(Un)Informed Charitable Giving*

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Abstract

Evidence suggests little informed giving. To understand this behavior, we examine a model of charitable giving with costly information. We find that an individual who considers a smaller contribution is less likely to seek information, and thus the percentage of informed giving diminishes as the population grows. We also find that a direct grant to the charity exacerbates crowding-out by discouraging information acquisition, whereas a matching grant increases donations by encouraging it. We further show that a (first-order) stochastic increase in valuations for charity can decrease donations; and that facilitating private acquisition of information can be a better fund-raising strategy than directly supplying it.

JEL Classifications: H00, H41, D82, D83

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"It is more difficult to give money away intelligently than to earn it in the first place."— Andrew Carnegie (The Gospel of Wealth, 1889)

1 Introduction

According to a recent survey conducted by Hope Consulting,[1] only 35% of people did *any* research before donating to a charity.[2] One explanation for this "disinterest" in informa-

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[1]The 2010 survey includes 4,000 people with incomes over $80K in the U.S, and its results are available at <www.hopeconsulting.us/money-for-good>.

[2]This evidence is consistent with online fund-raising statistics. According to 2012 eNonprofit Benchmarks Study across four sectors, the average open rate for e-mail fund-raising is 12%; click-through rate is 0.47%; and the response rate is 0.08% (www.e-benchmarksstudy.com). That is, out of every 10,000 deliverable e-mail solicitations, 1,200 are opened by their subject lines; 47 are clicked through for more information about the cause, but only 8 end up generating donations. See also Chen et al. (2006) for a field experiment of online fund-raising. In direct mail fund-raising, it is difficult to track who actually opens and reads solicitation mails, but a 1% response rate is often considered a success (Bray 2010, Sharpe 2007).

The survey evidence is also consistent with the experimental finding of Fong and Oberholzer-Gee (2011): although donors become more generous if they know their assistance benefits a group they like, only a third of subjects have purchased such information prior to giving.

tion is that people repeatedly give to the same organization. But, despite significant loyalty in giving, the same survey also found that 85% of donors would value more information about those charitable projects. An alternative explanation could be that people are motivated purely by a "warm-glow" obtained from the act of giving. Yet the surveyed people were most worried about their money being wasted by the charity.[3] In this paper, we offer a rational explanation for these findings by explicitly identifying donors' incentives to seek costly information. In doing so, we contribute to the theoretical, policy-making, and fund-raising aspects of charitable giving.

We cast our model as private provision of a "discrete" public project that yields little to no benefit when unfinished, such as a new bridge, local library, public radio program, or a concert organization. Unlike the extant literature, we assume that each donor is initially uninformed of her true value for the project; however, she can find it out by researching, perhaps through navigating the charity's website, calling its employees, or opening its solicitation letter. The decisions to research and to donate are privately made.

A donor's decision to acquire information trades off its (net) benefit and cost. It is intuitive that being informed should be more beneficial to a donor who considers giving more. Due to the classical free-riding incentive, however, a donor will consider giving less as the population grows; and indeed, we show that the equilibrium probability of being informed decreases, and it converges to zero in a limit economy. Such uninformed giving adversely affects the provision of the public good (even in the limit) because we also show that an uninformed individual is, on average, *less* generous than an informed one. For the fund-raiser, this means that informing donors or at least reducing their cost of information can enhance the likelihood of a successful project.

Our analysis has important policy implications. As is common in models of pure public goods,[4] a *direct* grant to charity would crowd out private giving if information were costless. With costly information, a direct grant further crowds out private giving by discouraging information acquisition. While this observation raises questions about the efficacy of a direct grant, we show that a *matching* grant will have the opposite effect: it will encourage donors to be informed and give more as a result. We believe that this novel (informational) rationale for the use of matching grants in fund-raising complements oth-

[3] In addition, there is ample evidence that people often possess both the altruistic and warm-glow motives for giving; see, e.g., Andreoni (1993), Eckel et al. (2005), Palfrey and Prisbrey (1997), Ribar and Wilhelm (2002). Andreoni (2006a) and Vesterlund (2006) provide excellent surveys of charitable giving literature.

[4] See, e.g., Bergstrom et al. (1986).

ers in the literature that are based on lowering the price of giving (e.g., Auten et al. 2002; Karlan and List 2007).[5]

Our analysis also has implications for the fund-raising strategy. First, we establish that it may be more effective to lower the information cost for all donors through, e.g., better-designed websites than to eliminate this cost for a subset of them through, e.g., personal visits. The reason is that when people already have private incentives to be informed, the fund-raiser's direct provision of information to some is likely to crowd out these incentives for the uncontacted individuals without changing the total percentage of informed giving in the population. Second, unlike the case with exogenously informed donors, we find that a (first-order) stochastic increase in donors' values for the charity may actually *decrease* their total expected donation, and thus the probability of the project's success, when information is costly to acquire. This is because while stochastic dominance may imply higher values and thus higher expected contributions from informed donors, it may also imply a lower variance and thus a lower benefit from being informed, decreasing expected contributions. This means that the project design can be a nontrivial task for the fund-raiser even if it costs little to add value-enhancing features to the project.

Our analysis further reveals that contrary to common wisdom,[6] a warm-glow motive for giving does not necessarily diminish one's incentives to be informed; in contrast, since a warm-glow donor would have a greater incentive to give, we demonstrate that she might also have a greater incentive to acquire information than to stay uninformed and give less.

Related Literature. As mentioned above, our theoretical model is cast as private provision of discrete public goods. Admati and Perry (1991), Bagnoli and Lipman (1989), and Palfrey and Rosenthal (1984) offer early analyses of such a model under complete information and a commonly known cost. To these, Nitzan and Romano (1990) and McBride (2006) introduce cost uncertainty while Laussel and Palfrey (2003), Martimort and Moreira (2010), and Menezes et al. (2001), among others, introduce private information to valuations for the public good. The closest paper to our setting in this literature is by Barbieri and Malueg (2010), who consider both private information and cost uncertainty. Our benchmark case with exogenous information can be viewed as an extension of Barbieri and Malueg's.

In highlighting informational problems with charitable giving, our paper relates to An-

[5] The contrast between direct and matching grants may also explain the experimental observation of Chen et al. (2006) as to "...why one contribution mechanism might consistently draw more curiosity [about a fundraising campaign] than another." (p.20)

[6] Indeed, the Hope Consulting report views warm-glow motive to be a primary obstacle to informed giving.

dreoni and Payne (2003, 2011), Andreoni (2006b), Eckel and Grossman (1996), Fong and Oberholzer-Gee (2011), and Vesterlund (2003). Andreoni and Payne assume that fund-raisers can eliminate donors' information costs by contacting them. They empirically demonstrate that a significant portion of the crowding out can be attributed to reduced fund-raising effort (see Correa and Yildirim (forthcoming) for a theoretical analysis). Our paper complements theirs by focusing on donors' private incentives to acquire information, though we also briefly examine the interaction between the two information channels. Eckel and Grossman (1996) experimentally show that individuals give more generously when they are paired with recipients who belong to their preferred group. Fong and Oberholzer-Gee (2011) investigate individuals' willingness to pay for such information (as in our model), and find that only one third of subjects do so. Both papers, however, consider a dictator game between the donor and the recipient; therefore, unlike in our model, a free-rider problem in giving does not affect the donor's demand for information.

Finally, Andreoni (2006b) and Vesterlund (2003) examine "common value" settings where the charity's quality is unknown to donors. They show that a large leadership gift can signal quality and generate subsequent donations. Instead, we consider a "private value" setting in which people have heterogenous preferences for the charity and invest in information in a decentralized manner.

The rest of the paper is organized as follows. The basic model is presented in the next section, followed by a benchmark analysis of exogenous information in Section 3. Section 4 characterizes the symmetric equilibrium with endogenous information. The policy implications of direct and matching grants are considered in Section 5. Sections 6 and 7 examine two fund-raising strategies, one about stochastically improving valuations and the other about how to inform donors. Section 8 extends the model to warm-glow giving, and Section 7 concludes. Proofs of all formal results are relegated to an appendix.

2 Basic Model

A fund-raiser collects donations from $n \geq 2$ risk-neutral individuals to provide a discrete public good. At the outset, each individual i is uncertain of her value, v_i, for the public good but believes that it is an independent draw from a continuous distribution whose support is $[0, 1]$.[7] Let F and f denote the c.d.f. and the p.d.f. of this distribution, respec-

[7] The unit interval is a normalization. What is important is that there be potentially very low and very high value donors in the population to avoid the (uninteresting) equilibria with everyone or no one contributing.

tively, with mean μ and variance σ^2. We assume that individual i can learn v_i by incurring a fixed cost $c \geq 0$, which could reflect her time and effort cost of reading the charity's website or its solicitation letter. Neither the decision to be informed nor its outcome is observed by others. Based on their private information, individuals simultaneously make contributions toward the public good. Let $x_i \geq 0$ be i's contribution and $X \equiv \sum_i x_i$ be the total.

The (discrete) public good is provided if and only if $X \geq \kappa$, where κ is the production cost. At the time of the contributions, κ is unknown to both the donors and the fund-raiser. It is, however, commonly believed that κ is independent of all v_i's and *uniformly* distributed in $[0, k]$, with $k > \frac{n}{2}$. The contributions are of subscription nature (Admati and Perry, 1991): they are refunded if the cost threshold is not met ex post; but the excess funds are kept by the fund-raiser.[8] In the case of no public good, donors receive a reservation utility of 0. As is common in the literature, the objective of the fund-raiser is to maximize the probability of providing the public good, which is equivalent to maximizing the expected contributions, $\overline{X}$, in equilibrium. Our solution concept is symmetric Bayesian-Nash equilibrium.

2.1 Discussion of the Assumptions

We envision that the production cost, κ, is largely determined by uncertain market conditions. For instance, the exact cost of a construction project may be the result of a procurement auction; the price of a high-tech equipment needed for a radio program may depend on fluctuating supply conditions; and the minimum number of ticket sales needed for a concert may be uncertain due to the rival venues. (For additional examples, see Nitzan and Romano 1990; McBride 2006; and Spencer et al. 2009.) The uniform cost assumption is admittedly restrictive but it will greatly facilitate our equilibrium analysis, and more importantly, it will help isolate the endogenous nature of information acquisition. By $k > \frac{n}{2}$, we require that the cost distribution have a sufficiently wide support so that individuals always view their contributions as perfect substitutes, which is key to finding a unique symmetric equilibrium.[9] The exact condition for k, however, stems from the fact that con-

We could also allow for negative values to signify undesirable charitable projects.

[8]Perhaps, they are used for other projects that these donors do not care about.

[9]If the project cost, κ, were commonly known, our "subscription" game with private valuations would suffer from a multiplicity of (symmetric) equilibria due to coordination incentives [Menezes et al., 2001]. Moreover, characterizing the full set of (symmetric) equilibria in this setting would become complicated even for

tributions above $\frac{1}{2}$ cannot be part of an equilibrium (see Appendix B).[10] We should note that for many public projects such as a local library and a local public radio, the production cost is likely to increase with the population size, n; for instance, $k(n) = k_0 n$, with $k_0 > \frac{1}{2}$. However, in order to disentangle its incentive and cost effects, we will treat k to be independent of n *unless* stated otherwise.

