Collegio Carlo Alberto

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No. 209
May 2011

Carlo Alberto Notebooks

www.carloalberto.org/working_papers

Community Matters: How the Volunteering of Others Affects One's Likelihood of Engaging in Volunteer Work

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March 14, 2011

Abstract

We investigate the effect of the volunteering of others on the likelihood that an individual will also engage in volunteering activities. The theoretical part of our analysis is based on a sequential signaling framework, in which the decisions of others to volunteer are informative as to the benefit from volunteering. In this framework, the interaction between one's private information and the public belief when she is called upon to act makes it more likely that she will volunteer, given a higher average level of contributions by her predecessors. To test this empirically, we measure the effect of average volunteering in the community on the likelihood that an individual will volunteer, controlling for individual and community characteristics. We use Census 2000 Summary File 3 and Current Population Survey (CPS) 2004-2007 September supplement files. Our results are robust to various choices of sample, by years analyzed, working status, and whether or not the volunteering included religious activities. We account for reflection bias by means of an instrumental variables strategy which further verifies the pattern of our results.

Keywords: volunteer, public good, signaling, community characteristics

JEL Classification Numbers: H4, D8

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1 Introduction

Economists have become increasingly interested in determining what motivates individuals to engage in volunteer work and to participate in what has been termed the "unpaid labor" sector.[1] In contrast to earlier research, which considered unpaid labor to be indistinguishable from leisure, economists have recently begun modeling volunteering and similar activities as a different type of decision. They have also empirically documented (primarily in small experimental studies) the fallacy of attempting to explain an individual's choice to volunteer within a purely public goods framework. In the current study, we theoretically and empirically examine an alternative explanation as to why individuals volunteer. Specifically, we show that individuals are more likely to contribute when they observe higher levels of volunteering by other members of their community.

A particular challenge to the pure public goods framework comes from mounting evidence showing that, although individuals commonly engage in activities which are costly to themselves and (seemingly) primarily beneficial to others, for a significant class of important cases, the presence of individuals with other-regarding preferences alone does not suffice as an explanation. There is evidence for some additional private value to be gained from volunteering, be it from a motivation to acquire what has been termed "warm glow", "prestige," or "self-worth."

Broadening the set of motives that influence pro-social behavior has led economists to ask the natural question of how these motives interact with one another and with the economic environment.[2] On the one hand, in some situations, the intrinsic motives of individuals seem to play such a vital role that providing rewards and punishments to foster pro-social conduct can actually crowd them out and lead to the perverse effect of reducing individual contributions both in size and in number. On the other hand, social pressure and norms that favor pro-social deeds and punish selfish acts do push people towards the former and away from the latter. To make matters even more complicated, most people value the opinion others have of them (sometimes referred to as "self-image"), but they also strive to maintain at least a minimal amount of consistency between their actions and their core values or beliefs.

These issues are fundamental when it comes to identifying the personal and communal determinants of pro-social behavior and comparing their relative strengths. Nevertheless, the actions and interactions of these drivers are contingent not only upon the context of the pro-social behavior in question (contributing towards a public good, volunteering one's

[1] See Freeman[1], Govekar and Govekar [2], and Greisling [32]

[2] See the introduction of Benabou and Tirole [12] for a review of these issues.

labor or other resources, etc.) but also upon the specific social group from which the social motives emanate and within which they operate (in conjunction with the personal ones). It is, therefore, equally imperative to look into the effect of the social group itself on the pro-social conduct of its members. Within the context of engaging in volunteer work, this is the primary focus of our analysis.

We investigate the interaction between the characteristics of the community in which an individual resides and her decision to volunteer. Volunteering, as we see it, is an activity that imposes costs on the individual and primarily benefits other members of the community. We develop a model of sequential choices in which, at each stage, a different member of the community faces the decision of whether or not to make a contribution towards a public good. In this setting, the contributions of others provide publicly available information about one's total net benefit (private and social benefit minus private cost) from one's own contribution. This is important information because one's total net benefit is not a priori known. Instead, it depends on the actual desirability of the public good in question, which may itself be a function of a variety of factors, such as the degree of efficiency in the provision of the good, the good's value relative to other private or public projects that may be funded by individual resources, etc.

To keep matters tractable, we depict the respective uncertainty by a binary random variable. When called upon to act, prior to her choice, the individual receives a private signal regarding the underlying state of nature. She also observes the total number of past contributions; equivalently, as she knows how many agents have been called upon to contribute in the past, the average number of past contributions. This simple setting of sequential learning has an equilibrium in which the average number of past contributions is positively correlated with the individual's decision to contribute. That is, the higher the average rate of contributions by others within one's community, the more likely it is that an individual will choose to contribute.

In the empirical part of our analysis, we show that this positive relationship is indeed supported by the evidence. We verify that this relationship is robust to the inclusion of various community and demographic control factors, types of volunteering (nonreligious vs. a more general measure of volunteering), and populations of interest (working age vs. full). We also use an instrumental variables strategy to reduce issues of reflection bias inherent in this type of structure. In all the respective scenarios, the results are consistent with our theoretical prediction.

To the best of our knowledge, within the realm of the volunteering and public goods literature, we are the first to approach the interaction between one's own propensity to engage in

prosocial behavior and that of the others around her from an informational perspective. Our theoretical framework is the standard one used in the literature on herding and informational cascades: each agent observes what others do and takes a binary action in a pre-ordered sequence. In that literature, the actions of others matter for one's payoff only indirectly, by carrying information regarding the underlying state of the world. In contrast, within our context, the actions of others also matter directly by determining the total amount of the public good.

This additional functionality of others' behavior allows the standard model to deliver results that are not observed in the literature on herds and informational cascades. In that literature, when agents receive a binary signal, informational cascades occur almost certainly. As a consequence, there is only very limited social learning; the actions of others matter only in so far as they bring the public belief to the critical level for a cascade to begin.[3] In our setting, on the other hand, informational cascades occur only in limiting cases, with a vanishing probability as the size of the community increases. Intuitively, as long as the sequence of decision makers is long enough, a string of the same choice will have to eventually be broken because we can neither have too much nor too little of the public good. When the amount of observed contributions is sufficiently high, the problem of the commons manifests itself, precluding further contributions. When it is sufficiently low, the net benefit from contributing is so high in the good state that an agent prefers to contribute for any but vanishingly small prior beliefs.

Within the social learning that generically takes place in our setting, the role of the average number of past contributions turns out to be crucial. On the one hand, this average is a sufficient statistic for the individual posterior belief about the state of world, being positively (negatively) related to the belief that the state is favorable (unfavorable). On the other hand, it is positively related to the individual's expected marginal rate of substitution between contributing and not contributing. In a fully revealing equilibrium, in which an individual contributes to the public good if and only if her signal is favorable, the decision-maker compares her expected rate of marginal substitution to her posterior beliefs as if they

[3] An informational cascade is a situation in which the public belief, gathered from the history of observed actions, dominates the private signal of any individual so that the action of all subsequent agents do not depend on their private information. It is a concept distinct from that of a herd, which is defined as an outcome where all agents take the same action after some period. In a cascade, all agents are herding and, because actions do not convey any private information, nothing is learned, the cascade goes on forever, possibly with an incorrect action. In a herd, however, not all agents may be herding and those that do may herd because of a particular sequence of private signal realizations. In such herds, some social learning does take place since there is a positive probability that the herd may be broken. See Bikhchandani et.al. [13] and Chamley [21] for a more detailed analysis and discussion of these points.

were relative prices in a standard consumer utility maximization problem.

With respect to testing this theoretical intuition empirically, our data set being the largest and most representative sample of volunteering data available to date, the novelty of our investigation lies in the extent to which it is comprehensive and allows us to be confident in its validity.[4]

The remainder of this paper is organized as follows. Section II provides a review of the relevant literature while Section III presents the theoretical model and its findings. Section IV discusses data sources and Section V outlines the empirical methodology. The empirical findings and results are discussed in Section VI and Section VII concludes.

2 Related Literature

As a prerequisite to any attempt to understand how the average volunteering of others in the community affects one's own propensity to volunteer, we need to identify the reasons why an individual might choose to volunteer.[5] In this section, we first outline the theories currently accepted in the literature regarding the individual decision to volunteer, in general as well as specifically within the context of the provision of a public good.

2.1 The Volunteering of Others

Public Good and Private Value

Traditionally, volunteering was considered a purely public good in the economics literature. As such, invoking the problem of the commons, one would predict an individual's propensity towards volunteering to decrease as the number of observed contributions to the public good increased. It might also be expected that private contributions would be crowded out by governmental provision of the public good.[6]

These two assertions need not be valid, however, if the very act of contributing towards a public good brings an individual some private benefit alongside the good's social value.

