rho_1}$ rather than mimicking and pretending to be someone who bought information and received a high signal. Hence, $g_A^0(1,h)$ must be set such that the following constraint is satisfied:[23]

$$(2) \qquad \ln \frac{2m}{2+\rho_1} + \rho_1 \ln \frac{2\rho_1 m}{2+\rho_1} \geq \ln \left[m - g_A^0(1,h) \right] + \rho_1 \ln \frac{m + g_A^0(1,h)}{2}.$$

In the separating equilibrium with an equilibrium contribution, $g_A^0(1,h)$, 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 the contribution that involves the least amount of inefficient signaling.

Note, however, 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 choose 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 $g_B^1(g_A^0) = \frac{\rho_1 m}{2+\rho_1}$, and it can be shown that the mimicking type-h first-mover will make an additional donation $g_A^1(1,h) = -g_A^0(1,h) + \frac{2m-(2+\rho_1)c}{4+2\rho_1}$ after the announcement. For a separating equilibrium to exist it must be the case that the equilibrium contribution $g_A^0(1,h)$ satisfies the condition

$$(3) \qquad \ln\left(m - c - g_A^0(1,h) - g_A^1(1,h)\right) + \ln \frac{m + g_A^0(1,h) + g_A^1(1,h)}{2} \geq 2 \ln \frac{2(m-c) + \rho_1(2m-c)}{2(2+\rho_1)}.$$

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

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

[23] 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.

As is common in signaling models, there often exist a continuum of contributions $g_A^0(1,h)$ that satisfy equations (2), (3) and (4). Fortunately, as demonstrated in Appendix I it can be shown that if the single-crossing property does not hold then contributor A has no incentive to buy information, i.e. since B knows A's cost, she also knows that A is uninformed. Thus the intuitive criterion is easily applied and only the Riley outcome survives. 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 $g^H > \frac{m-2c}{3}$, then a separating equilibrium exists only if the first contributor is willing to let $g_A^0(1,h) = g^H$ and $g_A^1(1,h) = 0$ such that $g_B^1(1, g^H) = \frac{m-g^H}{2}$ and $G^H = \frac{m+g^H}{2}$. Otherwise $G^H = \frac{2m-c}{3}$.[24]

3.4. Equilibria

Using the optimal strategies 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.

TABLE 1
Total Contributions to the Fundraiser

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

[24] If $g^H \leq \frac{m-2c}{3}$, then $g_A^0(1,h) + g_A^1(1,h) = \frac{m-2c}{3}$ where $g_A^0(1,h) \geq g^H$, and $g_B^1(1, g_A^0) = \frac{m+c}{3}$, such that the overall contribution is $G^H = \frac{2m-c}{3}$.

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 independent of the fundraiser's action, i.e. $I_A(0) = I_A(1) = 1$; (4) Information is purchased only when no announcement is made, i.e. $I_A(0) = 0$ and $I_A(1) = 1$. Given the contributions in Table 1, it can be shown that neither (3) nor (4) can be supported as equilibria, and depending on the cost of information both (1) and (2) are equilibria of the game. Specifically, (1) results in pooling equilibria and (2) results in hybrid equilibria. These results are demonstrated below.

Proposition 3.1. *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. If A's purchasing decision is independent of the announcement decision then it must be the case that the fundraiser, independent of type, has a positive probability of both announcing and not announcing the first contribution. The reason is that A only buys information when the value of the public good is unknown. However, in the case where information is bought independent of the fundraiser's strategy, 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 type L. Given this belief it is not optimal for A to buy information about the public good when no announcement is made.[25] ■

Likewise, we can rule out the case where information is bought only when no announcement is made.