With respect to the refund policy, it is, in general, well-understood that more money is raised with a refund than without it (see, e.g., Admati and Perry 1991, and Palfrey and Rosenthal 1984 in theory; Marks and Croson 1998, Rondeau et al.1999, and Spencer et al. 2009 in experiments). This is also true in a stark way in our setting: if there were no refunds, then the unique equilibrium would generate *no* contributions. While a refund policy may be difficult to implement in some cases, it is not in others. In the wake of advanced technology, many donations can now be pledged online by credit cards; and if pledges turn out insufficient to cover the cost, no charges are made. Similarly, it is a common practice to fully refund concert tickets if the event is cancelled.

To develop a benchmark as well as a first step toward understanding incentives to be informed, we begin our analysis by fixing donors' decisions to acquire information.

3 Benchmark: Exogenous Information

Suppose that with a fixed probability ϕ, each person privately knows her value v while with probability $1 - \phi$, she is uninformed. Let $x^I(v, \phi)$ and $x^U(\phi)$ be her informed and uninformed contributions, respectively, in equilibrium. Also let $x(v, \phi)$ denote the person's unconditional contribution, which is x^I with probability ϕ, and x^U with probability $1 - \phi$. Note that an informed donor i who gives x_i will enjoy utility $v_i - x_i$ if the public good is provided, and her reservation utility 0 otherwise. As a result, donor i's expected utility

two donors [Barbieri and Malueg, 2008, 2010; Laussel and Palfrey, 2003]. Nevertheless, we believe that our basic trade-off between donation size and the value of information under project cost uncertainty will carry over to the known cost case.

[10] A weaker but distribution-based condition for a unique symmetric equilibrium is that $k > \frac{n}{2}(1 - \frac{n-1}{n+1}\mu)$, because one's contribution is the largest when she has the highest valuation and others are uninformed (see eq. 6 below).

from being informed can be expressed as:

$$
\begin{aligned}
u^I(x_i, v_i) &\equiv (v_i - x_i)\,\Pr\{x_i + \textstyle\sum_{j\neq i} x(v_j, \phi) \geq \kappa\} \\
&= (v_i - x_i) E_{j\neq i} \min\{1, \frac{x_i + \sum_{j\neq i} x(v_j, \phi)}{k}\} \\
&= (v_i - x_i) E_{j\neq i}[\frac{x_i + \sum_{j\neq i} x(v_j, \phi)}{k}],
\end{aligned} \tag{1}
$$

where the second line follows from the uniform cost, and the third line follows from the assumption that $k > \frac{n}{2}$ and the fact that contributions above $\frac{1}{2}$ are eliminated by iterative strict dominance as shown in the appendix.

The expectation term in (1) further simplifies by noticing that in a symmetric equilibrium, the contributions, $x(v_j, \phi)$, are independently and identically distributed, and that $E[x(v_j, \phi)] = \phi \overline{x}^I(\phi) + (1 - \phi) x^U(\phi)$, where $\overline{x}^I(\phi) \equiv E[x^I(v_i, \phi)]$ is the expected informed contribution. Thus, letting $\overline{z}(\phi)$ represent the total expected contribution by $n - 1$ others, eq.(1) can be written:

$$
u^I(x_i, v_i) = (v_i - x_i)\left(\frac{x_i + \overline{z}(\phi)}{k}\right). \tag{2}
$$

Maximizing (2) with respect to x_i yields i's optimal informed contribution:

$$
x^I(v_i, \phi) = \max\{0, \frac{v_i - \overline{z}(\phi)}{2}\}. \tag{3}
$$

Not surprisingly, donor i's contribution is increasing in her value and decreasing in others' contributions, $\overline{z}(\phi)$. In particular, $\overline{z}(\phi)$ constitutes the cutoff value for i to start giving.

With probability $1 - \phi$, donor i is uninformed of v_i, in which case her expected utility is given by:

$$
u^U(x_i) \equiv E[u^I(x_i, v_i)] = u^I(x_i, \mu), \tag{4}
$$

whose maximization results in i's optimal uninformed contribution:

$$
x^U(\phi) = x^I(\mu, \overline{z}(\phi)). \tag{5}
$$

Eq.(5) reveals that in our model, an uninformed donor behaves the same as an informed donor with the mean valuation, μ. Refer to Figure 1.

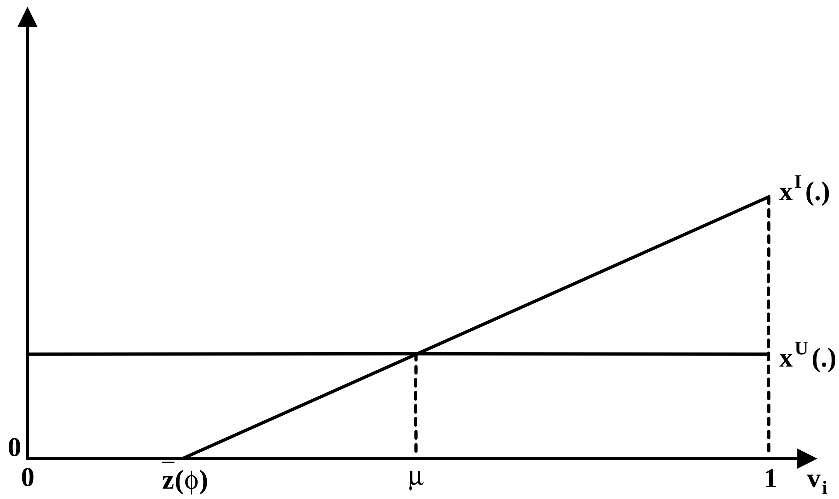

Figure 1. Informed and Uninformed Contributions

By monotonicity, an informed donor may be more or less generous than an uninformed donor, depending on the discovery of her value. For the fund-raiser, it is also important to know how the expected informed contribution, $\overline{x}^I(\phi)$, compares to the uninformed contribution, $x^U(\phi)$. The following result establishes this key comparison along with the equilibrium existence.

Proposition 1 *For a fixed $\phi \in [0,1]$, there is a unique symmetric equilibrium, and it satisfies:*

$$\overline{x}^I(\phi) > x^U(\phi),$$

where $\overline{x}^I(\phi)$ can be expressed as: $\overline{x}^I(\phi) = \frac{1}{2}\int_{\overline{z}(\phi)}^{1}[1-F(v)]dv$.

That is, in equilibrium, the expected informed contribution exceeds the uninformed contribution. This relation directly follows from the Jensen's inequality because, as is also evident from Figure 1, $x^I(v_i,\phi)$ is convex in v_i, and $\overline{z}(\phi) \in (0,1)$ in equilibrium. Intuitively, an uninformed donor can be considered contributing for *any* value realization and taking the expectation of these contributions. Note that the lowest of these contributions corresponding to the values close to zero are necessarily negative, which are truncated to zero by an informed donor.

Proposition 1 suggests that in equilibrium, the total expected contribution, $\overline{X}(\phi)$, and thus the likelihood of provision, should increase with the amount of information, ϕ, in the population. This suggestion would obviously be true if the individual contributions did not change with ϕ; but in fact they do, as the next result shows.

Proposition 2 *In equilibrium, both $\overline{x}^I(\phi)$ and $x^U(\phi)$ are strictly decreasing in ϕ while $\overline{X}(\phi)$ is strictly increasing in ϕ.*

Proposition 2 demonstrates that as each donor anticipates others to be informed with a higher probability, she believes their aggregate contribution to be higher, and in turn, reduces her own. Despite this reduction, the total expected contribution increases in equilibrium, confirming her initial belief.

Proposition 2 has two important implications. First, the amount of information in the population and the realized individual contributions are likely to be inversely related. That is, the more informed the population, the worse the free-rider problem is, though not to the extent of depressing the total expected contribution. Second, the fund-raiser would strictly prefer having more informed donors.

Proposition 2 further reveals that the two extreme information regimes, $\phi = 0, 1$, constitute the bounds for the total expected contribution, i.e., $\overline{X}(0) \leq \overline{X}(\phi) \leq \overline{X}(1)$. Since these bounds will also play a role in identifying equilibrium incentives to be informed, we briefly characterize them here. For $\phi = 0$, note that $x^U(0) = \frac{\mu - \overline{z}(0)}{2}$ and $\overline{z}(0) = (n-1)x^U(0)$. Thus, in a fully uninformed population, $x^U(0) = \frac{\mu}{n+1}$ and

$$\overline{X}(0) = \frac{n}{n+1}\mu. \tag{6}$$

For $\phi = 1$, on the other hand, equilibrium contributions are determined by:[11] $\overline{x}^I(1) = \frac{1}{2}\int_{\overline{z}(1)}^1 [1 - F(v)]dv$ and $\overline{z}(1) = (n-1)\overline{x}^I(1)$. Thus, in a fully informed population, $\overline{z}(1)$ uniquely solves,

$$\overline{z}(1) = \frac{n-1}{2}\int_{\overline{z}(1)}^1 [1 - F(v)]dv, \tag{7}$$

which yields

$$\overline{X}(1) = \frac{n}{n-1}\overline{z}(1). \tag{8}$$

For instance, if valuations are uniform, i.e., $F(v) = v$, then $\overline{X}(1) = \frac{n}{(1+\sqrt{n})^2}$.

[11] This fully informed case is also the one considered by Barbieri and Malueg (2010).

4 Endogenous Information

While enlightening, the benchmark case is restrictive in that it does not allow individuals to acquire information about how closely the charitable project aligns with their preferences. In fact, even if the fund-raiser describes its project through a website, solicitation letter, or phone call, it may still be the person's decision to process such information. By describing its project better, the fund-raiser may simply be lowering the information cost, c, to donors. When choosing whether to become informed, each donor will trade off this cost and the value of being informed, which we characterize next.

4.1 The Value of Information

Ignoring the information cost, let $U^I(\bar{z})$ and $U^U(\bar{z})$ be the indirect utilities of an individual from being informed and uninformed, respectively, where we drop the argument ϕ from $\bar{z}(\phi)$ for brevity. Formally,

$$U^I(\bar{z}) = E\left[\max_{x_i}(v_i - x_i)(\frac{x_i + \bar{z}}{k})\right] \tag{9}$$

and

$$U^U(\bar{z}) = \max_{x_i}(\mu - x_i)(\frac{x_i + \bar{z}}{k}). \tag{10}$$

The value of information for each individual can then be defined as:

$$\Delta(\bar{z}) \equiv U^I(\bar{z}) - U^U(\bar{z}). \tag{11}$$

Applying the Envelope theorem, note that

$$U^{I\prime}(\bar{z}) = \frac{1}{k}\left(\mu - \bar{x}^I(\bar{z})\right) \text{ and } U^{U\prime}(\bar{z}) = \frac{1}{k}(\mu - x^U(\bar{z})),$$

and thus

$$\Delta'(\bar{z}) = \frac{1}{k}[x^U(\bar{z}) - \bar{x}^I(\bar{z})]. \tag{12}$$

Since $\bar{x}^I(\bar{z})$ and $x^U(\bar{z})$ are each less than $\frac{\mu}{2}$, we have $U^{I\prime}(\bar{z}) > 0$ and $U^{U\prime}(\bar{z}) > 0$. Moreover, since $\bar{x}^I(\bar{z}) > x^U(\bar{z})$ for $\bar{z} \in (0,1)$, we also have $\Delta'(\bar{z}) < 0$. Lemma 1 collects these and related properties.