[4]See Brudney and Gazley [17] for a discussion of the problems that plague data-gathering in the volunteer sector.

[5]It should be pointed out that, in this paper, we do not take into account volunteering motivations that are related to fulfilling one's particular and explicit obligations, such as requirements of school volunteering for students. To our knowledge, no such analysis is yet in existence and would be an interesting extension to the present analysis. For an introduction to service learning as a related concept, see for example McGoldrick et.al. [37]

[6]For early work on this topic, see for example Bergstrom et.al. [11]

Recent empirical evidence does indeed show that, as the number of individual contributions towards a public good increases, an individual's propensity to contribute can consequently increase. In particular, Andreoni ([10], [8]) documents that the provision of a public good appears to increase with the concurrent level of giving in the community and that individual contributions do not seem to be crowded out by governmental ones.[7].

A general idea that has been put forth in the literature to support these findings is to regard individuals as impurely altruistic. That is, to view them as receiving a private benefit which is tied to the very act of giving, above and beyond the intrinsic social value of the public good. In some cases, such as those considered by Andreoni [9], the associated private valuation may be as simple as a "warm glow" from contributing to the public good; in others, it may be a bit more complex.[8] In what follows, we briefly review some examples of factors that may determine an individual's private value of her public good contribution. They all highlight the importance of social influences in establishing private values.[9]

Socially-Motivated Private Valuations

Studying charitable contributions, Harbaugh [33] as well as Glazer and Konrad [30] found that many individuals choose to donate their money due to a feeling of "prestige" from being considered philanthropists. As Francois [28] points out, this kind of prestige from "making a difference" seems to be linked to the number of other individuals who are acting in a similar way. Specifically, the more others contribute, the more prestigious they render the cause to which the individual is called upon to donate. It is also likely that one would want to be an early contributor to the cause since this would gain her more prestige and attention than falling within the dense ranks of later, less-visible donors. Regardless of whether it relates to the timing of the contribution decision, prestige as a motive will operate as one of the possible social influences allowing individuals to retain a private value from contributing to the public good.[10]

In addition to gaining prestige by being one of the early donators to a charity, individuals may choose to time their donation in order to gain information on the intrinsic value of the public good in question. In contrast to the prestige motivation, the informational one would

[7]For an interesting extension, where individuals have differing valuations they place on the public good, see Bilodeau and Slivinski [14]

[8]Andreoni [6] provides an excellent introduction to the issues and research on volunteering and charitable giving.

[9]For a more exhaustive overview of the area of social interactions as it relates to economics, see Blume and Durlauf [16]

[10]For a more general discussion on this topic, see Carman [19] and Knox [35].

encourage individuals to contribute only after many others have already done so. The number of observed donations would then serve as a signal of the charity's quality. This effect was documented experimentally by Potters et.al. [42] who found that sequential contributions to a public good can operate as a useful signal when there is uncertainty about its underlying quality. More precisely, the authors concluded that the informed agents regarding the good's quality should be the first to make their decisions in order to provide the uninformed agents with a signal regarding the quality of the good.[11] This "signaling" motivation additionally helps to explain the finding in Vesterlund [50] that those charities which announce early contributions and their size receive on average higher total levels of contributions.

Another motivator that is based upon private considerations is what Andreoni [6] refers to as the "warm glow" effect from contributing to a public good. This may also be linked to the usefulness an individual attributes to her contribution. Specifically, Andreoni presents a model in which individuals would much rather give to a charity providing x of their dollars to one recipient rather than distributing their contribution to n recipients and splitting it into amounts of x/n to be shared by each of the recipients. That is, the size of one's contribution going to each of the recipients matters for the warm-glow feeling, a theoretical finding lending support to the idea that individuals may tie their donations to the size of the community receiving them.[12]

A different possible approach in associating private valuations with public contributions is to assume that individuals take a moral stance on the issue of volunteering. This is to say that they might regard free-riding as morally wrong and thus feel an obligation to donate to the public good. This scenario, put forth by Sugden [46], suggests that donating to the public good offers individuals the private benefit of establishing themselves as moral human beings.

The aforementioned factors motivating public good contributions through private valuations may all operate in the context of multiple types of charitable behaviors. These could be (a) donating one's material resources to charity or (b) volunteering one's time or effort to a common good or cause. This is not at all surprising, since volunteering is sometimes analyzed in the context of being either a substitute or complement to charitable donations. However, some of the reasons individuals volunter are distinct from those motivating charitable monetary donations. For instance, individuals may want to volunteer for certain tasks to increase their human capital, either by complementing interests or skills employed in their paid labor or, more importantly, during times of unemployment. They may also choose to volunteer

[11] See also Andreoni [6] for a related finding.

[12] This is also one of the reasons for our decision to include community size as an explanatory factor in our empirical analysis, since we believe it to be likely that many donations occur within the community itself.

because it makes them feel more productive or less socially isolated after retirement. With the above reasons in mind, we see that the resulting private benefit from volunteering can differ substantially from reasons associated with charitable giving of one's money.

This analysis focuses on the idea of volunteering of one's time in particular. It contributes to the literature on social interactions by offering an explanation as to how one's social environment affects one's prosocial behavior using the concept of signaling. In this context, individual prosocial behavior is affected by one's community and the actions of its members, not only due to specific characteristics of her community and her relationships with others, but also because of the underlying information these provide about the value of the prosocial behavior itself.

3 The Model

To model the interaction between the prosocial behavior of others and one's own choice to engage or not in such behavior, we consider the following scenario. A community consists of a finite number N of members who are going to decide in sequence whether or not to contribute towards a given public good, whose total amount is given, of course, by the sum of all individual donations added to any social endowment the community might start with. Each individual's decision is between increasing the amount of the public good available in the community and decreasing her own consumption of a given consumption good by the same amount, private consumption being what remains from the individual's wealth endowment once her public good contribution has been deducted. And what makes this decision not trivial is the fact that the relative value the individuals of this community attach to private versus public consumption is stochastic. To keep matters tractable, we will depict the corresponding uncertainty by a doubleton state space, $\Omega = \{0, 1\}$, partitioning the world into an unfavorable ($\omega = 0$) and a favorable ($\omega = 1$) state. Our focus being on the individual decisions to whether or not contribute towards the public good, the underlying state being favorable (unfavorable) is meant to depict the situation in which it is socially optimal (i.e., it would be chosen by a social planner) for everyone in the community to (not) contribute.

Prior to making her decision, each agent obtains two pieces of information regarding this underlying uncertainty. The first one is private and comes in the form of a binary signal. All signals are drawn from the set $S = \{0, 1\}$ and are equally informative about the true state of the world, which has already obtained prior to the beginning of the game. When the typical agent in the sequence receives the signal $s_n = 1$ ($s_n = 0$), she takes it to mean

that the probability of the state being favorable (unfavorable) is $q = \Pr[s_n = 1|\omega = 1] = \Pr[s_n = 0|\omega = 0]$. To ensure that the actual order in which the agents are called upon to act does not matter, the signal precision will be common across all individuals.[13] Of course, the signals are informative ($q > 1/2$).

The second piece of information an agent has concerns the actions of her predecessors in the sequence. The possible action of the typical individual is $x_n \in \mathcal{X} = \{0, x\}$. Being binary, it reflects her choice to contribute either an amount x towards the community-wide stock of the public good or nothing. Having x exogenously fixed, it abstracts from factors that influence an individual's decision of how much to contribute (such as, for example, the opportunity cost of one's resources, time, or effort). It allows us, therefore, to maintain the focus of the analysis on the decision to contribute or not per se; in particular, on how this decision is influenced by the behavior of one's peers within a context of signalling.

It is standard in this setting to assume that each player observes the entire history of past actions but none of the past signals. To take, that is, the historical information up to the nth period of play as being carried forward by an element of the set $\mathcal{X}^{n-1}$. For our purposes, however, it is enough to consider instead the sum of its elements, $X_{n-1} = \sum_{i=1}^{n-1} x_i$. In other words, the total amount of past public good contributions (along, of course, with any initial social endowment) is the publicly available information at the beginning of each period of play.

For the typical player, therefore, a (mixed) strategy in this game is a mapping $\sigma_n : S \times \mathcal{X}^{n-1} \mapsto \Delta(\mathcal{X})$, assigning the probability $\sigma_{s,n}^{x_n}(X_{n-1})$ on the action x_n when the agent's signal is s and the history she observes is X_{n-1}. To keep the analysis tractable, however, we will restrict our attention to strategies that do *not* depend upon the history of play. That is, to mappings $\sigma_n : S_n \mapsto \Delta(\mathcal{X})$ that assign the probability $\sigma_{s,n}^{x_n}$ on the action x_n when the agent's signal is s, irrespectively of the history she observes. Of course, this does not mean that the history the player observes does not matter for her play. For, in conjunction with her signal realization, X_{n-1} does affect her belief about ω and, along with the strategies she believes the other players to be following, the rule that determines her optimal action.