[25] As an illustration let us consider the case where the high and low-type charity play identically mixed strategies. Given this strategy the consistent prior is one half, independent of the announcement strategy. At this prior A will not buy information, and hence contributions when no announcement is made equals $\frac{2m}{5}$, independent of the charity's type. In contrast the aggregate contribution following an announcement equals $0.7m$ to the high-type charity and the low-type charity does not receive any donations. Given the high-type charity's incentive to announce, the belief that charities are equally likely not to announce is not consistent.

Proposition 3.2. *There does not exist a perfect Bayesian equilibrium where information is bought only when no announcement is made, i.e.*
$I_A(z = 1) = 0 \rightarrow I_A(z = 0) = 0$.

Proof. Suppose $I_A(z = 1) = 0$ and $I_A(z = 0) = 1$. This action is only optimal if the fundraiser, independent of type, chooses the no-announcement strategy with positive probability. 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. Since no information is bought when the first contribution is announced, both types of fundraisers receive the same contribution when employing this strategy. Hence, for both fundraisers to be playing $z = 0$ with positive probability, it must be the case that the low-type either prefers $z = 0$ or is indifferent between $z = 0$ and $z = 1$. As a result the high-type fundraiser will strictly prefer $z = 0$. Since a fundraiser has an equal probability of being high or low, the resulting consistent beliefs are $\rho_0 \geq 0.5$ and $\rho_1 = 0$. However, since $\rho_0 > \frac{m-c}{2m}$ the low-type fundraiser will receive a positive contribution when not announcing the first contribution and no contribution when announcing the first contribution. Hence, the low-type fundraiser will never announce the first contribution, and a consistent belief is $\rho_0 = 0.5$. Given these beliefs there does not exist a $c \geq 0$ such that equation (1) is satisfied, and therefore A does not have an incentive to buy information. ■

Taking account of propositions 3.1 and 3.2 we are left with two potential types of equilibria: one where, independent of the announcement decision, no information is purchased, and another where information is bought only when the first contribution is 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: $G_H(z) = G_L(z) = \frac{2\rho_z m}{2+\rho_z}$ where $z = 0, 1$. Now 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 ρ_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 the case that $\rho_0 = \rho_1 = 0.5$.

In order to sustain these equilibria it has to be the case that A does not have an incentive to purchase information. As shown in Proposition 3.2 at $\rho_0 = 0.5$, there does not exist a cost $c > 0$ that will cause A to buy information when no announcement is made.

Now 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. In order 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 $g^H = 0.39m$. Since $g^H > \frac{m-2c}{3}$ for all c, the incentive constraint is exactly 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 $g^H = 0.39m$, condition (4) is a binding constraint at $c_{z=1} = 0.17m$. Therefore, if the cost of information is higher than $0.17m$, then A will not buy information when $z = 1$.

Finally, it is easily shown that contributor A, when she buys information, prefers to signal that it is a high-type charity, i.e. (3) is satisfied.

In summary, if $c \geq 0.17m$ contributor A and B each make a total donation $\frac{\rho_z m}{2+\rho_z}$. Given consistent beliefs of $\rho_0 = \rho_1 = 0.5$ the best response by the fundraiser is to announce with probability γ and not to announce with probability $1-\gamma$. Note that these are pooling equilibria since, independent of type, the fundraiser plays the same mixed strategy. See Appendix II for a complete description of the equilibrium.

3.4.2. Equilibria II: Information Bought When Announcement is Made

Now let us show that an equilibrium exists where information is bought when the first contribution is announced, but not when it is unannounced. Given the announcement of the first contribution, we know that 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 the case that $\rho_1 \in (0,1)$, otherwise there is no reason to buy information. This requirement implies that a type-L 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 γ, and $z_L = 0$ with probability $1 - \gamma$, where $\gamma \in (0, 1]$, generating consistent beliefs $\rho_0 = 0$ and $\rho_1 = \frac{1}{1+\gamma} \in [0.5, 1)$.