Lemma 1

- *Both $U^I(\bar{z})$ and $U^U(\bar{z})$ are strictly increasing in $\bar{z} \in [0,1]$.*

- $\Delta(\overline{z}) > 0$*, and it is strictly decreasing in* $\overline{z} \in (0,1)$*, with* $\Delta(0) = \frac{\sigma^2}{4k}$ *and* $\Delta(1) = 0$*. Moreover,*

$$\Delta''(\overline{z}) = \frac{1}{2k} \times \begin{cases} -F(\overline{z}) & if \quad \overline{z} \leq \mu \\ 1 - F(\overline{z}) & if \quad \overline{z} > \mu. \end{cases}$$

- $\Delta(\overline{z})$ *is strictly decreasing in* k*.*

Lemma 1 says that an individual always benefits from others' contributions, $\overline{z}$, and that this benefit is greater for an informed individual. Note that $\overline{z}$ has both a direct effect through the probability of public good provision and an indirect effect through the optimal contribution. While the direct effect is present regardless of one's state of information, the indirect effect is more pronounced for an informed individual since she can tailor her contribution to $\overline{z}$ better than an uninformed individual.

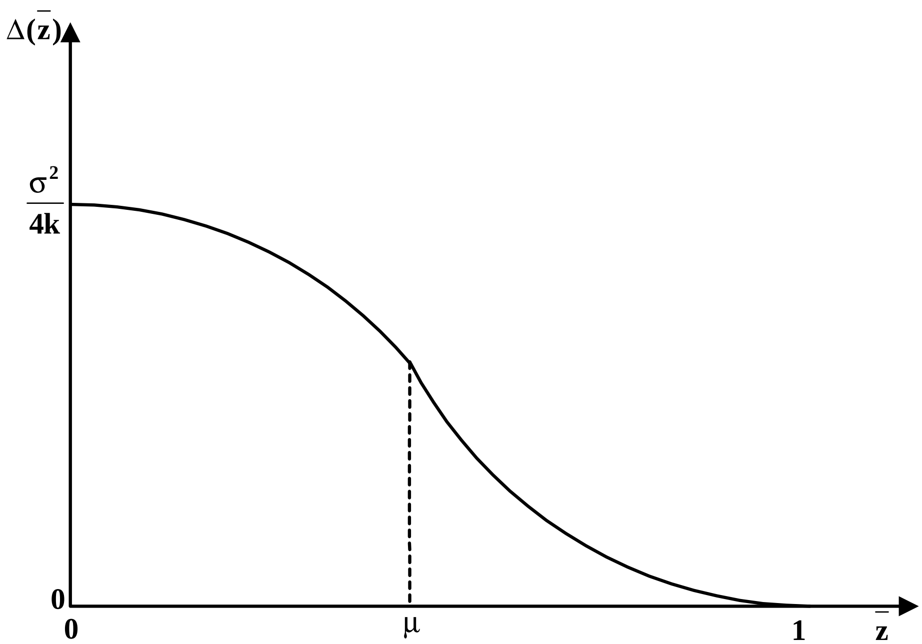

Figure 2. The Value of Information

Lemma 1 also says that the value of information decreases with others' contributions (see Figure 2). This also makes sense: learning about the charitable project should be more valuable for someone who is contemplating giving more. But, as others raise their contributions, she will free ride and give less. For instance, if others' expected contribution already reached the maximum expected total, $\overline{X} = 1$, then the individual would optimally give nothing regardless of her value, rendering information worthless, $\Delta(1) = 0$. By the same token, being informed would be most valuable for someone who believes herself to be the sole contributor. Finally, the value of information strictly decreases as the project becomes (stochastically) costlier and thus less likely to succeed.

4.2 Equilibrium Characterization

Let ϕ^* be the equilibrium probability that a donor learns her valuation. The value of information for a given donor is then $\Delta(\overline{z}(\phi^*))$. Clearly, a fully uninformed equilibrium, $\phi^* = 0$, occurs if $c \geq \Delta(\overline{z}(0))$, while a fully informed equilibrium, $\phi^* = 1$, occurs if $c \leq \Delta(\overline{z}(1))$. For an intermediate cost, i.e., $\Delta(\overline{z}(1)) < c < \Delta(\overline{z}(0))$, donors will strictly mix between acquiring and not acquiring information. Decomposing $\Delta(\overline{z})$ as $\Delta(\overline{z}) \equiv \frac{1}{k}\Lambda(\overline{z})$, the following result completely characterizes the equilibrium.

Proposition 3 *Let $\overline{z}(0) = \frac{n-1}{n+1}\mu$, and $\overline{z}(1)$ be the unique solution to: $z = \frac{n-1}{2}\int_z^1 [1 - F(v)]dv$. The unique symmetric equilibrium is described as follows:*

- *for $kc \geq \Lambda(\overline{z}(0))$,*
$$\overline{X}^* = \frac{n}{n-1}\overline{z}(0) \text{ and } \phi^* = 0;$$
- *for $kc \leq \Lambda(\overline{z}(1))$,*
$$\overline{X}^* = \frac{n}{n-1}\overline{z}(1) \text{ and } \phi^* = 1;$$
- *for $\Lambda(\overline{z}(1)) < kc < \Lambda(\overline{z}(0))$,*
$$\overline{X}^* = \frac{n}{n-1}\Lambda^{-1}(kc) \text{ and } \phi^* = \frac{\frac{\Lambda^{-1}(kc)}{n-1} - x^{U*}}{\overline{x}^{I*} - x^{U*}} \in (0, 1),$$
where
$$\overline{x}^{I*} = \frac{1}{2}\int_{\Lambda^{-1}(kc)}^1 [1 - F(v)]dv \text{ and } x^{U*} = \max\{0, \frac{\mu - \Lambda^{-1}(kc)}{2}\}.$$

Aside from the fully informed and fully uninformed equilibria, Proposition 3 describes the mixed strategy equilibrium, in which only part of the population is likely to be informed. It can be readily verified that the probability of being informed, ϕ^*, is decreasing in its cost, c.[12] Since, on average, uninformed donors give less than the informed, this

[12]In the mixed strategy region, recall that $\Lambda(\overline{z}(\phi^*)) = kc$, and we have $\overline{z}' > 0$ and $\Lambda' < 0$ by Proposition 2 and Lemma 1, respectively.

implies that the expected total contribution, $\overline{X}^*$, is also decreasing in c. Note, however, that the individual contributions, $\overline{x}^{I*}$ and x^{U*}, are increasing in c due to the weakened free-riding incentive in a less informed population. Proposition 3 further indicates that the project cost, k, has the same effect on donor's acquisition strategy as the cost: a donor who is less optimistic about the project cost will also attach a lower value to being informed. One implication of this observation is that if the project cost were to rise with the number of donors (perhaps, donors are also the users), then the percentage of uninformed giving would rise, too. Nevertheless, even without such a scale effect of the population size on the project cost, it is evident that ϕ^* is decreasing in n. This is because as the population grows, so does others' expected contribution, diminishing one's value of being informed (see Figure 2). Interestingly, this diminished level of informed giving can overwhelm the direct scale effect of n on the total contribution, as we demonstrate in Example 1.

Example 1 *Suppose that valuations are uniform, i.e., $F(v) = v$. Then, the highest and lowest total expected contributions are, respectively, $\overline{X}(\phi = 1) = \frac{n}{(\sqrt{n}+1)^2}$ and $\overline{X}(\phi = 0) = \frac{n}{2(n+1)}$. Letting $k = 51$ and $c = .0002$, the following table records the changes in these bounds as well as those in ϕ^* and $\overline{X}^*$ with respect to the population size, n. In equilibrium for each n, an uninformed individual does not contribute (because $\mu < \overline{z}^*$).*

n	ϕ^*	$\overline{X}^*$	$\overline{X}(\phi = 1)$	$\overline{X}(\phi = 0)$
5	1	.4775	.4775	.4167
10	.9077	.5594	.5772	.4545
25	.3404	.5245	.6944	.4808
50	.1667	.5138	.7676	.4902
75	.1104	.5103	.8037	.4934
100	.0825	.5086	.8264	.4950

***Table 1. Decreasing Total Contribution in** n*

Inspecting Table 1, it is evident that the probability of being informed steadily drops with the size of the economy while the expected number of the informed, $n\phi^*$ stays constant at about 8. It is also evident that the reduced percentage of informed giving lowers the total contribution whereas the fully informed total gradually rises. This example suggests that in a large economy, the percentage of informed giving should be negligible. Although, due to the assumption that $k > \frac{n}{2}$, our equilibrium characterization for a finite economy precludes a direct limit analysis, a more general argument shows that this intuitive conjecture holds in the limit.

Proposition 4 *Fix $c > 0$, and suppose that $\phi^*(n) > 0$ for each n. Then, as $n \to \infty$, $\phi^*(n)$ converges to 0 but $n\phi^*(n)$ remains positive and finite. Moreover, as $n \to \infty$, the probability of project's success, $\Pr\{X^*(n) \geq \kappa\}$, stays strictly below that of the fully informed population's.*

To understand Proposition 4, note that if, in a large economy, the percentage of informed giving remained nonnegligible, then there would be a large number of informed donors with a positive contribution, which would in turn exacerbate the free-riding incentive and drive the value of information to zero. But, for a positive cost, this would imply a negligible percentage of informed giving instead. Nevertheless, Proposition 4 says that the population does not turn completely uninformed in the limit because the expected number of the informed people, $n\phi^*(n)$, is positive. Since, for a positive cost, this expected number is also finite, the fully informed equilibrium is no longer attainable in a large economy. As a result, the probability of the project's success is strictly below that of an exogenously informed population – an observation in line with Example 1.

4.3 Discussion

Proposition 3 suggests that in order to increase contributions, the fund-raiser should reduce donors' cost of information. For instance, the fund-raiser can make his project website more user-friendly and/or design more informative solicitation letters.[13] Proposition 3 also suggests that the fund-raiser should reduce the expected cost of the project.[14] It is worth noting that with exogenous information, a lower project cost would have *no* effect on equilibrium contributions in our model (see eq.(3)), but with endogenous information, it would encourage donors to be informed and increase their contributions as a result.[15] Though somewhat extreme, our limit result in Proposition 4 also appears consistent with the survey evidence alluded to in the introduction, that only a small percentage of donors do any research before deciding on donation. Assuming that their cost of research is not too large, our model predicts that in a large economy, only a small subset of those individuals who seek information about the charity will make a donation.[16] As such, it is also

[13]Indeed, charitable fundraising is a higly professional and innovative industry. The Association of Fundraising Professionals (AFP) represents 30,000 members; and every year, billions of dollars are spent on professional fundraisers (Kelly, 1998).

[14]For instance, the fundraiser may seek additional bidders to lower cost for a construction project.

[15]The uniform cost assumption plays a role here, but it clearly serves our purpose in highlighting the endogenous nature of information.

[16]Note that for a low enough $c > 0$, we will have $z^* > \mu$, implying that $x^{U*} = 0$.

consistent with online fund-raising statistics in that response rates are much lower than click-through rates (see n.2).

Building on our equilibrium characterization, we next address several policy and fund-raising issues, beginning with the external grants.