As is well-known, if we let $\pi_n = \Pr[\omega = 1|X_{n-1}, \vec{\sigma}_{-n}]$ denote the prior (to her signal realization) belief of the typical player about the event $\omega = 1$, given the history of prior play X_{n-1} and her belief that her opponents are following the strategy profile $\vec{\sigma}_{-n}$, her posterior

[13] Suppose otherwise and let q_n be the probability in question for the typical agent. Consider also the signal realizations $\{s_n, s_{n+1}\} = \{1, 0\}$. By (1), $\mu_{1,n} = \frac{q_n \pi_n}{q_n \pi_n + (1-q_n)(1-\pi_n)}$ and $\mu_{0,n+1} = \frac{(1-q_{n+1})\mu_{1,n}}{(1-q_{n+1})\mu_{1,n} + q_{n+1}(1-\mu_{1,n})} = \frac{1}{1+\left(\frac{q_{n+1}}{1-q_{n+1}}\right)\left(\frac{1-\mu_{1,n}}{\mu_{1,n}}\right)}$. Since $\frac{1-\mu_{1,n}}{\mu_{1,n}} = \left(\frac{1-q_n}{q_n}\right)\left(\frac{1-\pi_n}{\pi_n}\right)$, the two opposing signals cancel out (so that $\mu_{0,n+1} = \pi_n$) only if $q_n = q_{n+1}$. It is trivial to verify that the same is true when $\{s_n, s_{n+1}\} = \{0, 1\}$.

belief about this event will be given by[14]

$$\mu_{1,n} = \frac{q\pi_n}{q\pi_n + (1-q)(1-\pi_n)} \qquad \mu_{0,n} = \frac{(1-q)\pi_n}{(1-q)\pi_n + q(1-\pi_n)} \tag{1}$$

when she receives the signal $s_n = 1$ and $s_n = 0$, respectively. Needless to say, $\pi_1 = \pi$ reflects the common prior belief at the beginning of the game about the state being favorable. As usual with an informative signal, the posterior of the typical agent is (i) stronger (weaker) than the prior under $s_n = 1$ ($s_n = 0$), and (ii) increasing in the prior under either signal.[15]

The agent's posterior reflect her belief, once all her available information has been utilized, about the underlying state of the world. It matters because it determines the payoff from either of her two available actions. Given that the true state is ω and the actions of all other players are given by the profile $\{x_i\}_{i\in\{1,\ldots,N\}\setminus\{n\}}$, her payoff is

$$U_{n,\omega}\left(e_n - x, X_{n-1} + x + \sum_{i=n+1}^{N} x_i\right)$$

if she contributes towards the public good and

$$U_{n,\omega}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)$$

if she doesn't. In words, the typical agent has state-dependent preferences over consumption bundles of two goods, a private and a public, representable by the function $U_{n,\omega}(c, G)$ with all quantities denominated in units of a single underlying commodity of exchange (such as money). The total amount of the public good G is given by the sum of all individual donations added to any initial social endowment. The amount of the private good c is the remainder from the individual's wealth endowment e_n once her public good contribution has been deducted.

Regarding her preferences, we will assume throughout that $U_{n,\omega}$ is everywhere differentiable, strictly increasing with respect to either of its arguments (A.1), and strictly concave

[14] As usual, $\vec{\sigma}_{-n}$ denotes the strategy profile of all other players, $(\sigma_1, \ldots, \sigma_{n-1}, \sigma_{n+1}, \ldots, \sigma_N)$. Of course, π_n depends here only upon the $(\sigma_1, \ldots, \sigma_{n-1})$ part of $\vec{\sigma}_{-n}$. Recall also that the strategies do not depend here upon the histories of past plays while the action space is binary. Hence, for the probability that the player will volunteer for the task given her strategy σ_n and the signal s_n, we have $\Pr[x_n = x | s_n, \sigma_n] = \sigma^1_{s_n,n}$ with $\sigma^0_{s_n,n} = 1 - \sigma^1_{s_n,n}$ being the probability that she will not.

[15] It is trivial to verify that, for any $\pi_n \in (0,1)$, the statements $\mu_{0,n} < \pi_n < \mu_{1,n}$ and $2q > 1$ are equivalent. Moreover, $\frac{\mathrm{d}\mu_{1,n}}{\mathrm{d}\pi_n} = \frac{q(1-q)}{[q\pi_n + (1-q)(1-\pi_n)]^2} = \frac{\mathrm{d}\mu_{0,n}}{\mathrm{d}\pi_n}$.

in the second (A.2).[16] More importantly since (A.1)-(A.2) are completely standard conditions, we require that the marginal utility of either good cannot fall when the quantity of the other increases (A.3) and that the state of nature matters by affecting the marginal rate of substitution between the two goods.

Specifically, the marginal rate of substitution of public for private consumption is always greater (less) than unity when the favorable (unfavorable) state obtains (A.4). We take, therefore, the underlying uncertainty to be about the relative value the individuals in this community attach to consuming the private versus the public good. For, if these two goods were traded in a perfectly competitive market at say prices p_c and p_G, respectively, this condition would require that $p_G > p_c$ ($p_G < p_c$) when $\omega = 1$ ($\omega = 0$).[17] That is, in the favorable (unfavorable) state, it is strictly dominant for all individuals (thus, socially optimal) to (not) contribute to the public good.

Formally, the following conditions will be taken to apply for all agents $n \in \{1, \ldots, N\}$ at either state.

(A.1) For either good, more is preferred to less:

$$\frac{\partial U_{n,\omega}(c,G)}{\partial c}, \frac{\partial U_{n,\omega}(c,G)}{\partial G} > 0 \qquad \forall (c,G) \in \mathbb{R}_{++} \times \mathbb{R}_{+}$$

(A.2) Risk aversion with respect to the public good:

$$\frac{\partial^2 U_{n,\omega}(c,G)}{\partial G^2} < 0 \qquad \forall (c,G) \in \mathbb{R}_{++} \times \mathbb{R}_{+}$$

(A.3) The marginal utility from each good is non-decreasing in the amount of the other:

$$\frac{\partial^2 U_{n,\omega}(c,G)}{\partial c \partial G} \geq 0 \qquad \forall (c,G) \in \mathbb{R}_{++} \times \mathbb{R}_{+}$$

(A.4) The marginal utility of private consumption is dominated by (dominates) that of the public when the state is favorable (unfavorable):

$$(-1)^{\omega} \left(\frac{\partial U_{n,\omega}(c, G+z)}{\partial G}|_{c=e_n-x} - \frac{\partial U_{n,\omega}(c-z, G)}{\partial c}|_{c=e_n-x} \right) < 0 \qquad \forall z \in (0,x) \ \forall G \in \mathbb{R}_{+}$$

[16] Concavity of the utility function with respect to private consumption is not necessary given that the choice problem in this dimension is discrete.

[17] Assuming, of course, an interior optimal consumption bundle $(c^*, G^*) \in \mathbb{R}^2_{++}$.

Putting together the elements of the model described above, given that the others are following the strategy profile $\vec{\sigma}_{-n}$, the expected payoff of the nth agent when she receives the signal s_n will be[18]

$$\mu_{s_n,n}\mathbb{E}_{\vec{\mathbf{x}}_n}\left[U_{n,1}\left(e_n - x, X_{n-1} + x + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 1\right]$$
$$+ (1 - \mu_{s_n,n})\,\mathbb{E}_{\vec{\mathbf{x}}_n}\left[U_{n,0}\left(e_n - x, X_{n-1} + x + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 0\right]$$

if she contributes, and

$$\mu_{s_n,n}\mathbb{E}_{\vec{\mathbf{x}}_n}\left[U_{n,1}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 1\right]$$
$$+ (1 - \mu_{s_n,n})\,\mathbb{E}_{\vec{\mathbf{x}}_n}\left[U_{n,0}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 0\right]$$

if she doesn't. Hence, for $x_n \in \{0, x\}$,

$$\mathbb{E}_{\vec{\mathbf{x}}_n}\left[U_{n,\omega}\left(e_n, X_{n-1} + x_n + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega\right]$$
$$= \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx|\vec{\sigma}_n, \omega\right] U_{n,\omega}\left(e_n - x, X_{n-1} + x_n + kx\right)$$

is the conditional (on the state realization) expected payoff of the player. As shown in the Appendix, moreover, the conditional (upon the underlying state and her successors' strategy profile $\vec{\sigma}_n$) probability that exactly $k \in \{0, \ldots, N-n\}$ successors will contribute is given by

$$\Pr\left[X_N - X_n = kx|\vec{\sigma}_n, \omega\right]$$
$$= \sum_{(s_{n+1},\ldots,s_N)\in\{0,1\}^{N-n}} \left(\prod_{i=n+1}^{N} \Pr\left[s_i|\omega\right] \left(\sum_{\sum_{i=n+1}^{N}\alpha_i = k,\ \alpha_i\in\{0,1\}} \prod_{i=n+1}^{N} \sigma_{s_i,i}^{\alpha_i}\right)\right) \tag{2}$$

Theoretical Predictions

In presenting the theoretical results that will form the basis of our empirical investigation, it will be of significant notational convenience to define

$$\Delta_x U_{n,\omega}(c, G) = U_{n,\omega}(c - x, G + x) - U_{n,\omega}(c, G)$$

[18]Throughout this exposition, we adopt the vector notation $\vec{\sigma}_n = (\sigma_{n+1}, \ldots, \sigma_N)$ and $\vec{\mathbf{x}}_n = (x_{n+1}, \ldots, x_N)$. Notice also that the latter vector is random from the perspective of the nth player in the sequence; it depicts the yet unknown profile of play by her successors.