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

$$\ln \frac{2m}{2 + \rho_1} + \rho_1 \ln \frac{2\rho_1 m}{2 + \rho_1} = \ln(m - ym) + \rho_1 \ln \frac{m + ym}{2}.$$

Figure 1 illustrates the solution $y(\rho_1)$. Note that an increase in the posterior ρ_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 first contributor, hence y increases. On the other hand an increase in ρ_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 ρ_1. Clearly as ρ_1 approaches 1, A's contribution $y(\rho_1)$ approaches $\frac{m}{3}$. Since $g_A^0(1, h) > \frac{m-2c}{3}$ contributor A will never make a contribution after the announcement, that is $g_A^1(1, h) = 0$.

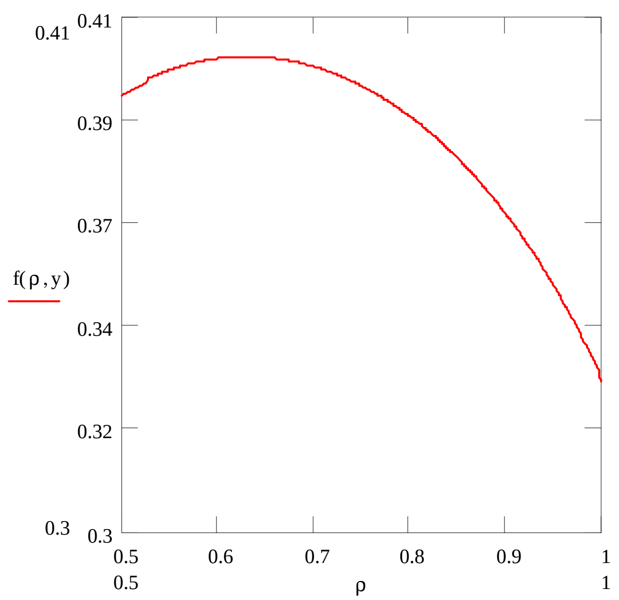

Figure 1: A's contribution to the high quality charity, $y(\rho_1)$.

Given $y(\rho_1)$ we are able to 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

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

For all $c < mx(\rho_1)$, contributor A purchases information about the charity. Figure 2 illustrates the contributor's maximum willingness to pay, $c(z=1)/m$, conditional on ρ_1 and $y(\rho_1)$.

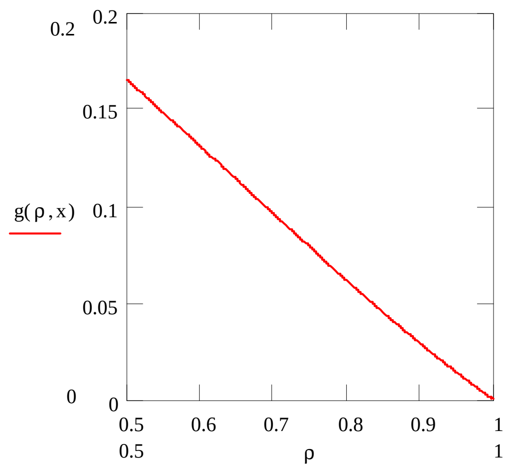

Figure 2: Maximum Willingness to Pay for Information, $x(\rho_1)$.

Not surprisingly contributor A's willingness to pay for information decreases with the posterior ρ_1. Note also that A is not willing to pay for information when she knows that the public good is of high quality. Given this set of costs and contributions, it can be shown that contributor A always reveals the quality of the public good.

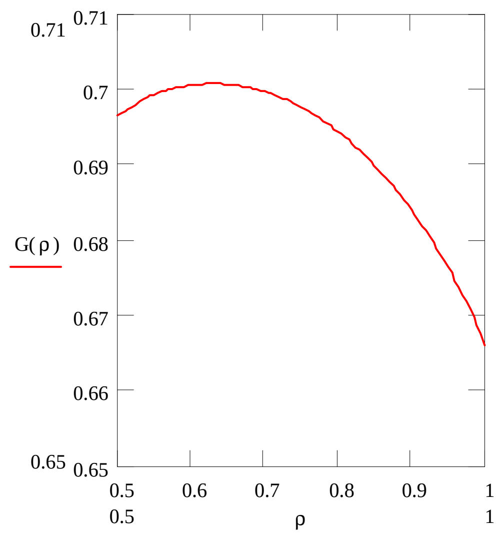

Figure 3: Total contribution to high quality charity, $G_H(\rho_1)$.