5 Direct vs. Matching Grants

A fundamental policy issue in public finance is the effectiveness of direct grants to charity, which are often awarded by the government. Numerous empirical and experimental studies find varying degrees of crowding out of private donations in response to such grants, attributing them to donors' preferences (see Andreoni 2006a and Vesterlund 2006 for a literature review). As in the standard models of giving (e.g., Bergstrom et al. 1986; Andreoni 1990), these studies ignore informational problems associated with charitable giving. In contrast, Andreoni and Payne (2003, 2011) have recently drawn attention to these problems and uncovered that 70 to 100% of the crowding-out can be explained by the reduced fund-raising efforts aimed at informing donors. As an alternative policy, Andreoni and Payne (2011, p. 342) suggest that "...in general, requirements that charities match a fraction of government grants with increases in private donations could be a feasible response to crowding out." Several recent papers on fund-raising strategies offer strong evidence in favor of matching grants (e.g., Chen et al. 2006, Eckel and Grossman 2008, Karlan and List 2007, and Meier 2007).

By extending our basic model, we provide a new and informational rationale for the use of matching grants. We show that while a direct grant causes additional crowding out by discouraging information acquisition, a matching grant increases private giving by encouraging information acquisition.

5.1 Direct Grant

Let $R < k - \frac{n}{2}$ denote the direct grant available to the charity if the public good is produced. Then, similar to (2) and (4), the expected payoffs of an informed and uninformed donor i can be written respectively:

$$u^I(x_i, v_i) = (v_i - x_i)\frac{x_i + \bar{z} + R}{k} \tag{13}$$

$$u^U(x_i, \mu) = (\mu - x_i)\frac{x_i + \bar{z} + R}{k}. \tag{14}$$

Note that R raises donor i's marginal cost of giving to $\frac{2x_i+\bar{z}}{k} + \frac{R}{k}$ while leaving her marginal benefit unchanged at $\frac{v_i}{k}$ and $\frac{\mu}{k}$, respectively. Thus, private donations will be crowded out in the "classical" sense regardless of the donor's information. However, since a donor who considers a smaller contribution is less likely to acquire information, we also expect an "informational" crowding-out when acquisition decision is endogenous, further dampening private donations. Proposition 5 formalizes these observations.

Proposition 5 *Let $R < k - \frac{n}{2}$ be the level of the direct grant. Then, in equilibrium*

- **(a)** *with exogenous information, the total expected donation, $\overline{X}(\phi, R)$ is strictly decreasing in R while the total expected revenue, $R + \overline{X}(\phi, R)$ is strictly increasing in R;*
- **(b)** *with endogenous information, both $\phi^*(R)$ and $\overline{X}^*(R)$ are decreasing in R. Moreover, $R + \overline{X}^*(R)$ is strictly decreasing in R if and only if $\phi^*(R) \in (0, 1)$.*

With exogenous information, only the classical crowding out is operational. Thus, part (a) says that the expected donations will decrease, but they will not be completely crowded out. With endogenous information, part (b) reveals that the informational crowding out is also operational. Most interestingly, part (b) reveals that the total crowding out can now exceed dollar-for-dollar, rendering the direct grant ineffective. To understand why, note that in a mixed strategy equilibrium, the value of information must be equal to its cost for donors, i.e. $\Delta(\bar{z}(\phi^*) + R) = c$. That is, an increase in R is exactly offset by a lower ϕ^* in equilibrium so that $\bar{z}(\phi^*) + R = \Delta^{-1}(c)$. Since the average donation per person is $\bar{z}(\phi^*)/(n-1)$, the total expected donations are,

$$\overline{X}^*(R) = \frac{n}{n-1}\bar{z}(\phi^*) = \frac{n}{n-1}\Delta^{-1}(c) - \frac{n}{n-1}R,$$

which implies that $\frac{\partial}{\partial R}[R + \overline{X}^*(R)] = -\frac{1}{n-1} < 0$.[17] It can also be verified that $R + \overline{X}^*(R)$ is increasing in R if the equilibrium is fully informed or fully uninformed so that marginal incentives for information acquisition are not in place.

5.2 Matching Grant

Under a matching grant, the external funding, R_m, is tied to private donations. Let $R_m = rX$, where r is the match ratio that is assumed less than $\frac{k}{n/2} - 1$ for technical ease. Then, the expected payoffs of the informed and the uninformed donor are modified as follows:

[17] Although they use a different model, Andreoni and Payne (2011) find evidence of a 124 % crowding out in a treatment including youth development organizations.

$$u^I(x_i, v_i) = (v_i - x_i)\frac{(1+r)(x_i + \bar{z})}{k} \tag{15}$$

$$u^U(x_i, \mu) = (\mu - x_i)\frac{(1+r)(x_i + \bar{z})}{k}. \tag{16}$$

From (15) and (16), it is evident that, similar to the direct grant, an increase in the matching grant raises the likelihood of the public good provision. However, in contrast to the direct grant, the matching grant leads to a proportional increase in both the marginal benefit and the marginal cost of giving, regardless of the donor's information. Hence, the classical crowding out is not present. But, since the value of information also increases by $(1+r)$, the matching grant encourages donors to be informed, which, in turn, positively affect their donations, as the following proposition shows.

Proposition 6 *Let $r < \frac{k}{n/2} - 1$ be the match ratio. Then, in equilibrium*

(a) *with exogenous information, $\overline{X}(\phi)$ is neutral to r;*

(b) *with endogenous information, if $\phi^*(r) \in (0,1)$, then $\phi^*(r)$ and $\overline{X}^*(r)$ are strictly increasing in r.*

(c) *Let R be the direct grant equal to the (expected) matching grant, i.e., $R = r\bar{X}^*(r)$. Then, the matching grant generates a higher total expected donation than does the direct grant.*

According to part (a), with exogenous information, private giving is unaffected by the matching grant due to the absence of the classical crowding out. With endogenous information, however, the matching grant encourages informed giving and raises private donations, as indicated in part (b). Part (c) reinforces this finding by noting that a matching grant engenders more private donations than does an equal amount of direct grant.

Comparing Propositions 5 and 6, our analysis has the following testable implication: a matching grant is likely to increase the percentage of informed giving whereas a direct grant is likely to decrease this percentage. More importantly, it points to an informational rationale for the use of matching grants. As such, it complements other explanations in the literature based on lowering the price of giving (e.g., Auten et al. 2002, Karlan and List 2007) as well as those based on motivating the fund-raiser who is the sole source of information for donors (Andreoni and Payne 2003, 2011).

6 Stochastic Increase in Values

We have taken the distribution of valuations, F, as given in the analysis so far. In order to increase donations, however, the fund-raiser can sometimes influence this distribution through the project design. For instance, the fund-raiser can add sidewalks and bike paths to a bridge project; he can introduce internet access and children's space to a library project; or he can promise to include local as well as the world news in a new public radio program. Conceivably, these additional features to a project will make it more appealing to donors and positively shift their distribution of valuations. To the extent that this occurs at little extra cost, it is natural to conjecture that the expected contributions, and thus the likelihood of the project's success, should increase. We show that while with exogenous information this conjecture is correct, it may not be with endogenous information.

To formalize our arguments, we let $F(v;\alpha)$ be a family of distributions on $[0,1]$ such that $F_\alpha(v;\alpha) < 0$. That is, a higher α makes high valuations more likely in the sense of a first-order stochastic dominance (FOSD). A trivial consequence of the FOSD is that the mean valuation, $\mu(\alpha)$, increases with α. For a fixed probability of being informed, ϕ, FOSD thus implies from eq.(3) and (5) that on average, both informed and uninformed donors contribute more for a given level of others' contributions, $\overline{z}(\phi)$. This observation leads us to:

Proposition 7 *Fixing $\phi \in [0,1]$, the total expected contribution in equilibrium increases with a FOSD shift in the value distribution, i.e., $\overline{X}(\phi;\alpha)$ increases with α.*

Proposition 7 indicates that with exogenous information, individuals, on average, become more generous as they become more likely to have high values. With endogenous information, the FOSD affects contributions by also affecting individuals' incentives to acquire information. In particular, to the extent that these incentives are diluted, the total expected contribution can diminish due to less informed giving. To understand when this can occur, we first re-write the value of information in (11) as:

$$\Delta(\overline{z};\alpha) = \frac{1}{k} \times \begin{cases} \int_{\overline{z}}^{1} \left(\frac{v-\overline{z}}{2}\right)[1-F(v;\alpha)]dv - \left(\frac{\mu(\alpha)-\overline{z}}{2}\right)^2 & \text{if} \quad \overline{z} \leq \mu(\alpha) \\ \int_{\overline{z}}^{1} \left(\frac{v-\overline{z}}{2}\right)[1-F(v;\alpha)]dv & \text{if} \quad \overline{z} > \mu(\alpha). \end{cases} \tag{17}$$

From (17), it is clear that $\Delta(\overline{z};\alpha)$ is increasing in α for $\overline{z} > \mu(\alpha)$; but its sign is ambiguous for $\overline{z} < \mu(\alpha)$. As mentioned above, a FOSD shift in valuations increases willingness to give for both the informed and uninformed donors. However, if others' contributions, $\overline{z}$, are sufficiently high, an uninformed individual completely free rides, which in turn raises the value of being informed. Otherwise, an individual who anticipates giving even when uninformed may attach a lower value to being informed in response to a FOSD shift. It can be established that a necessary condition for the latter is that the uncertainty about valuations (measured by their variance) be decreasing in α so that the need for costly information is reduced.[18] The next example numerically demonstrates that a FOSD shift can indeed discourage informed giving and diminish the total expected contribution as a result.

Example 2 *Let $F(v;\alpha) = v^{\alpha}$, with $v \in [0,1]$ and $\alpha \geq 1$. The mean and variance are, respectively, given by $\mu = \frac{\alpha}{\alpha+1}$ and $\sigma^2 = \frac{\alpha}{(\alpha+1)^2(\alpha+2)}$. Clearly, $F_{\alpha}(v;\alpha) < 0$, and σ^2 is strictly decreasing in α. In the computations, we take $n = 10$, $k = 5.01$ and $c = .002$.*

α	μ	σ^2	ϕ^*	$\overline{X}^*$
1.70	.6296	.0630	.6686	.6187
1.75	.6363	.0617	.6124	.6190
1.80	.6428	.0604	.5465	.6189
1.85	.6491	.0592	.4690	.6183
1.90	.6551	.0579	.3779	.6171
1.95	.6610	.0567	.2703	.6155
2.00	.6667	.0556	.1430	.6133

Table 2. Nonmonotone Contributions with FOSD

From Table 2, observe that for α values between 1.70 and 2, the total expected contribution, $\overline{X}^*$ first rises and then falls with α, indicating a non-monotonicity with FOSD. In particular, for α between 1.75 and 2, $\overline{X}^*$ strictly decreases, which is in sharp contrast with Proposition 7.

The message from Example 2 is that even without the cost concerns, the project design for the charity is a nontrivial matter when donors need to invest in information. Designing a more appealing project for donors may not necessarily generate larger donations, and guarantee the project's success, if the donors lose interest in finding out about the project and become "average" givers instead.