Using this quantity, it is trivial to verify that the necessary and sufficient condition for the typical agent to contribute if and only if she receives a favorable signal ($s_n = 1$) can be written as follows

$$\begin{aligned} & \frac{1}{\mu_{1,n}} - 1 \\ < & -\frac{\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1} + kx\right)}{\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + kx\right)} \\ < & \frac{1}{\mu_{0,n}} - 1 \end{aligned} \tag{3}$$

The Bounds of Altruism

The theoretical framework described above is the standard one used in the literature on herds and informational cascades: each agent observes what others do and takes a zero-one action in a preordered sequence. Yet, in that literature, the actions of others matter for one's payoff only indirectly, as they carry information regarding the underlying state of the world. By contrast, in this model, they matter also directly since they determine the total amount of the public good. This additional functionality of others' behavior delivers results that are not observed in the literature on herds and informational cascades. In that literature, when agents receive a binary signal, informational cascades occur almost surely. As a consequence, there is only very limited social learning; the actions of others matter only in so far as they bring the public belief to the critical level for a cascade to start.

In our setting, on the other hand, informational cascades occur only as in limiting cases. Intuitively, as long as the sequence of agents is long enough, a sequence of the same action herd will have to be broken eventually because we can have neither too much nor too little of the public good. When the amount of observed contributions is sufficiently high, the problem of the commons kicks in and putting an end to the string of further contributions are precluded. When it is sufficiently low, the net benefit from contributing is so high in the good state that an agent prefers to contribute ex-ante for any but vanishingly small prior beliefs.

The respective bounds can be identified through the functions $\mathrm{MRS}_{\max}, \mathrm{MRS}_{\min} : \mathbb{R}_+ \mapsto \mathbb{R}_{++}$ which are defined by

$$\begin{aligned} \mathrm{MRS}_{\max}(G) &= \max_{n' \in \{1,\ldots,N\}} \left\{ -\frac{\Delta_x U_{n',1}\left(e_{n'}, G\right)}{\Delta_x U_{n',0}\left(e_{n'}, G\right)} \right\} \\ \mathrm{MRS}_{\min}(G) &= \min_{n' \in \{1,\ldots,N\}} \left\{ -\frac{\Delta_x U_{n',1}\left(e_{n'}, G\right)}{\Delta_x U_{n',0}\left(e_{n'}, G\right)} \right\} \end{aligned}$$

These relations provide sufficient conditions (Claims 2 and 5) for the two types of cascades our setting allows for (situations, that is, in which every or no one contributes). By doing so, however, they also delimit these situations indicating that they may occur only as limiting cases. On the one hand, as long as the existing amount of the public good is not too large, no contributions cascades are ruled out (4). On the other, contributions cascades are not possible in large communities (Corollary 3), unless the required individual contributions are vanishingly small and there is no initial social endowment of the public good (Corollary 6).

The Effect of the Average Level of Past Contributions

We are left, therefore, with the most possible scenario being the fully-revealing, symmetric equilibrium in which the n'th agent and each of her successors contribute if and only if their signal is favorable. For this, as shown in the Appendix (Claim **??**), it suffices that the following conditions

$$\begin{aligned}
\frac{1}{\mu_{1,n}} - 1 &\leq -\left(\frac{(1-q)^{N-n}}{N-n+1}\right)\left(\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\,x\right)}{\Delta_x U_{n,0}\left(e_n, X_{n-1} + (N-n)\,x\right)}\right) \\
\frac{1}{\mu_{0,n}} - 1 &\geq -\left(\frac{(1-q)^{N-n}}{N-n+1}\right)^{-1}\left(\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1}\right)}{\Delta_x U_{n,0}\left(e_n, X_{n-1}\right)}\right)
\end{aligned}$$

hold for every $n \in \{n', \ldots, N\}$.

These sufficient conditions are related to the average level of past contributions the nth agent observes, $\overline{x}_n = \frac{X_n}{n-1}$, in the following way: *a higher $\overline{x}_n$ makes it more likely that they will be met.* To see this, observe first that, other things being equal, the right-hand side of either inequality is increasing in $\overline{x}_n$ because $-\frac{\Delta_x U_{n,1}(c,\cdot)}{\Delta_x U_{n,0}(c,\cdot)}$ is strictly decreasing.[19]

By contrast, the left-hand side of either inequality is decreasing with $\overline{x}_t$. This can be verified by noticing first that it is the *net* number of past signals that matter for one's posterior belief. Once this observation has been made, it is straightforward to check that, for $\overline{x}_n = 0.5$, an equal number of the two signals have been observed so that the prior at the beginning of the nth stage is the same as that at the beginning of the game itself, $\pi_n = \pi$. If $\overline{x}_n > 0.5$ ($\overline{x}_n < 0.5$), on the other hand, there have been more favorable (unfavorable) signals in the first $n-1$ stages. Specifically, for $\overline{x}_n > 0.5$, there have been exactly $(2\overline{x}_n - 1)(n-1)$

[19] This is an immediate consequence of Lemmas 1 and 2 of Appendix C.

more favorable signals.[20] The prior, therefore, is

$$\pi_n = \frac{q^{(2\overline{x}_n-1)(n-1)}\pi}{q^{(2\overline{x}_n-1)(n-1)}\pi + (1-q)^{(2\overline{x}_n-1)(n-1)}(1-\pi)}$$

Similarly, we have exactly $(1-2\overline{x}_n)(n-1)$ more unfavorable signals when $\overline{x}_n < 0.5$. In this case,

$$\pi_n = \frac{(1-q)^{(1-2\overline{x}_n)(n-1)}\pi}{(1-q)^{(1-2\overline{x}_n)(n-1)}\pi + q^{(1-2\overline{x}_n)(n-1)}(1-\pi)}$$

Clearly, in either case, π_n and, thus, $\mu_{j,n}$ for $j = 0, 1$ are increasing in $\overline{x}_n$.[21]

The monotonicity relations exhibited by the sides of the first inequality above suggest unambiguously that an increase in $\overline{x}_n$ renders it more likely that the inequality will be met. With respect to the sides of the second inequality, both are increasing in $\overline{x}_n$. Recall, however, that the two inequalities above are sufficient conditions for the fully-revealing equilibrium under study. The sufficient and necessary ones are given by (6), the right-hand inequality of which is a weaker condition that the second inequality above. And as the quantity on the right-hand side of the first inequality above is a lower bound for the quantity in the middle of (6), we are guaranteed that the latter quantity increases with $\overline{x}_n$.

Therefore, the only case when it would not be more likely for (6) to be met when $\overline{x}_n$ increases is the case in which the quantity in the middle of (6) increases with $\overline{x}_n$ but not as fast as $\frac{1}{\mu_{0,n}}$ decreases. Whenever this is true, however, it becomes more likely that the right-hand side inequality of (6) will be violated. Equivalently, that the agent will contribute irrespectively of the signal she receives. Clearly, a higher $\overline{x}_n$ exerts always a positive effect towards the agent contributing, at least when her signal is favorable.

To test this relation empirically, we will take henceforth $x = 1$ so that the relevant decision-making dimension is indeed the binary choice between volunteering or not. We will also focus on the decision of the last individual in the sequence of contributions that occur in a given community during a given year. This allows us to interpret the average level of past contributions, $\overline{x}_N$, as the average level of contributions in a community in the current year; which is the only consistent measure of average contributions by others that can be obtained from our data.

[20] Let k_{n-1} be the number of favorable signals in the past $n-1$ stages. The average contribution level is then $\overline{x}_n = \frac{k_{n-1}}{n-1}$ while the number of unfavorable signals is $k'_{n-1} = n-1-k_{n-1}$. But $k_{n-1} > k'_{n-1}$ is the same as $2k_{n-1} > n-1$ while $k_{n-1} - k'_{n-1} = 2k_{n-1} - (n-1) = (2\overline{x}_n - 1)(n-1)$.