Figure 3 illustrates the overall contribution made to a type-H charity conditional on ρ_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 type-H charity from a type-L charity.[26] If the contributors are able to distinguish a type-H charity, the overall contribution is $\frac{2m}{3}$, which is strictly less than the equilibrium contributions just derived. See Appendix II for a complete description of the equilibrium strategies.

3.5. Discussion

The analysis presented here has demonstrated that when the cost of information is prohibitively high, $c \geq 0.17m$, 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 $G_i(z) = \frac{2m}{5}$, independent of z, and an equilibrium exists only if the two types of fundraisers play identical mixed strategies between $z = 0$ and $z = 1$. Hence, for sufficiently high information costs pooling equilibria arise and the contribution level is uncorrelated with the announcement strategy.

[26] For $\rho_1 \geq \frac{1}{2}$ the incentive constraint is never satisfied when evaluated at the perfect information contribution level ($g_A^0 = \frac{m}{3}$).

When the information cost $c \in (0, 0.17m)$ then we can support a range of hybrid equilibria. Characteristic of these equilibria is that the type-H fundraiser always announces the first contribution, while the type-L fundraiser mixes between announcing and not announcing the first contribution. Independent of her strategy, the low-type charity receives no contributions. While the fundraisers cannot separate via their choice of an announcement strategy, the first contributor can separate through her contribution choice.

An interesting aspect of these hybrid 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 type-H charity is $\frac{2m}{3}$ when information is perfect, contributions in the imperfect information scenario depend on the mixed strategy employed by the type-L 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 model.

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 strategy 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 the extent that the fundraiser is uncertain of A's cost of information, the high-type fundraiser will always choose to announce the first contribution.

In order 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. A natural question to ask is, how does the set of equilibria change when both contributors can buy information? Assuming that information is purchased prior to making a contribution, it can be shown that three types of equilibria may arise: two of these are semi-separating and the third is pooling. Two of these equilibria are exactly the equilibria we found when only one contributor can buy information. Not surprisingly, pooling equilibria arise when the cost of information is so high that neither contributor buys information, that is, when $c \geq 0.17m$. In this case the two types of fundraisers play identical mixed strategies between announcing and not announcing the first contribution. These are equilibria of type I from section 3.4.1.

For any $c < 0.17m$, we can sustain the hybrid equilibria that arise when only one 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 equilibria of type II from section 3.4.2. survive. That is, for the set of costs depicted in Figure 2, the high-type fundraiser always announces and the low-type fundraiser is indifferent between announcing and not announcing.

The only change that arises when we allow both contributors to buy information is that for very low cost there will exist equilibria where the high-type fundraiser never announces and the low-type fundraiser plays a mixed strategy between announcing and not announcing. Figure 4 illustrates the set of costs and posteriors for which this set of equilibria can be sustained. In this type of equilibrium both contributors buy information when no announcement is made and neither contributor buys information when an announcement strategy is used. This implies that a high-type charity receives contributions of $G_H(z=0) = \frac{2(m-c)}{3}$, while the low-type charity receives no contribution independent of its announcement strategy. Hence, the consistent posteriors are $\rho_1 = 0$ and $\rho_0 = \frac{1}{2-\gamma}$, where γ is the frequency by which the low-type fundraiser announces.

While we cannot rule out this third type of equilibrium, it is less damagining to the announcement equilibrium than it first appears. The reason is 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 ($G_H(z=1) > \frac{2m}{3}$) when it announces, this appears to be the more reasonable equilibrium strategy.