[18] Denoting partial derivatives by subscripts here, note from (17) that for $\overline{z} < \mu(\alpha)$, $\Delta_{\alpha}(\overline{z};\alpha)) = \frac{1}{k}\{\int_{\overline{z}}^{1}\left(\frac{v-\overline{z}}{2}\right)(-F_{\alpha}(.))dv - \frac{\mu(\alpha)-\overline{z}}{2}\mu_{\alpha}\}$. Since $\mu_{\alpha} = \int_0^1(-F_{\alpha}(.))dv$, we have $sign[\Delta_{\alpha}(0;\alpha)] = sign[\frac{\partial}{\partial\alpha}\sigma^2]$. Moreover, $\Delta_{\alpha z}(.) > 0$ for $\overline{z} \neq 0$. As a result, if $\frac{\partial}{\partial\alpha}\sigma^2 > 0$, then $\Delta_{\alpha}(\overline{z};\alpha) > 0$ for all $\overline{z} \geq 0$. If, however, $\frac{\partial}{\partial\alpha}\sigma^2 < 0$, then there is some $\widetilde{z} > 0$ such that $\Delta_{\alpha}(\overline{z};\alpha) < 0$ for all $\overline{z} < \widetilde{z}$.

7 Direct vs. Indirect Provision of Information

A robust prediction of our investigation is that the fund-raiser prefers informed giving. The fund-raiser can, however, inform donors in (at least) two different ways: (1) by directly contacting a subset of them through, e.g., phone calls and personal visits; and/or (2) by uniformly lowering the cost of information for all donors through, e.g., better-designed websites and solicitation letters. By extending our basic model, here we argue that the fund-raiser might make better use of his limited resources toward the latter strategy.

Let $\lambda \in (0,1)$ be the fixed probability that a person is directly contacted by the fund-raiser.[19] We assume that such a direct contact provides valuable information about the project and effectively eliminates one's cost of information. Without the fund-raiser contact, the person has to decide whether or not to pay for the cost, c, to learn her valuation as in the base model. Given the strategy, ϕ, in the latter case, the ex ante probability that the person knows her valuation is $\bar{\phi} = \lambda + (1-\lambda)\phi$. Note that if, in equilibrium, $\phi^* = 0$, then each individual is informed with probability λ and that their expected contribution is $\bar{z}(\lambda)$. Thus, $\phi^* = 0$ is an equilibrium whenever $c \geq \Delta(\bar{z}(\lambda))$. That is, for a sufficiently high cost of information, individuals will learn their valuations only when approached by the fund-raiser, namely $\overline{\phi}^*(\lambda) = \lambda$. Since this implies more informed giving than the base model, or equivalently the case with $\lambda = 0$, the total expected contribution will increase, namely $\overline{X}^*(\lambda) > \overline{X}^*(0)$. The more interesting case, however, occurs when $c < \Delta(\bar{z}(\lambda))$ so that there is some private incentive to acquire information in equilibrium. Consider, for instance, the partially informed equilibrium whereby $\overline{\phi}^*(\lambda) \in (\lambda, 1)$. This means that an uncontacted individual must strictly mix by $\phi^*(\lambda) \in (0,1)$ and be indifferent between acquiring and not acquiring information, i.e., $\Delta(\bar{z}(\overline{\phi}^*(\lambda))) = c$. This indifference, however, yields $\overline{\phi}^*(\lambda)$, which is exactly equal to ϕ^* in the base model. Therefore, in the presence of private incentives, we obtain a strong neutrality to the fund-raiser's direct information: $\overline{\phi}^*(\lambda) = \overline{\phi}^*(0)$ and $\overline{X}^*(\lambda) = \overline{X}^*(0)$. The same neutrality extends to the fully informed equilibrium because $\overline{\phi}^*(\lambda) = 1$ if and only if $\phi^*(\lambda) = 1$. We thus reach:

Proposition 8 *Fix $\lambda \in (0,1)$. If $c \geq \Delta(\bar{z}(\lambda))$, then $\overline{\phi}^*(\lambda) = \lambda$ and $\overline{X}^*(\lambda) > \overline{X}^*(0)$. If, however, $c < \Delta(\bar{z}(\lambda))$, then $\overline{\phi}^*(\lambda) = \overline{\phi}^*(0)$ and $\overline{X}^*(\lambda) = \overline{X}^*(0)$.*

Proposition 8 says that when the cost of information is not too large to completely deter

[19] Perhaps, given their ex ante symmetry, the fund-raiser commits to visiting a certain number of people randomly.

its private acquisition, the fund-raiser's direct supply of information will simply crowd out donors' incentives, though it will not change the percentage of informed donors or the total expected contribution. The reason is that an uncontacted donor who believes others to be informed with a higher probability due to a direct contact will also believe that their aggregate contribution will be higher. As a result, she will consider cutting back on her contribution and partially lose her interest in acquiring information.

Proposition 8 implies that if individuals have private incentives to be informed, the fund-raiser should invest in promoting these incentives rather than investing in the direct provision of information.[20] Otherwise, the fund-raiser's effort will merely crowd out donor's effort without affecting the funds raised. Proposition 8 also implies that the direct provision of information is a better strategy if this is the only way to induce informed giving.

8 Warm-Glow Motive

As noted in the Introduction, one reason for the low percentage of informed giving could be that individuals also experience a "warm-glow" from giving (see n.3), which dilutes their incentives for discovering valuations, v_i. An extension of our model, however, reveals that this logic is not necessarily true; on the contrary, because a warm-glow donor may possess a greater incentive to contribute than a (purely) rational donor without such a motive, she may also possess a greater incentive to be informed.

Suppose that if the public good is provided, an individual who contributes x_i receives an additional warm-glow utility wx_i, where $w < 1 - \frac{n/2}{k}$. Otherwise, she continues to receive her reservation utility 0 as before. Given others' expected contribution, $\bar{z}$, an informed individual's expected utility thus becomes

$$u^I(x_i; v_i) \equiv (v_i + wx_i - x_i)\left(\frac{x_i + \bar{z}}{k}\right) = (v_i - (1-w)x_i)\left(\frac{x_i + \bar{z}}{k}\right). \tag{18}$$

Eq.(18) implies that a warm-glow donor would behave as though her marginal cost of giving were lower. Note that instead of choosing x_i, individual i can be considered choosing $\widehat{x}_i = (1-w)x_i$, in which case eq.(18) reduces to

$$u^I(x; v_i) = (v_i - \widehat{x}_i)\left(\frac{\widehat{x}_i + \widehat{z}}{(1-w)k}\right), \tag{19}$$

[20]Recall from Proposition 3 that lowering c improves $\overline{X}^*$.

where $\widehat{z} = (1-w)\overline{z}$. Comparing (19) with (2), we see that a warm-glow donor would also behave the same as a rational donor who believes the project to be less costly and thus more likely to succeed. By Lemma 1, this belief strengthens her incentive to be informed of v_i. The equilibrium of the game with contributions $\widehat{x}_i$ can be readily characterized by replacing k with $(1-w)k$ in Proposition 3, and noting that $\phi^* = \widehat{\phi}^*$and $\overline{X}^* = \frac{\widehat{X}^*}{1-w}$.

Proposition 9 *Suppose that donors have identical warm-glow preferences such that $w < 1 - \frac{n/2}{k}$. Then, both ϕ^* and $\overline{X}^*$ are increasing in w.*

The intuition behind Proposition 9 parallels that of the matching grant discussed above. Warm-glow donors are more optimistic about the project's completion and thus have a greater value of being informed. Since, on average, informed donors give more, the result follows.

9 Conclusion

According to one estimate, a public charity registers with the Internal Revenue Service (IRS) every 10 to 15 minutes (NY Times 2009). With countless new projects, a donor is unlikely to know her true value without researching a project, perhaps through navigating the charity's website, calling its employees, or simply opening its solicitation letter. Evidence, however, suggests that people do little research before giving. To rationalize this behavior and explore its policy implications, we have examined a relatively standard model of giving with costly information.

From a theory perspective, our model is the first to endogenize the information structure in this environment. From a policy perspective, our investigation provides a novel and informational rationale for the widespread use of matching grants. And from fund-raising perspective, our analysis suggests that the fund-raiser should facilitate informed giving.

We believe that our analysis has also produced four testable predictions.

1. The average informed donation exceeds the uninformed donation.

2. The more informed the population, the lower the realized individual contributions.

3. The larger the population, the lower the percentage of informed giving.

4. A direct grant to charity discourages informed giving whereas a matching grant encourages it.

We should note that our results would be robust to heterogenous information costs. Suppose, for instance, that donors draw their costs independently from a continuous distribution on $[\underline{c}, \overline{c}]$. Then, it can be verified that there is a unique symmetric cutoff c^* such that a donor with $c \leq c^*$ will acquire information, and a donor with $c > c^*$ will not. However, all the comparative statics for a fixed cost can be shown to hold, albeit with added technical complexity.

While generating significant insights, our paper only scratches the surface as to the role of information in charitable giving. Extending our analysis to address the issue of competition can be a fruitful research avenue. With so many charities, it will be important to understand whether donors focus their attention on certain charities or split it evenly across. It can also be useful to explore the complementary setting in which people have a *common* but uncertain valuation for the public good. This could be relevant in environments where the quality of the charity –not individual preferences – is the driving factor for giving. As with the present analysis, we, however, conjecture significant free riding and thus significant uninformed giving in this environment, too.

Appendix A

Proof of Proposition 1. Fix $\phi \in [0,1]$. Since $x^U(\phi) = x^I(\mu, \overline{z}(\phi))$, we can write $\overline{z}(\phi) = (n-1)[\phi E x^I(v, \overline{z}(\phi)) + (1-\phi)x^I(\mu, \overline{z}(\phi))]$. Define $J(z) \equiv (n-1)[\phi E x^I(v,z) + (1-\phi)x^I(\mu,z)] - z$. Clearly, $J(0) = (n-1)\frac{\mu}{2} > 0$ and $J(1) = -1 < 0$. Moreover, $J(z)$ is continuous and strictly decreasing in $z \in [0,1]$. Hence, there is a unique $\overline{z}(\phi) \in (0,1)$ that solves $J(z) = 0$. Since $\overline{z}(\phi)$ uniquely determines $x^I(v, \overline{z}(\phi))$, there is a unique symmetric equilibrium for each $\phi \in [0,1]$.

Next, note that $x^I(v, \overline{z}(\phi))$ is convex in v. Thus, by Jensen's inequality, $\overline{x}^I(\phi) = Ex^I(v, \overline{z}(\phi)) \geq x^I(\mu, \overline{z}(\phi)) = x^U(\phi)$. For $\overline{z}(\phi) \in (0,1)$, it also follows that $\overline{x}^I(\phi) \neq x^U(\phi)$, revealing that $\overline{x}^I(\phi) > x^U(\phi)$. Finally, by definition, $\overline{x}^I(\phi) = E\max\{0, \frac{v-\overline{z}(\phi)}{2}\} = \int_{\overline{z}(\phi)}^1 \frac{v-\overline{z}(\phi)}{2} dF(v)$. A simple integration by parts shows $\overline{x}^I(\phi) = \frac{1}{2}\int_{\overline{z}(\phi)}^1 [1-F(v)]dv$.■

Proof of Proposition 2. We first prove that $\overline{x}^I(\phi) > \frac{\mu}{n+1}$. Note that since $x^U(\phi) \geq \frac{\mu - \overline{z}(\phi)}{2}$ by (5), we have $2x^U(\phi) + \overline{z}(\phi) \geq \mu$. Moreover, given that $\overline{x}^I(\phi) > x^U(\phi)$ by Proposition 1, we also have $2x^I(\phi) + \overline{z}(\phi) > \mu$ and $\overline{z}(\phi) < (n-1)x^I(\phi)$. Together, $(2 + (n-1))x^I(\phi) > \mu$, which implies that $\overline{x}^I(\phi) > \frac{\mu}{n+1}$, as desired.