[21] Let $y = \frac{q^n\pi}{q^n\pi + (1-q)^n(1-\pi)}$. Then $\mathrm{d}y/\mathrm{d}n$ is proportional to $q^n\pi\left[q^n\pi + (1-q)^n(1-\pi)\right]\ln q - q^n\pi\left[q^n\pi\ln q + (1-q)^n(1-\pi)\ln(1-q)\right] = q^n\pi(1-q)^n(1-\pi)\ln\left(\frac{q}{1-q}\right) > 0$. Similarly, if $z = \frac{(1-q)^n\pi}{(1-q)^n\pi + q^n(1-\pi)}$, then $\mathrm{d}z/\mathrm{d}n$ is proportional to $-q^n\pi(1-q)^n(1-\pi)\ln\left(\frac{q}{1-q}\right)$.

4 Data

The empirical portion of our analysis makes use of two data sets: the 2004-2007 September supplements to the Current Population Survey (CPS), and the Census 2000 Summary Files (STF3). The CPS and Census files were matched using Core Based Statistical Areas (CBSA's) via a county-level match.[22]

The CPS September supplement is unique with respect to other CPS supplements in its focus on questions related to individual volunteering. Our analysis focuses on individuals considered to be "adults" (ages 15 and up). Our robustness analysis restricts the sample further to include only working-age individuals (i.e., aged 25-65). We use this additional restriction because, as Mutchler et.al. [41] point out, it is possible that retirees or students volunteer for different reasons than do individuals currently in the workforce.[23]

The CPS information employed in our empirical investigation includes individual-level demographic characteristics and information on whether an individual chose to volunteer and for which organizations. Specifically, from the CPS data, we use information on an individual's gender, age, race, educational attainment, family income, family structure and size, as well as marital and employment status.[24] These variables will henceforth be collectively referred to as $DEMOG$. Also from the CPS data set, we import a binary variable denoting whether or not an individual volunteered, and note also the particular organizations for which he or she did so, paying particular attention to whether he or she volunteered

[22]At first, we attempted to match the two datasets entirely at the county level using county of residence information in the CPS. This strategy was abandoned due to the large number of individuals for whom county information in the CPS was unavailable. Instead, we adopted the method of matching the CBSA of residence in the CPS data to the corresponding county(ies) in the Census data. This matching technique alleviated the problem of missing CPS residence information significantly, allowing us to keep a substantially larger fraction of the data. Unfortunately, in order to maintain consistency of measurements for the merged years, we had to focus only on the years 2004-2007 as these are the ones for which CBSA information is available in the CPS. The 2002-2003 September Volunteering Supplements do have county and Metropolitan Statistical Area (MSA) information, however, they do not provide information on CBSA of residence since CBSA was not yet in use at that time in the supplements. It should also be noted that county information was generally unavailable for the CPS observations in the New England states. For these states, a New England City and Town Area(NECTA) to CBSA match was virtually impossible since there is a many-to-many relationship between NECTA's and CBSA's, even before accounting for county locations.

[23]Regarding its time span, our robustness analysis employs only the last two years of our data (2006-2007). We employed this constraint in order to facilitate a comparison of results between our baseline and IV specifications.

[24]Family structure denotes the presence of children of various ages in the individual's home. More precisely, the variables used to depict marital status are coded as: never married, married and spouse present, married and spouse absent, and divorced or separated.

for a religious organization. Our empirical analysis does not include the number of hours volunteered. This dimension of an individual's contribution decision is not captured by our theoretical structure and, to maintain rigor and consistency, our empirical investigation stays as much as is possible within the limits of our theoretical intuition.[25]

Our intuition for including the DEMOG control characteristics in our analysis is supported by the following evidence. As Simmons and Emanuele [45] document, females volunteer on average more and are thought to be differentially altruistic, at least in some settings, than males. According to Dee [23], moreover, wealth and education are intimately associated with an individual's likelihood of being civic-minded and engaging in volunteer activities. Regarding family structure and size, individuals with children, and in particular small children, are more likely to volunteer, at least for some types of organizations. Employment status is also important because of the possibility that individuals are either trading off volunteering with paid work in an effort to increase human capital or life satisfaction or instead, according to average statistics, such as in Kulik [36], the employed are also volunteering at higher rates. Finally, race is often implicated as affecting not only the choice of volunteering but also the type of the chosen volunteer activity. This effect is especially strong in studies of religious volunteering, such as in Musick *et.al.* [40].[26]

From the Census data, we gathered information on the average characteristics of the CBSA area.[27] Specifically, we included as controls the total population size (and its square), the average CPI-adjusted income level (and its square), and the fraction living in an urban location in the CBSA area. We also employed the fraction of various racial groups in the CBSA-area as part of the area-level controls. In what follows, these location-related variables

[25]We did examine regression specifications using hours of volunteering as an explanatory variable. Compared to the regressions in this paper (which use the binary indicator of whether or not an individual volunteered), those results (not presented here but available upon request) showed somewhat weaker relationships with the community average level of contributions. This is not surprising since the average level of volunteering in one's community ought to have a larger influence on one's choice as to whether or not to volunteer than on the choice of hours. Our reasoning being that the latter decision depends to a much larger extent on factors, such as the opportunity cost of one's time and effort, that are not related directly to the information one has about the quality of the public good or the importance of the cause about which one is called upon to volunteer. Within our theoretical framework, it is this information that provides the dimension on which the average level of volunteering in the community operates.

[26]The regression coefficients on these variables are not shown in our regression results due to length of exposition, and also due to the fact that these coefficients are not the main consideration of our analysis. Results available upon request.

[27]We use the term "CBSA area" to reflect the fact that we averaged information across all counties within a particular CBSA. To define a "CPS-CBSA area," an additional (and easily met within our sample) restriction was that at least 10 individuals had to be found in the area.

will be collectively referred to as $CBSACHAR$.[28]

Finally, regarding the average level of volunteering in the community, we created a measure of the average level of volunteering that occurred within the CBSA area in the current year (using the leave-out mean to mitigate reflection bias) and also employing a two-year lag. We chose two years since it is a long enough time period for our instrumentation strategy (which is discussed in detail in the methodology section) and it further allows us to maintain more than one year of data. We used the same strategy for nonreligious volunteering, constructing average values in the current year as well as after employing a two-year lag. It should be emphasized that nonreligious volunteering is examined separately and in detail due to the possibility that it differs in motivation from religious volunteering.[29] Within our sample of volunteers, we considered as "non-religious" volunteers those individuals who had not volunteered for a religious or church-based organization. [30]

5 Empirical Analysis

The primary goal of our empirical investigation is to determine the effect of average volunteering by others on one's probability of engaging in volunteer work, after we have accounted for other factors at the individual and area-level of analysis which may affect one's volunteering decision. We have generally for indiivdual i in CBSA area j:

$$VOL_{i,j} = f\left(DEMOG_i, CBSACHAR_j, AVGVOL_j\right)$$

[28]We experimented with regression specifications including measures of fractionalization (by race, immigrant, and income inequality using Gini coefficients) at the CBSA area-level as control variables. These were constructed in the same way as the ethno-linguistic type of fractionalization measures. Empirically, these required a slightly less favored measure of race for the individual-level since our probit models using the same racial structure as in this analysis did not achieve numerical convergence. Nevertheless, also in these alternative race-coded models, the average level of volunteering in the community has a positive effect on an individual's decision to volunteer, both in the baseline OLS/probit regressions as well as in their respective instrumented versions. This was true with respect to both general and non-religious volunteering. We also used variants of our fraction urbanized vs. total population size and found no substantive difference from including both in the regressions. We chose to include both population size and fraction urbanized so that we could distinguish larger areas from simply different types of areas by urban-rural distinction.

[29]See for example Isham *et.al.* [34], Tao and Yeh [47], and Segal *et.al.* [44].

[30]More precisely, we used the responses to the question in the survey asking about the organization for which the individual had volunteered. Answering that one had volunteered but not for a religious organization renders one a "nonreligious" volunteer. The difference in questions asked changes the respective sizes of the regression samples.

where VOL is the binary volunteering decision (either total or non-church), $DEMOG$ are demographic characteristics of the individual, $CBSACHAR$ are characteristics of the CBSA area, and $AVGVOL$ measures the average level of volunteering in the area.