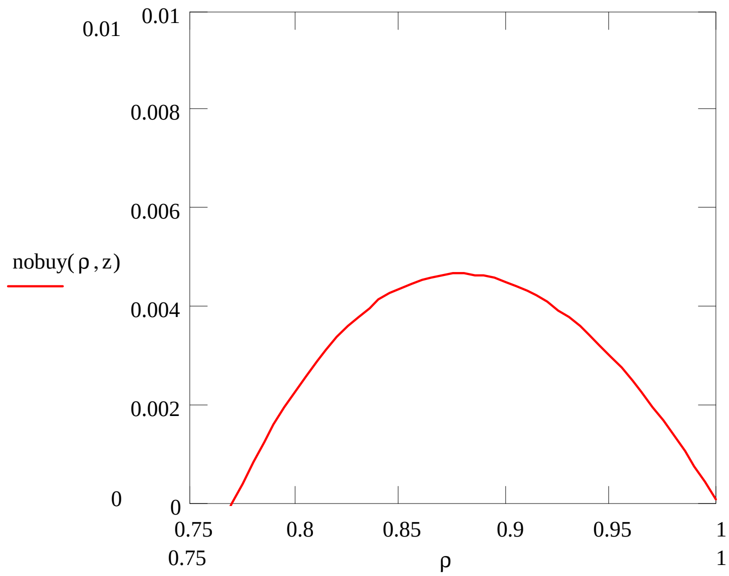

Figure 4: $j's$ willingness to pay for information when $I_{-j} = 1$.

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 about the public good from a high-type charity and has preferences of the form $U_B^H = \ln x_B + \beta \ln G$, where $\beta < 1$. If we limit attention to the cases where β is not too small, and A does not crowd out B's contribution, then one finds that there exist equilibria which have the exact same characteristics as those that result when preferences are identical. In particular we still get the result that the overall contribution level 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 overall contribution level 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. However we do consider this assumption to be reasonable, first the the contribution level is verifiable, and second we are not familiar with any 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 fund-raiser 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, a high quality fundraiser strictly prefers to announce first contributions. In this case announcements help high quality charities to be recognized as such. Furthermore, 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, may not only help good organizations reveal their type, but may also helps 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 contributor who cares most for the public good. Hence the fundraiser will have an optimal solicitation strategy, and it will not be possible for the fundraiser to convince anyone but the wealthiest contributor that he should be the first to donate to the public good. Once the optimal solicitation ordering is known the donor with the largest potential gift will have no option but to be the first to donate.

While a heterogenous 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.

One of the interesting results of this paper is that when both contributors have the option to buy information then 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 I

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

$$\text{(1A)} \qquad \ln \frac{2m}{2+\rho_0} + \rho_0 \ln \frac{2m\rho_0}{2+\rho_0} < 2\rho_0 \ln \frac{m-c}{2} + (1-\rho_0)\ln(m-c),$$

and when $\rho_0 > \frac{m-c}{2m}$, contributor A purchases information if and only if

$$\text{(1B)} \qquad \ln \frac{2m}{2+\rho_0} + \rho_0 \ln \frac{2m\rho_0}{2+\rho_0} < 2\rho_0 \ln \frac{\rho_0(2m-c)}{1+2\rho_0} + (1-\rho_0)\ln(m-c).$$

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 3.0. *If c satisfies equation (4) then the single crossing property holds.*

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

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

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

Appendix II

Equilibria I: No Information is Purchased

$\rho_0 = \rho_1 = 0.5$

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

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

No announcement strategy

$$I_A(z=0) = 0 \qquad \text{if } c \geq 0$$
$$g_A(0,u) = g_B(0, I_A = 0) = \tfrac{\rho_1 m}{2+\rho_1}$$