Now, we consider two cases for $x^U(\phi)$. If $x^U(\phi) > 0$, then by (5), $x^U(\phi) = \frac{\mu - (n-1)[\phi\overline{x}^I(\phi) + (1-\phi)x^U(\phi)]}{2}$, which reveals $x^U(\phi) = \frac{\mu - (n-1)\phi\overline{x}^I(\phi)}{2 + (n-1)(1-\phi)}$. Inserting this into $\overline{z}(\phi) = (n-1)[\phi\overline{x}^I(\phi) + (1-\phi)x^U(\phi)]$, we obtain

$$\overline{z}(\phi) = (n-1)\frac{\mu(1-\phi) + 2\phi\overline{x}^I(\phi)}{2 + (n-1)(1-\phi)} \equiv Z(\phi, \overline{x}^I(\phi)). \tag{A-1}$$

Proposition 1 implies that

$$2\overline{x}^I(\phi) = \int_{Z(\phi, \overline{x}^I(\phi))}^1 [1 - F(v)]dv. \tag{A-2}$$

Differentiating both sides of (A-2) with respect to ϕ yields $2\overline{x}^{I\prime}(\phi) = -[1 - F(Z(.))](\frac{\partial}{\partial\phi}Z(.) + \frac{\partial}{\partial\overline{x}^I}Z(.) \times \overline{x}^{I\prime})$, which, by arranging terms, yields that

$$\overline{x}^{I\prime} = -[1 - F(Z(.))]\frac{\frac{\partial}{\partial\phi}Z(.)}{2 + [1 - F(z(.))]\frac{\partial}{\partial\overline{x}^I}z(.)} < 0,$$

because $Z(.) \in (0,1)$; $\frac{\partial}{\partial\overline{x}^I}Z(.) > 0$; and $\frac{\partial}{\partial\phi}Z(.) = \frac{2(n-1)(n+1)}{(2+(n-1)(1-\phi))^2}\left[\overline{x}^I(\phi) - \frac{\mu}{n+1}\right] > 0$ from (A-1).

If, on the other hand, $x^U(\phi) = 0$, then $2\overline{x}^I(\phi) = \int_{(n-1)\phi\overline{x}^I(\phi)}^1 [1 - F(v)]dv$. Differentiation again shows $\overline{x}^{I\prime}(\phi) < 0$. By (3), the fact that $\overline{x}^{I\prime}(\phi) < 0$ implies that $\overline{z}(\phi)$ is strictly increasing in ϕ, which, in turn, implies that $x^U(\phi)$ is strictly decreasing in ϕ whenever $x^U(\phi) > 0$.

Moreover, since, in a symmetric equilibrium, $\overline{X}(\phi) = \frac{n}{n-1}\overline{z}(\phi)$, $\overline{X}(\phi)$ is strictly increasing in ϕ. ■

Proof of Lemma 1. We only show the parts remaining from the text. Since $x^U(\mu) = 0$, $\Delta'(\mu)$ exists, which means $\Delta'(\overline{z})$ exists for all $\overline{z} \in [0,1]$. Since $\overline{x}^I(1) = x^U(1) = 0$, we also have $\Delta(1) = 0$. Thus, $\Delta(\overline{z}) > 0$ for $\overline{z} \in [0,1)$. Note also that,

$$\Delta(0) = \frac{1}{k}\left[\int_0^1 \left(\frac{v}{2}\right)^2 dF(v) - \left(\frac{\mu}{2}\right)^2\right] = \frac{1}{k}Var(\frac{v}{2}) = \frac{\sigma^2}{4k}.$$

To derive $\Delta''(\overline{z})$, differentiate (12) with respect to $\overline{z}$:

$$\Delta''(\overline{z}) = \frac{1}{2k} \times \begin{cases} -F(\overline{z}) & if \quad \overline{z} \leq \mu \\ 1 - F(\overline{z}) & if \quad \overline{z} > \mu, \end{cases}$$

where we use the facts: $\frac{\partial}{\partial \overline{z}}\overline{x}^I(\overline{z}) = -\frac{1}{2}[1 - F(\overline{z})]$ and $\frac{\partial}{\partial \overline{z}}x^U(\overline{z}) = -\frac{1}{2}$ whenever $x^U(\overline{z}) > 0$. Finally, since $\Delta(\overline{z}) = \frac{1}{k}\Lambda(\overline{z})$ for some function Λ, $\Delta(\overline{z})$ is strictly decreasing in k. ■

Proof of Proposition 3. Let $\overline{z}(0) = \frac{n-1}{n+1}\mu$, and $\overline{z}(1)$ be the unique solution to: $z = \frac{n-1}{2}\int_z^1 [1 - F(v)]dv$. Since $\overline{z}'(\phi) > 0$ by Proposition 2, and $\Delta'(\overline{z}) < 0$ by Lemma 1, it follows that $\Delta(\overline{z}(\phi))$ is strictly decreasing in ϕ. Clearly, $\phi^* = 0$ is an equilibrium if $c \geq \Delta(\overline{z}(0))$, or equivalently if $kc \geq \Lambda(\overline{z}(0))$. In this case, $\overline{X}^* = \frac{n}{n-1}\overline{z}(0)$. On the other hand, if $kc \leq \Lambda(\overline{z}(1))$, $\phi^* = 1$ is an equilibrium, in which case $\overline{X}^* = \frac{n}{n-1}\overline{z}(1)$.

Finally, suppose $\Lambda(\overline{z}(1)) < kc < \Lambda(\overline{z}(0))$. Then, there is a unique $\phi^* \in (0,1)$ that solves $\Lambda(\overline{z}(\phi^*)) = kc$, which is an equilibrium. To characterize this mixed strategy equilibrium, note that $\overline{z}^* = \Lambda^{-1}(kc)$, which implies that $\overline{X}^* = \frac{n}{n-1}\Lambda^{-1}(kc)$ and $x^{I*} = \frac{1}{2}\int_{\Lambda^{-1}(kc)}^1 [1 - F(v)]dv$ by Proposition 1. If $\Lambda^{-1}(kc) < \mu$, then $x^{U*} = \frac{\mu - \Lambda^{-1}(kc)}{2} > 0$. Since $\overline{z}^* = (n-1)[\phi^*\overline{x}^{I*} + (1-\phi^*)x^{U*}]$, it follows that $\phi^* = \frac{\frac{\Lambda^{-1}(kc)}{n-1} - x^{U*}}{\overline{x}^{I*} - x^{U*}}$. Observe that since $\overline{x}^{I*} > x^{U*}$ by Proposition 1, we have

$$\phi^* > 0 \Longleftrightarrow \frac{\Lambda^{-1}(kc)}{n-1} - x^{U*} > 0 \Longleftrightarrow \frac{(n-1)\mu}{n+1} < \Lambda^{-1}(kc) \Longleftrightarrow \Lambda(\overline{z}(0)) > kc,$$

which is true by hypothesis. Note also that $\phi^* < 1$ because $\Lambda(\overline{z}(1)) < kc$, or equivalently $\overline{z}(1) > \Lambda^{-1}(kc)$. If, on the other hand, $\mu \geq \Lambda^{-1}(kc)$, then $x^{U*} = 0$, in which case $\phi^* = \frac{\Lambda^{-1}(kc)}{(n-1)\overline{x}^{I*}}$. Using a similar argument, we see that $\phi^* \in (0,1)$. ■

Proof of Proposition 4. As in the text, let $x^I(v, \phi, n)$, $x^U(\phi, n)$, and $x(v_i, \phi, n)$ be one's informed, uninformed, and unconditional contributions in equilibrium, respectively. Also, let $\Delta(\phi, n)$ be the value of information. We first note the following familiar fact on bounded sequences and then prove a claim.

Fact A1. *Suppose that $y(n)$ is a bounded sequence. Then, it has a convergent subsequence. Moreover, if all of its convergent subsequences have the same limit, y_ℓ, then $y(n)$ converges (to y_ℓ).*

Note that each sequence we are examining below is bounded; thus, in light of Fact A1, we actually show the limit of its convergent subsequences without explicitly stating it.

Claim A1. *Fix $\phi > 0$. Then, as $n \to \infty$, we have $x^I(v, \phi, n) \to 0$ for all $v < 1$, and $\Delta(\phi, n) \to 0$.*

Proof. Fix $\phi > 0$. Suppose, to the contrary, that $x^I(\widehat{v}, \phi, n) \to \widehat{x}_\ell(\phi) > 0$ for some $\widehat{v} < 1$, as $n \to \infty$. Then, by monotonicity of $x^I(v, .)$ in v, $x^I(v, \phi, n) \nrightarrow 0$ for all $v \in [\widehat{v}, 1)$. Since the distribution of valuations is continuous, this implies that $\overline{x}^I(\phi, n) \nrightarrow 0$, and given $\phi > 0$, $\overline{x}(\phi, n) \nrightarrow 0$. Moreover, since $x(v_i, \phi, n)$ are i.i.d. and $\kappa < \infty$, it must be that $\Pr\{\sum_{j \neq i} x(v_j, \phi, n) \geq \kappa\} \to 1$ as $n \to \infty$ by the law of large numbers. But then, an informed agent would be strictly better off choosing $x_i = \widehat{x}_\ell(\phi) - \varepsilon$ for $v = \widehat{v}$, violating the equilibrium. Thus, $x^I(v, \phi, n) \to 0$ for all $v < 1$. Using this observation and recalling that $x^U(\phi, n) = x^I(\mu, \phi, n)$, next note that as $n \to \infty$,

$$\Delta(\phi, n) \to E\left[(v - 0)\Pr\{0 + \textstyle\sum_{j \neq i} x(v_j, \phi, n) \geq \kappa\}\right] - (\mu - 0)\Pr\{0 + \textstyle\sum_{j \neq i} x(v_j, \phi, n) \geq \kappa\} = 0,$$

completing the proof of the claim. ■

We now prove that $\phi^*(n) \to 0$, as $n \to \infty$. By hypothesis, fix $c > 0$, and suppose that $\phi^*(n) > 0$ for each n. This implies that $\Delta(\phi^*(n), n) \geq c$; otherwise, $\Delta(\phi^*(n), n) < c$ would imply that $\phi^*(n) = 0$. Suppose, to the contrary, that $\phi^*(n) \to \phi_\ell > 0$. Then, Claim A1 reveals that $\Delta(\phi^*(n), n) \to 0 < c$ as $n \to \infty$, yielding a contradiction. Hence, $\phi_\ell = 0$.