We instantiate this general model with a probit structure (and a differenced probit for marginal effects). Specifically, we view each individual as having some inherent desire to volunteer and actually doing so once this desire exceeds an unknown threshold α. This can be represented with a latent variable structure where VOL^* is the latent desire to volunteer and VOL is the observed decision of whether or not to volunteer. Formally, we will assume the specification

$$\begin{aligned} VOL^*_{i,j} &= \beta_0 + \beta_1 DEMOG_i + \beta_2 CBSACHAR_j + \beta_3 AVGVOL_j + \epsilon_i \\ VOL_{i,j} &= \begin{cases} 1 & \text{if } VOL^*_{i,j} > \alpha \\ 0 & \text{if } VOL^*_{i,j} \leq \alpha \end{cases} \end{aligned}$$

for some value α. All of our regressions additionally include state and year fixed effects, clustering of standard errors by CBSA, and probability weighting for sample inclusion.

The issue of reflection bias of focus in our analysis is in the decision to volunteer conditional on average volunteering rates in the community. As mentioned earlier, we instrument for average volunteering in the current year (leave-out-mean) with the two-year lagged value of average volunteering in the CBSA.[31] This instrument is not weak since, in the first stage, our F-statistic is above 10 in all cases.[32]

To further test the robustness of our Probit results, we compare them with those from an Ordinary Least Squares (OLS) model. Even though the linearized probability model is clearly an inferior fit compared to the Probit one, we do present the results for reasons of

[31] Technically-speaking, it is sufficient to use one year's lagged value of the level of average volunteering because of the sampling design of the CPS data. We nevertheless chose a longer lag to increase the plausibility of our instrument.

[32] We did attempt to use several other instrumentation strategies. For instance, one approach was to use as an instrument the average observable demographic characteristics of volunteers in the community. Still another was to instrument for the amount of non-church volunteering activity by employing the number of churches and measures of church-going behavior in the community (with respect to both *catholic only* as well as *all* churches). Our instruments suffered from being too weak to reasonably employ in the current analysis. In particular, they were weaker than the first stage of the instrument we finally settled upon. Of course, our instrument of interest in this analysis, namely, the two-year lagged value of average volunteering, does not fully account for individuals sorting by location. It is, therefore, possible that this behavior affects an individual's likelihood of volunteering. This will, however, operate in conjunction with the informational effect that the average level of volunteering in the community has in our signalling framework. Given that this latter relation is the focus of our empirical investigation, our primary concern is that our instrumental strategy address the issue of reflection bias.

completeness in our exposition. For the ith individual in the jth CBSA area, the OLS model is specified as follows:

$$VOL_{i,j} = \alpha_0 + \alpha_1 DEMOG_i + \alpha_2 CBSACHAR_j + \alpha_3 AVGVOL_j$$

6 Empirical Findings

Summary Statistics

Table 1 displays the mean, minimum, and maximum of each variable in our analysis, the full sample including all individuals in the CPS September Supplement Files (2004-2007). By contrast, the regressions in Tables 3 and A1 refer to an age-restricted sample (age 15 and up or age 25-65, respectively). Even though, for reasons of generality in the reported results, we chose to focus on the full sample, the age-restricted samples show similar patterns of results.

In Table 1, means are shown for the full sample as well as by year. The annual results are quite similar albeit with a few exceptions. In particular, the fraction of individuals with a family income above $75,000 varies from a low of 29% in 2004 to a high of 35% in 2007. Variation over time is also present in the the fraction of who volunteer, going from a high of 30% in 2004 to a low of 27% in 2007.[33] We feel that there may have been a break in volunteer activities with a greater number of individuals choosing to volunteer at the beginning of the 2004-2007 period due to outside environmental factors. There is also some small variation in the composition of individuals based on education level and age. Overall, however, the similarities in the summary statistics of our sample over the relevant time period are such that they do not point to any significant biases in the data.

Table 2 displays the breakdown of volunteering by category, amongst the individuals who chose to volunteer. Of course, there are discrepancies in the percentages for religious volunteering between this table and the preceding one because the respective ratios use different denominators.[34] It is clear from this table that volunteering for religious organizations, chil-

[33]Since it was reported in a categorical fashion, individual income data from the CPS files could not reasonably employ a CPI-adjustment. This partially explains the variation we see over time in the summary statistics of individual income at the highest brackets. We did run our regression specifications with and without CPI-adjusted average income in the CBSA area to create conformity of CPI-adjustments in our personal and average-area income variables. The respective results were not distinguishably different in any way. The effects of income were also similar when our regressions were run with yearly data rather than using the full sample, further showing little reliance of our results on the CPI-adjustment.

[34]Specifically, this table shows the percentage who do volunter work of a particular type, using, as the denominator representations of different types of volunteering in the community. In contrast, table 1 uses the full population as the denominator.

dren's educational or sports groups, as well as social and community service is generally the largest portion of volunteer work in this survey. Together, these three categories account for between 71% and 76% of the volunteering activities in any year of the sample. The observed high rate of participation in religious organizational volunteering is an additional reason for separating out this type of volunteer work in the regression portion of our analysis. We note that, despite a few fluctuations, the time period under study is characterized by a relatively constant flow of volunteer work by type of activity.[35]

Regression Analysis

Table 3 displays the effect of average level of volunteering in the CBSA on an individual's likelihood of engaging in volunteer work. Controls for demographic and local area characteristics were added into the regressions in a progressive fashion. The results are shown both for the probit as well as the OLS linearized regressions. Coefficients are shown with t-statistics in brackets. Marginal probit coefficients are in italics below the probit coefficients and their t-statistics. Panel A shows the effect on volunteering in general while Panel B depicts the effect on non-religious volunteering in particular. Each panel reports the results from 11 regressions, 3 OLS, 3 Probit, 2 IV, and 3 Marginal Probit.

It is clear from this table that the average level of volunteering in one's CBSA area has a positive impact on one's likelihood of engaging in volunteer work. This is true in both the regular OLS/Probit as well as in the instrumented regressions. It is also true both for volunteering in general as well as volunteering for non-religious organizations in particular. Coefficients in the instrumented versions are somewhat larger than in the OLS/Probit regressions and display smaller t-statistics.

The decrease in t-statistics is to be expected because we are using an instrumental variable (and also because we are using a larger sample for the OLS/Probit regressions) while the increase in size shows evidence that we may indeed see some problems of bias in our relationships.[36] It is also clear that controlling for measures of individual and community characteristics, while reducing the effect of average volunteering (because presumably there will be some relationship between other characteristics of communities and individuals and the volunteering rate), does not manage to entirely erase the relationship. The coefficient on

[35]Notice that changes in the identification of volunteering organizations over time (the inclusion of immigration volunteering being one of the most important) altered the way these questions are coded. This is why an "other" category is missing from our 2007 data and explains part of the variation by category.

[36]The robustness check of Table A1 does not strictly counter this particular table since we are also focusing on the working age population in Appendix Table 1. We did, however, see more similar coefficients between the IV and OLS/Probit results when only using years 2006-2007 and retaining the same age structure.

the average level of volunteering in the community remains highly significant and positive. Table A1 further confirms the strength and direction of this relationship. The results are not substantially altered when the investigation is restricted to the working age population with a focus on only the years 2006-2007.

7 Conclusions

We examined the effect of average community-level volunteering as creating a signal for whether people will individually choose to volunteer. Our theoretical model predicted that individuals choose to volunteer with a higher probability when receiving signals that there are higher levels of volunteering within their community. This is true because of theoretical herding that will occur in equilibrium.

We substantiated this theoretical prediction with empirical data from the Census Summary Files and CPS Supplement data and found that it is not simply a reflection of community characteristics or demographic characteristics known to correlate with volunteering.

Our result was true regardless of whether we focused on the working-age or full population of individuals and whether we examined volunteering generally or only non-religious volunteering. Thus, our result is not driven by religious volunteering, nor is it only true for the retired or student populations. Our result is not unique to a particular econometric technique: It is true whether we use a probit or a linearized regression model. Our results also obtain after introduction of our instrument to deal with the issue of reflection bias. We believe that our work has made a step forward in understanding how the volunteering of individuals in the community as a whole affect individual choices of whether or not to volunteer.

8 Acknowledgements

Neymotin is grateful for funding provided by an NSF ADVANCE grant through Kansas State University. A previous version of this paper was presented at the 2009 Missouri Economics Association conference, the 2010 Western Economics Association International conference and the 2010 Southern Economics Association conference CSWEP session. We thank Rebecca Blank, David Card, Daniel Hamermesh, Dong Li, Giovanni Mastrobuoni, Mario Pagliero and James Powell for many helpful comments and suggestions. We are grateful to Urmimala Sen for outstanding research assistance wtih the empirical portion of the analysis. All mistakes are our own.