One announcement strategy

$$I_A(z=1) = 0 \qquad \text{if } c \geq 0.166m$$
$$I_A(z=1) = 1 \qquad \text{if } c < 0.166m$$

$$g_A^0(1,l) = g_A^1(1,l) = 0$$
$$g_A^0(1,h) = 0.394m,\ g_A^1(1,h) = 0$$
$$g_A^0(1,u) + g_A^1(1,u) = \tfrac{\rho_1 m}{2+\rho_1}$$

$$\mu_B(t_A = l | g_A^0 = 0) = 1$$
$$\mu_B(t_A = u | 0 < g_A^0 < 0.394m) = 1$$
$$\mu_B(t_A = h | g_A^0 \geq 0.394m) = 1$$

$$\mu_B(H | g_A^0 = 0) = 0$$
$$\mu_B(H | 0 < g_A^0 < 0.394m) = \rho_1$$
$$\mu_B(g_A^0 \geq 0.394m) = 1$$

$$g_B^1(1, g_A^0 = 0) = 0$$
$$g_B^1(1, 0 < g_A^0 \leq \tfrac{\rho_1 m}{2+\rho_1}) = \tfrac{\rho_1 m}{2+\rho_1}$$
$$g_B^1(1, \tfrac{\rho_1 m}{2+\rho_1} < g_A^0 < 0.394m) = \tfrac{\rho_1 m - g_A^0}{1+\rho_1}$$
$$g_B^1(1, g_A^0 \geq 0.394m) = \max\{\tfrac{m - g_A^0}{2}, 0\}$$

Equilibria II: Information Bought When Announcement is Made

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.

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

The sequentially rational strategies and consistent beliefs are:

$\rho_0 = 0$, $\rho_1 = \frac{1}{1+\gamma}$

$z_H = 1$ with probability 1 $\quad$ $z_H = 0$ with probability 0

$z_L = 1$ with probability γ $\quad$ $z_L = 0$ with probability $1-\gamma$, where $\gamma \in (0, 1]$

No announcement strategy

$I_A(z = 0) = 0 \qquad$ if $c \geq 0$

$g_A(0, u) = g_B(0, I_A = 0) = 0$

One announcement strategy

$I_A(z = 1) = 0 \qquad$ if $c \geq x(\rho_1)m$

$I_A(z = 1) = 1 \qquad$ if $c < x(\rho_1)m$

$g^0_A(1, l) = g^1_A(1, l) = 0$

$g^0_A(1, h) = m\, y(\rho_1)$, where $y(\rho_1)$ is s.t. $\ln \frac{2}{2+\rho_1} + \rho_1 \ln \frac{2\rho_1}{2+\rho_1} = \ln(1-y) + \rho_1 \ln \frac{1+y}{2}$

$g^1_A(1, h) = 0$

$g^0_A(1, u) + g^1_A(1, u) = \frac{\rho_1 m}{2+\rho_1}$

$\mu_B(t_A = l | g^0_A = 0) = 1$

$\mu_B(t_A = u | 0 < g^0_A < y(\rho_1)m) = 1$

$\mu_B(t_A = h | g^0_A \geq y(\rho_1)m) = 1$

$\mu_B(H | g^0_A = 0) = 0$

$\mu_B(H | 0 < g^0_A < y(\rho_1)m) = \rho_1$

$\mu_B(g^0_A \geq y(\rho_1)m) = 1$

$g^1_B(1, g^0_A = 0) = 0$

$g^1_B(1, 0 < g^0_A \leq \frac{\rho_1 m}{2+\rho_1}) = \frac{\rho_1 m}{2+\rho_1}$

$g^1_B(1, \frac{\rho_1 m}{2+\rho_1} < g^0_A < y(\rho_1)m) = \frac{\rho_1 m - g^0_A}{1+\rho_1}$

$g^1_B(1, g^0_A \geq y(\rho_1)m) = \max\{\frac{m-g^0_A}{2}, 0\}$