To show that $\lim_{n\to\infty} n\phi^*(n) \in (0, \infty)$, we first make two observations: (1) for some $\widehat{v} < 1$, $\lim_{n\to\infty} x^{I*}(v, n) > 0$ for all $v \in [\widehat{v}, 1)$; otherwise, having $\lim_{n\to\infty} x^{I*}(v, n) = 0$ for all $v \leq 1$ would result in $\lim_{n\to\infty} \Delta(\phi^*(n), n) = 0 < c$, a contradiction; (2) $\lim_{n\to\infty} x^{U*}(n) = 0$; otherwise, $\lim_{n\to\infty} x^{U*}(n) > 0$ would, given that $\phi^*(n) \to 0$, imply $\Pr\{\sum_{j\neq i} x(v_j, \phi, n) \geq \kappa\} \to 1$ by the law of large numbers, which would, in turn, imply a profitable deviation for an uninformed donor.

Now, suppose that $\lim_{n\to\infty} n\phi^*(n) = \infty$. Then, given $\kappa < \infty$, we would have $\Pr\{\sum_{j\neq i} x(v_j, \phi, n) \geq \kappa\} \to 1$ by the law of large numbers and thus $x^{I*}(v, n) \to 0$ for $v \geq \widehat{v}$, a contradiction. Hence, $\lim_{n\to\infty} n\phi^*(n) < \infty$. Next, suppose that $\lim_{n\to\infty} n\phi^*(n) = 0$. Since $\phi^*(n) \to 0$ and $x^{U*}(n) \to 0$, this implies that $\Pr\{\sum_{j\neq i} x(v_j, \phi, n) \geq \kappa\} \to 0$. But then, $\lim_{n\to\infty} x^{U*}(n) > 0$, yielding a contradiction. Thus, $\lim_{n\to\infty} n\phi^*(n) > 0$.

Finally, to show that $\lim_{n\to\infty} \Pr\{X^*(n) \geq \kappa\} < \lim_{n\to\infty} \Pr\{X(\phi = 1) \geq \kappa\}$, note that one's expected informed payoff is decreasing in c and the fully informed equilibrium corresponds to $c = 0$. Thus, since $x^I(v, 1, n) \to 0$, and $x^{I*}(v, n) \nrightarrow 0$ for all $v \in [\widehat{v}, 1)$, it follows that as $n \to \infty$,

$$\begin{aligned} E[(v-0)\Pr\{\textstyle\sum_{j\neq i} x(v_j, 1) \quad &\geq \quad \kappa\}] \geq E\left[(v - x^{I*})\Pr\{x^{I*} + \textstyle\sum_{j\neq i} x(v_j, \phi^*) \geq \kappa\}\right] \\ &= c + \mu \Pr\{\textstyle\sum_{j\neq i} x(v_j, \phi^*) \geq \kappa\} \ , \end{aligned}$$

where the equality is due to $x^{U*}(n) \to 0$ and $\Delta(\phi^*, n) \to c$. Since $c > 0$, this implies that $\Pr\{\sum_{j\neq i} x(v_j, 1) \geq \kappa\} > \Pr\{\sum_{j\neq i} x(v_j, \phi^*) \geq \kappa\}$, which, given that both $x(v_j, 1) \to 0$ and $x(v_j, \phi^*) \to 0$, reveals that $\Pr\{\sum_j x(v_j, 1) \geq \kappa\} > \Pr\{\sum_j x(v_j, \phi^*) \geq \kappa\}$ as $n \to \infty$. ■

Proof of Proposition 5. Let $\hat{z}(\phi, R) = \bar{z}(\phi) + R$. To prove part (a), note that given that $\bar{z}(\phi, R) = (n-1)[\phi\bar{x}^I(\phi, R) + (1-\phi)x^U(\phi, R)]$ and $x^U(\phi, R) = \max\{0, \frac{\mu - \hat{z}(\phi,R)}{2}\}$, we can write $x^U(\phi, R)$ and $\hat{z}(\phi, R)$:

$$x^U(\phi, R) = \max\left\{\frac{\mu - (n-1)\phi\bar{x}^I(\phi, R) - R}{2 + (n-1)(1-\phi)}, 0\right\}$$

and

$$\hat{z}(\phi, R) = (n-1)\max\left\{\phi\bar{x}^I(\phi, R), \frac{2\phi\bar{x}^I(\phi, R) + (1-\phi)\mu - (1-\phi)R}{2 + (n-1)(1-\phi)}\right\} + R \equiv \hat{Z}(\phi, R, \overline{x}^I(\cdot)) \tag{A-3}$$

where $\overline{x}^I(\phi, R) = \frac{1}{2}\int_{\hat{Z}(\phi,R,\overline{x}^I)}^1 [1 - F(v)]dv$ by Proposition 1. Clearly, $\frac{\partial\bar{x}^I(\phi,R)}{\partial R} = -\frac{(1-F(\hat{Z}(\cdot)))\frac{\partial\hat{Z}(\cdot)}{\partial R}}{2+(1-F(\hat{Z}(\cdot)))\frac{\partial\hat{Z}(\cdot)}{\partial\bar{x}^I}} < 0$. Consider the following two cases for $x^U(.)$.

- $x^U(.) = 0$. Then, $\overline{X}(\phi, R) = n\phi\bar{x}^I(\phi, R)$ and $\frac{\partial\overline{X}(\phi,R)}{\partial R} = n\phi\frac{\partial\bar{x}^I(\phi,R)}{\partial R} < 0$. Moreover, $\frac{\partial\hat{Z}(\cdot)}{\partial\bar{x}^I} = (n-1)\phi$, $\frac{\partial\hat{Z}(\cdot)}{\partial R} = 1$, and

$$\frac{d(\overline{X}(\phi, R) + R)}{dR} = \frac{2 - \phi(1 - F(\hat{Z}(\cdot)))}{2 + (n-1)(1 - F(\hat{Z}(\cdot)))\phi} > 0.$$

- $x^U(.) > 0$. Then, $\overline{X}(\phi, R) = \frac{n}{n-1}[\hat{Z}(\phi, \overline{x}^I(\cdot)) - R]$ and

$$\frac{\partial\overline{X}(\phi, R)}{\partial R} = \frac{n}{n-1}\left[\frac{d\hat{Z}(\cdot)}{dR} - 1\right] = n\frac{2\phi\frac{\partial\bar{x}^I(\phi,R)}{\partial R} - (1-\phi)}{2 + (n-1)(1-\phi)} < 0.$$

Moreover, after substituting for $\frac{\partial \bar{x}^I(\phi,R)}{\partial R}$, and using the facts that $\frac{\partial \hat{Z}(\cdot)}{\partial \bar{x}^I} = \frac{2\phi(n-1)}{2+(n-1)(1-\phi)}$ and $\frac{\partial \hat{Z}(\cdot)}{\partial R} = \frac{2}{2+(n-1)(1-\phi)}$, we have $\frac{d(\overline{X}(\phi,R)+R)}{dR} = \frac{1+\phi F(\hat{Z}(\cdot))}{n+1-\phi(n-1)F(\hat{Z}(\cdot))} > 0$.

Next, we prove part (b). Note that by Lemma 1, $\Delta(\hat{z}(\phi,R))$ is strictly decreasing in $\hat{z}$. Moreover, $\hat{z}(0,R) = \frac{n-1}{n+1}\max\{\mu - R, 0\} + R$, and $\hat{z}(1,R)$ uniquely solves $z = \frac{n-1}{2}\int_z^1 [1 - F(v)]dv + R$. Clearly, $\frac{\partial \hat{z}(0,R)}{\partial R} > 0$ and $\frac{\partial \hat{z}(1,R)}{\partial R} = \frac{2}{2+(n-1)(1-F(\hat{z}(\cdot)))} > 0$. We now exhaust the three equilibrium regions in Proposition 3.

- For $kc \geq \Lambda(\hat{z}(0,R))$, the equilibrium involves $\phi^*(R) = 0$ and $\overline{X}^*(\phi,R) = \frac{n}{n-1}(\hat{z}(0,R) - R)$. Thus, $\frac{\partial \overline{X}^*(\phi,R)}{\partial R} = \frac{n}{n-1}\left(\frac{\partial \hat{z}(0,R)}{\partial R} - 1\right) \leq 0$, and $\frac{d(\overline{X}^*(R)+R)}{dR} > 0$.
- For $kc \leq \Lambda(\hat{z}(1,R))$, the equilibrium involves $\phi^*(R) = 1$ and $\overline{X}^*(\phi,R) = \frac{n}{n-1}(\hat{z}(1,R) - R)$. Moreover, $\frac{d\phi^*(R)}{dR} = 0$ for all R such that $kc \leq \Lambda(\hat{z}(1,R))$. Therefore, in this region $\frac{\partial \overline{X}^*(\phi,R)}{\partial R} = \frac{n}{n-1}\left(\frac{\partial \hat{z}(1,R)}{\partial R} - 1\right) \leq 0$ and $\frac{d(\overline{X}^*(R)+R)}{dR} > 0$.
- For $\Lambda(\hat{z}(1,R)) < kc < \Lambda(\hat{z}(0,R))$, the mixed strategy equilibrium involves $\phi^*(R) = \frac{\frac{\Lambda^{-1}(kc)-R}{n-1} - x^{U*}}{\bar{x}^{I*} - x^{U*}}$ and $\overline{X}^*(R) = \frac{n}{n-1}\left(\Lambda^{-1}(kc) - R\right)$. Since, in equilibrium, $\Lambda(\hat{z}^*(\phi^*,R)) = kc$, we have $\hat{z}^*(\phi^*,R) = \Lambda^{-1}(kc)$. It is immediate that both $\overline{X}^*(R)$ and $\overline{X}^*(R) + R = \frac{1}{n-1}\left(n\Lambda^{-1}(kc) - R\right)$ are strictly decreasing in R. Moreover, $\frac{d\phi^*(R)}{dR} = -\frac{\partial \hat{z}^*(\phi^*,R)/\partial R}{\partial \hat{z}^*(\phi^*,R)/\partial \phi}$. The equilibrium value of $\hat{z}^*(\phi^*,R)$ is given by

$$\hat{z}^*(\phi^*,R) = \frac{n-1}{2}\phi^*(\cdot)\int_{\hat{z}^*(\cdot)}^1 [1 - F(v)]dv + \frac{n-1}{2}(1 - \phi^*(\cdot))\max\{\mu - \hat{z}^*(\cdot), 0\} + R \tag{A-4}$$

Differentiating (A-4) with respect to R results in

$$\begin{aligned}\frac{\partial \hat{z}^*(\phi^*,R)}{\partial R} &= \begin{cases} 1/(1 + \frac{n-1}{2}(1 - \phi F(\hat{z}^*(\cdot)))) & if \quad \hat{z}^* \leq \mu \\ 1/(1 + \frac{n-1}{2}\phi(1 - F(\hat{z}^*(\cdot)))) & if \quad \hat{z}^* > \mu \end{cases} \\ &> 0.\end{aligned}$$

Differentiating (A-4) with respect to ϕ results in

$$\begin{aligned}\frac{\partial \hat{z}^*(\phi^*,R)}{\partial \phi} &= \begin{cases} \int_0^{\hat{z}^*} F(v)dv/[2/(n-1) + (1 - \phi F(\hat{z}^*(\cdot)))] & if \quad \hat{z}^* \leq \mu \\ \int_{\hat{z}^*}^1 (1 - F(v))dv/[2/(n-1) + \phi(1 - F(\hat{z}^*(\cdot)))] & if \quad \hat{z}^* > \mu \end{cases} \\ &> 0.\end{aligned}$$

Hence, $\frac{d\phi^*(R)}{dR} < 0$. ■

Proof of Proposition 6. From eq. (15) and (16), it is immediate that $\overline{x}^I(\phi)$ and $\bar{x}^U(\phi)$ are each independent of r; and so is $\overline{X}(\phi) = n[\phi\overline{x}^I(\phi) + (1-\phi)\bar{x}^U(\phi)]$, proving part (a). To prove part (b), note that the value of information is $(1+r)\Delta(\overline{z}) = \frac{\Lambda(\overline{z})}{\bar{k}}$, where $\bar{k} = \frac{k}{1+r}$. Thus, it suffices to show that $\phi^*(\bar{k})$ and $\overline{X}^*(\bar{k})$ are decreasing in $\bar{k}$.