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A Proofs

Claim 1 *For $n \in \{1, \ldots, N\}$, let the nth agent observe $X_n \in \{0, \ldots, (n-1)\,x\}$ past contributions. Then, the following conditions*

$$\begin{aligned}
\frac{1}{\mu_{1,n}} &\leq 1 - \left(\frac{(1-q)^{N-n}}{N-n+1}\right)\left(\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\,x\right)}{\Delta_x U_{n,0}\left(e_n, X_{n-1} + (N-n)\,x\right)}\right) \\
\frac{1}{\mu_{0,n}} &\geq 1 - \left(\frac{N-n+1}{(1-q)^{N-n}}\right)\left(\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1}\right)}{\Delta_x U_{n,0}\left(e_n, X_{n-1}\right)}\right)
\end{aligned}$$

are sufficient for the fully-revealing symmetric equilibrium in which this agent and all her successors follow the strategy of contributing if and only if they receive a good signal.

Proof. As we have shown in the main text, given the strategic profile $\vec{\sigma}_n$ of her successors, the necessary and sufficient condition for the nth agent to contribute iff $s_n = 1$ is the simultaneous validity of the following inequalities

$$\begin{aligned}
& \mu_{0,n}\mathbb{E}_{\vec{\mathbf{x}}_n}\left[\Delta_x U_{n,1}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 1\right] \\
< \; & -\left(1-\mu_{0,t}\right)\mathbb{E}_{\vec{\mathbf{x}}_n}\left[\Delta_x U_{n,0}\left(x_n; e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 0\right]
\end{aligned} \tag{4}$$

$$\begin{aligned}
& \mu_{1,n}\mathbb{E}_{\vec{\mathbf{x}}_n}\left[\Delta_x U_{n,1}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 1\right] \\
\geq \; & -\left(1-\mu_{1,t}\right)\mathbb{E}_{\vec{\mathbf{x}}_n}\left[\Delta_x U_{n,0}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)|\vec{\sigma}_n, \omega = 0\right]
\end{aligned} \tag{5}$$

Observe now the following fact

Lemma 1

$$\Delta_x U_{n,0}\left(c, G\right) < 0 < \Delta_x U_{n,1}\left(c, G\right) \qquad \forall\left(c, G\right) \in \mathbb{R}_{++} \times \mathbb{R}_{+}$$

Proof. Recall the definition of $\Delta_x U_{n,\omega}\left(c, G\right)$ in the main text. It is the difference between two utility differences:

$$U_{n,\omega}\left(c-x, G+x\right) - U_{n,\omega}\left(c-x, G\right) - \left[U_{n,\omega}\left(c, G\right) - U_{n,\omega}\left(c-x, G\right)\right]$$

The first term is evaluated as $\int_0^x \frac{\partial U_{n,\omega}(c-x,G+z)}{\partial G}\mathrm{d}z$ by the fundamental theorem of calculus. The second is also written as $\int_{c-x}^{c} \frac{\partial U_{n,\omega}(w,G)}{\partial c}\mathrm{d}w = -\int_{c}^{c-x} \frac{\partial U_{n,\omega}(w,G)}{\partial c}\mathrm{d}w$. Equivalently,

$\int_0^x \frac{\partial U_{n,\omega}(c-x,G)}{\partial c}\mathrm{d}z$, taking $z = c - w$.
If $\omega = 0$, we have

$$\begin{aligned} U_{n,0}(c-x, G+x) - U_{n,0}(c-x, G) &= \int_0^x \frac{\partial U_{n,0}(c-x, G+z)}{\partial G}\mathrm{d}z \\ &< \int_0^x \frac{\partial U_{n,0}(c-x+z, G)}{\partial c}\mathrm{d}z \\ &= U_{n,0}(c, G) - U_{n,0}(c-x, G) \end{aligned}$$

the inequality following from (A.4). The argument for the case $\omega = 1$ is trivially similar. □

Using this result, the system (4)-(5) can be written more compactly as follows

$$\frac{1}{\mu_{1,n}} - 1 < -\frac{\mathbb{E}_{\mathbf{x}_n}\left[\Delta_x U_{n,1}\left(e_n, X_{n-1} + \sum_{i=n+1}^N x_i\right)|\vec{\sigma}_n, \omega = 1\right]}{\mathbb{E}_{\mathbf{x}_n}\left[\Delta_x U_{n,0}\left(e_n, X_{n-1} + \sum_{i=n+1}^N x_i\right)|\vec{\sigma}_n, \omega = 0\right]} < \frac{1}{\mu_{0,n}} - 1 \tag{6}$$

Consider now the last agent in the sequence. As there is no one to act after her, (6) reads

$$\frac{1}{\mu_{1,N}} - 1 < -\frac{\Delta_x U_{N,1}(e_N, X_{N-1})}{\Delta_x U_{N,0}(e_N, X_{N-1})} < \frac{1}{\mu_{0,N}} - 1$$

For the penultimate individual, on the other hand, the conditional (on the state and her successor's strategy) expected payoff is given by

$$\begin{aligned} & \mathbb{E}_{x_N}\left[U_{N-1,1}(e_{N-1} - x, X_{N-2} + x + x_N)|\sigma_N, \omega = 1\right] \\ = & \left[q\sigma_{1,N}^1 + (1-q)\sigma_{0,N}^1\right] U_{N-1,1}(e_{N-1} - x, X_{N-2} + 2x) \\ & + \left[(1-q)\sigma_{0,N}^0 + q\sigma_{1,N}^0\right] U_{N-1,1}(e_{N-1} - x, X_{N-2} + x) \end{aligned}$$

$$\begin{aligned} & \mathbb{E}_{x_N}\left[U_{N-1,0}(e_{N-1} - x, X_{N-2} + x + x_N)|\sigma_N, \omega = 0\right] \\ = & \left[q\sigma_{0,N}^1 + (1-q)\sigma_{1,N}^1\right] U_{N-1,0}(e_{N-1} - x, X_{N-2} + 2x) \\ & + \left[(1-q)\sigma_{1,N}^0 + q\sigma_{0,N}^0\right] U_{N-1,0}(e_{N-1} - x, X_{N-2} + x) \end{aligned}$$

if she contributes, and

$$\begin{aligned} & \mathbb{E}_{x_N}\left[U_{N-1,1}(e_{N-1}, X_{N-2} + x_N)|\sigma_N, \omega = 1\right] \\ = & \left[q\sigma_{1,N}^1 + (1-q)\sigma_{0,N}^1\right] U_{N-1,1}(e_{N-1}, X_{N-2} + x) \\ & + \left[(1-q)\sigma_{0,N}^0 + q\sigma_{1,N}^0\right] U_{N-1,1}(e_{N-1}, X_{N-2}) \end{aligned}$$

$$\begin{aligned} & \mathbb{E}_{x_N}\left[U_{N-1,0}(e_{N-1}, X_{N-2} + x_N)|\sigma_N, \omega = 0\right] \\ = & \left[q\sigma_{0,N}^1 + (1-q)\sigma_{1,N}^1\right] U_{N-1,0}(e_{N-1}, X_{N-2} + x) \\ & + \left[(1-q)\sigma_{1,N}^0 + q\sigma_{0,N}^0\right] U_{N-1,0}(e_{N-1}, X_{N-2}) \end{aligned}$$

if she doesn't. That is, for the penultimate player, (6) is given by[37]

$$\begin{aligned}\frac{1}{\mu_{1,N-1}}-1 &< -\frac{\sum_{k=0}^{1}\Pr\left(x_N=kx|\sigma_N,\omega=1\right)\Delta_x U_{N-1,1}\left(e_{N-1},X_{N-2}+kx\right)}{\sum_{k=0}^{1}\Pr\left[x_N=kx|\sigma_N,\omega=0\right]\Delta_x U_{N-1,0}\left(e_{N-1},X_{N-2}+kx\right)}\\ &< \frac{1}{\mu_{0,N-1}}-1\end{aligned}$$