Take any $\bar{k}' > \bar{k}$. If $\bar{k}c \geq \Lambda(\overline{z}(0))$, then, by Proposition 3, $\phi^*(\bar{k}) = \phi^*(\bar{k}') = 0$ and $\overline{X}^*(\bar{k}) = \overline{X}^*(\bar{k}') = \frac{n}{n-1}\overline{z}(0)$. If, on the other hand, $\bar{k}c \leq \Lambda(\overline{z}(1))$, then either $\bar{k}'c < \Lambda(\overline{z}(1))$, which implies that $\phi^*(\bar{k}) = \phi^*(\bar{k}') = 1$ and $\overline{X}^*(\bar{k}) = \overline{X}^*(\bar{k}') = \frac{n}{n-1}\overline{z}(1)$, or $\bar{k}'c > \Lambda(\overline{z}(1))$, which implies that $\phi^*(\bar{k}') < 1$ and $\overline{X}^*(\bar{k}') < \overline{X}^*(\bar{k}) = \frac{n}{n-1}\overline{z}(1)$.

Finally, if $\Lambda(\overline{z}(1)) < \bar{k}c < \Lambda(\overline{z}(0))$, then since $\Lambda(\overline{z}^*(\bar{k})) = \bar{k}c$, simple differentiation yields: $\dfrac{d\overline{z}^*(\bar{k})}{d\bar{k}} = \dfrac{c}{\Lambda'(\overline{z}^*(\bar{k}))} = -\frac{c}{\overline{x}^{I*}(\bar{k}) - \overline{x}^{U*}(\bar{k})} < 0$. Hence, $\dfrac{d\overline{X}^*(\bar{k})}{d\bar{k}} < 0$. To show that $\dfrac{d\phi^*(\bar{k})}{d\bar{k}} < 0$, first suppose that $\overline{z}^*(\bar{k}) > \mu$. Then, $x^{U^*} = 0$ and $\dfrac{d\phi^*(\bar{k})}{d\bar{k}} = \dfrac{d}{d\bar{k}}[\frac{\overline{z}^*(\bar{k})}{(n-1)\overline{x}^{I*}(\bar{k})}]$. Since $\dfrac{d}{d\bar{k}}\overline{x}^{I*}(\bar{k}) = -\dfrac{1-F(\overline{z}^*(\cdot))}{2} \times \dfrac{d\overline{z}^*(\bar{k})}{d\bar{k}} = \dfrac{1-F(\overline{z}^*(\cdot))}{2} \times \dfrac{c}{\overline{x}^{I*}(\bar{k}) - x^{U*}(\bar{k})} > 0$, it follows that

$$\frac{d\phi^*(\bar{k})}{d\bar{k}} = \frac{-c(n-1) - (n-1)\overline{z}^*(\bar{k})\dfrac{d\overline{x}^{I*}(\bar{k})}{d\bar{k}}}{[(n-1)\overline{x}^{I*}(\bar{k})]^2} < 0.$$

Next, suppose that $\overline{z}^*(\bar{k}) \leq \mu$. Then, $\dfrac{d\phi^*(\bar{k})}{d\bar{k}} = \dfrac{d}{d\bar{k}}[\frac{\overline{z}^*(\bar{k}) - (n-1)x^{U*}(\bar{k})}{(n-1)(\overline{x}^{I*}(\bar{k}) - x^{U*}(\bar{k}))}]$. Since $x^{U*}(\bar{k}) = \dfrac{\mu - \overline{z}^*(\bar{k})}{2}$, $\dfrac{d}{d\bar{k}}x^{U*}(\bar{k}) = -\dfrac{1}{2} \times \frac{d\overline{z}^*(\bar{k})}{d\bar{k}}$. Hence,

$$\frac{d\phi^*(\bar{k})}{d\bar{k}} = \frac{[n+1-(n-1)\phi^*(\bar{k})F(\overline{z}^*(\cdot))](\overline{x}^{I*}(\bar{k}) - x^{U*}(\bar{k}))\dfrac{d\overline{z}^*(\bar{k})}{d\bar{k}}}{2(n-1)[\overline{x}^{I*}(\bar{k}) - x^{U*}(\bar{k})]^2} < 0.$$

To prove part (c), suppose that $R(r)$ is the direct grant such that $R(r) = r\overline{X}^*(r)$. Since, by part (b), $\frac{d\overline{X}^*(r)}{dr} \geq 0$, we have $\frac{dR(r)}{dr} = \overline{X}^*(r) + r\frac{d\overline{X}^*(r)}{dr} \geq 0$. Moreover, $\overline{X}^*(0) = \overline{X}^*(R(0))$ as $R(0) = 0$. Then, since, by Proposition 5, $\frac{d\overline{X}^*(R(r))}{dr} = \frac{\partial\overline{X}^*(R(r))}{\partial R}\frac{dR(r)}{dr} \leq 0$, it follows that $\overline{X}^*(r) \geq \overline{X}^*(R(r))$. ■

Proof of Proposition 7. Let $F(v;\alpha)$ be such that $F_\alpha(.) < 0$. Note that for a fixed $z \in [0,1]$, both $Ex^I(v,z;\alpha)$ and $x^I(\mu(\alpha), z)$ are increasing in α, and so is $J(z;\alpha)$ that is defined in the proof of Proposition 1. Then, the unique solution $\overline{z}(\phi;\alpha) \in (0,1)$ to $J(z;\alpha) = 0$, and thus $\overline{X}(\phi;\alpha) = \frac{n}{n-1}\overline{z}(\phi;\alpha)$, is increasing in α, too. ■

Proof of Proposition 8. The proof is a direct consequence of the arguments made in the text and Proposition 3. In particular, letting $\overline{z}(\lambda)$ be the expected contribution of others when each is exogenously informed with probability λ, and $\overline{z}(1)$ be the unique solution to $z = \frac{n-1}{2}\int_z^1 [1 - F(v)]dv$, the unique symmetric equilibrium is described as follows:

- for $kc \geq \Lambda(\overline{z}(\lambda))$,
$$\overline{X}^*(\lambda) = \frac{n}{n-1}\overline{z}(\lambda) \text{ and } \overline{\phi}^*(\lambda) = \lambda;$$
- for $kc \leq \Lambda(\overline{z}(1))$,
$$\overline{X}^*(\lambda) = \frac{n}{n-1}\overline{z}(1) \text{ and } \overline{\phi}^*(\lambda) = 1;$$
- for $\Lambda(\overline{z}(1)) < kc < \Lambda(\overline{z}(\lambda))$,
$$\overline{X}^*(\lambda) = \frac{n}{n-1}\Lambda^{-1}(kc) \text{ and } \overline{\phi}^*(\lambda) = \frac{\frac{\Lambda^{-1}(kc)}{n-1} - x^{U*}}{\overline{x}^{I*} - x^{U*}} \in (0, 1),$$

  where
$$\overline{x}^{I*} = \frac{1}{2}\int_{\Lambda^{-1}(kc)}^1 [1 - F(v)]dv \text{ and } x^{U*} = \max\{0, \frac{\mu - \Lambda^{-1}(kc)}{2}\}. \blacksquare$$

Proof of Proposition 9. Since warm-glow effectively reduces the cost bound to $(1 - w)k$, it suffices to show that ϕ^* and $\overline{X}^*$ are decreasing in k. The proof is analogous to that of Proposition 6. ■

Appendix B

Proposition B1. *Let $k > \frac{n}{2}$. Then, individual contributions $x_i > \frac{1}{2}$ do not survive iterated elimination of strictly dominated strategies.*

Proof. Consider first an informed donor i. Let v_{-i} denote a vector of others' valuations and $F_{-i}(v_{-i})$ denote its distribution on $[0, 1]^{n-1}$. Then, given an arbitrary strategy profile by the other players $x_{-i}(v_{-i}, \phi_{-i})$, donor i's informed expected utility can be written:

$$E_{-i}[\tilde{u}^I(x_i, v_i|x_{-i}(v_{-i}, \phi_{-i}))] = E_{-i}[(v_i - x_i)H(x_i + \textstyle\sum_{j\neq i} x_j(v_j, \phi_j))],$$

where $H(y) = \min\{1, \frac{y}{k}\}$.

Clearly, $x_i(v_i, \phi_i) > 1$ is strictly dominated by $x_i(v_i, \phi_i) = 1$ since it generates a negative payoff for i. Thus, we can restrict attention to $x_{-i} \in [0, 1]^{n-1}$. Next we show that

$E_{-i}[\tilde{u}^I(\frac{1}{2}, v_i|x_{-i})] > E_{-i}[\tilde{u}^I(x_i, v_i|x_{-i})]$ for all $x_i > \frac{1}{2}$ and all $x_{-i} \in [0,1]^{n-1}$. It suffices to show that $\tilde{u}^I(\frac{1}{2}, v_i|x_{-i}) > \tilde{u}^I(x_i, v_i|x_{-i})$ for all $x_i > \frac{1}{2}$ and all $x_{-i} \in [0,1]^{n-1}$. Note that $H(x_i + \sum_{j\neq i} x_j(v_j, \phi_j))$ is differentiable for $x_i < k - x_{-i}$, which means that $\tilde{u}^I(x_i, v_i|x_{-i})$ attains a unique maximum at $x_i(v_i, x_{-i}) = \frac{v_i - \sum_{j\neq i} x_j(v_j,\phi_j)}{2}$ in this region. Obviously, $x_i(v_i, x_{-i}) < k - \sum_{j\neq i} x_j(v_j, \phi_j)$ because $v_i \leq 1 \leq n - \sum_{j\neq i} x_j(v_j, \phi_j) < 2k - \sum_{j\neq i} x_j(v_j, \phi_j)$, where the second inequality follows from $x_{-i} \in [0,1]^{n-1}$ and the last inequality follows from $k > \frac{n}{2}$. Next, note that by strict concavity, $\frac{\partial}{\partial x_i}\tilde{u}^I(x_i, v_i|x_{-i}) < 0$ for $x_i > x_i(v_i, x_{-i})$, and since $x_i(v_i, x_{-i}) = \frac{v_i - \sum_{j\neq i} x_j(v_j,\phi_j)}{2} \leq \frac{1}{2}$ for all v_i, we have $\tilde{u}^I(\frac{1}{2}, v_i|x_{-i}) > \tilde{u}^I(x_i, v_i|x_{-i})$ for all $x_i > \frac{1}{2}$ and all $x_{-i} \in [0,1]^{n-1}$. Hence, $x_i > \frac{1}{2}$ does not survive iterated elimination of strictly dominated strategies. The case of an uninformed donor is analogous because she is simply an informed donor with the mean valuation, μ. ■

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