In a similar fashion, the conditional expected payoff of the $N-2$ individual in the sequence can be expressed as

$$\begin{aligned}&\mathbb{E}_{X_N-X_{N-2}}\left[U_{N-2,1}\left(e_{N-2}-x,X_N\right)|\vec{\sigma}_{N-2},\omega=1\right]\\ =&\sum_{k=0}^{2}\Pr\left[X_N-X_{N-2}=kx|\left(\sigma_{N-1},\sigma_N\right),\omega=1\right]U_{N-2,1}\left(e_{N-2}-x,X_{N-3}+(k+1)x\right)\\ +&\sum_{k=0}^{2}\Pr\left[X_N-X_{N-2}|\left(\sigma_{N-1},\sigma_N\right),\omega=0\right]U_{N-2,0}\left(e_{N-2}-x,X_{N-3}+(k+1)x\right)\end{aligned}$$

if she contributes, and

$$\begin{aligned}&\mathbb{E}_{X_N-X_{N-2}}\left[U_{N-2,1}\left(e_{N-2},X_N\right)|\vec{\sigma}_{N-2},\omega=1\right]\\ =&\sum_{k=0}^{2}\Pr\left[X_N-X_{N-2}=kx|\left(\sigma_{N-1},\sigma_N\right),\omega=1\right]U_{N-2,1}\left(e_{N-2},X_{N-3}+kx\right)\\ +&\sum_{k=0}^{2}\Pr\left[X_N-X_{N-2}|\left(\sigma_{N-1},\sigma_N\right),\omega=0\right]U_{N-2,0}\left(e_{N-2},X_{N-3}+kx\right)\end{aligned}$$

if she doesn't. As a consequence, (6) now reads

$$\begin{aligned}&\frac{1}{\mu_{1,N-2}}-1\\ <&-\frac{\sum_{k=0}^{2}\Pr\left[X_N-X_{N-2}=kx|\left(\sigma_{N-1},\sigma_N\right),\omega=1\right]\Delta_x U_{N-2,1}\left(e_{N-2},X_{N-2}+kx\right)}{\sum_{k=0}^{2}\Pr\left[X_N-X_{N-2}=kx|\left(\sigma_{N-1},\sigma_N\right),\omega=0\right]\Delta_x U_{N-2,0}\left(e_{N-2},X_{N-2}+kx\right)}\\ <&\frac{1}{\mu_{0,N-2}}-1\end{aligned}$$

[37] The shorthand notation we are using here merits some explanation. As the signal realizations occur independently of the history of play, when the true state of nature is ω, under the strategy σ_N and the history X_{N-1}, we have $\Pr\left[x_N|\sigma_N,\omega\right] = \Pr\left[s_N=1|\omega\right]\Pr\left[x_N|\sigma_{1,N}\left(X_{N-1}\right)\right] + \Pr\left[s_N=0|\omega\right]\Pr\left[x_N|\sigma_{0,N}\left(X_{N-1}\right)\right]$ in general. Yet, as the players' strategies are independent here of history, this sum reads $\Pr\left[s_N=1|\omega\right]\Pr\left[x_N|\sigma_{1,N}\right]+\Pr\left[s_N=0|\omega\right]\Pr\left[x_N|\sigma_{0,N}\right]$. Hence, the probability that the last player will contribute is $q\sigma_{1,N}^1+(1-q)\sigma_{0,N}^1$ when $\omega=0$ and $(1-q)\sigma_{1,B}^1+q\sigma_{0,B}^1$ otherwise. $\Pr\left[x_N=0|\sigma_N,\omega\right]$, on the other hand, is given by $\Pr\left[s_N=1|\omega\right]\sigma_{1,N}^0+\Pr\left[s_N=0|\omega\right]\sigma_{0,N}^0$ which reads $q\sigma_{1,N}^0+(1-q)\sigma_{0,N}^0$ when $\omega=1$ and $(1-q)\sigma_{1,N}^0+q\sigma_{0,N}^0$ otherwise.

The conditional probabilities in this expression are derived as follows. Conditional on the underlying state of the world and the strategy profile (σ_{N-1}, σ_N), the probability that exactly one amongst the two successors of the $N-2$th agent will contribute is given by

$$\begin{aligned}
& \Pr\left[X_N - X_{N-2} = x \middle| \left(\sigma_{N-1}, \sigma_N\right), \omega = 1\right] \\
= \; & q^2 \left(\sigma^1_{1,N-1}\sigma^0_{1,N} + \sigma^0_{1,N-1}\sigma^1_{1,N}\right) + (1-q)^2 \left(\sigma^1_{0,N-1}\sigma^0_{0,N} + \sigma^0_{0,N-1}\sigma^1_{0,N}\right) \\
+ \; & q\,(1-q) \left(\sigma^1_{1,N-1}\sigma^0_{0,N} + \sigma^0_{1,N-1}\sigma^1_{0,N}\right) + (1-q)\,q \left(\sigma^1_{0,N-1}\sigma^0_{1,N} + \sigma^0_{0,N-1}\sigma^1_{1,N}\right)
\end{aligned}$$

$$\begin{aligned}
& \Pr\left[X_N - X_{N-2} = x \middle| \left(\sigma_{N-1}, \sigma_N\right), \omega = 0\right] \\
= \; & q^2 \left(\sigma^1_{0,N-1}\sigma^0_{0,N} + \sigma^0_{0,N-1}\sigma^1_{0,N}\right) + (1-q)^2 \left(\sigma^1_{1,N-1}\sigma^0_{1,N} + \sigma^0_{1,N-1}\sigma^1_{1,N}\right) \\
+ \; & q\,(1-q) \left(\sigma^1_{1,N-1}\sigma^0_{0,N} + \sigma^0_{1,N-1}\sigma^1_{0,N}\right) + q\,(1-q) \left(\sigma^1_{0,N-1}\sigma^0_{1,N} + \sigma^0_{0,N-1}\sigma^1_{1,N}\right)
\end{aligned}$$

The conditional probability that both of her successors will contribute is

$$\begin{aligned}
\Pr\left[X_N - X_{N-2} = 2x \middle| \left(\sigma_{N-1}, \sigma_N\right), \omega = 1\right] &= q^2\sigma^1_{1,N-1}\sigma^1_{1,N} + (1-q)^2\,\sigma^1_{0,N-1}\sigma^1_{0,N} \\
&+ q\,(1-q) \left(\sigma^1_{1,N-1}\sigma^1_{0,N} + \sigma^1_{0,N-1}\sigma^1_{1,N}\right) \\
\Pr\left[X_N - X_{N-2} = 2x \middle| \left(\sigma_{N-1}, \sigma_N\right), \omega = 0\right] &= q^2\sigma^1_{0,N-1}\sigma^1_{0,N} + (1-q)^2\,\sigma^1_{1,N-1}\sigma^1_{1,N} \\
&+ q\,(1-q) \left(\sigma^1_{1,N-1}\sigma^1_{0,N} + \sigma^1_{0,N-1}\sigma^1_{1,N}\right)
\end{aligned}$$

Finally, the probability that no contributions from the last two players will be observed is

$$\begin{aligned}
\Pr\left[X_N - X_{N-2} = 0 \middle| \left(\sigma_{N-1}, \sigma_N\right), \omega = 1\right] &= q^2\sigma^0_{1,N-1}\sigma^0_{1,N} + (1-q)^2\,\sigma^0_{0,N-1}\sigma^0_{0,N} \\
&+ q\,(1-q) \left(\sigma^0_{1,N-1}\sigma^0_{0,N} + \sigma^0_{0,N-1}\sigma^0_{1,N}\right) \\
\Pr\left[X_N - X_{N-2} = 0 \middle| \left(\sigma_{N-1}, \sigma_N\right), \omega = 0\right] &= q^2\sigma^0_{0,N-1}\sigma^0_{0,N} + (1-q)^2\,\sigma^0_{1,N-1}\sigma^0_{1,N} \\
&+ q\,(1-q) \left(\sigma^0_{1,N-1}\sigma^0_{0,N} + \sigma^0_{0,N-1}\sigma^0_{1,N}\right)
\end{aligned}$$

It is actually straightforward to verify that

$$\begin{aligned}
& \Pr\left[X_N - X_{N-2} = kx \middle| \vec{\sigma}_{N-2}, \omega\right] \\
= \; & \sum_{(s_{N-1}, s_N) \in \{0,1\}^2} \Pr\left[s_{N-1} \middle| \omega\right] \Pr\left[s_N \middle| \omega\right] \sum_{\alpha + \alpha' = k,\ (\alpha, \alpha') \in \{0,1\}^2} \sigma^{\alpha}_{s_{N-1}, N-1}\sigma^{\alpha'}_{s_N, N}
\end{aligned}$$

and to proceed inductively to obtain (2) in the main text. The conditional expected payoff of the nth player is then

$$\begin{aligned}
& \mu_{s_n} \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx \middle| \vec{\sigma}_n, \omega = 1\right] U_{n,1}\left(e_n - x, X_{n-1} + (k+1)\,x\right) \\
& + (1 - \mu_{s_n}) \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx \middle| \vec{\sigma}_n, \omega = 0\right] U_{n,0}\left(e_n - x, X_{n-1} + (k+1)\,x\right)
\end{aligned}$$

if she contributes, and

$$\mu_{s_n} \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] U_{n,1}\left(e_n, X_{n-1} + kx\right)$$
$$+ \left(1 - \mu_{s_n}\right) \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] U_{n,0}\left(e_n, X_{n-1} + kx\right)$$

if she doesn't. Clearly, the two system of inequalities in (3) is necessary and sufficient for the player to contribute iff $s_n = 1$.

Observe now that conditions (A.2) and (A.3) guarantee that $\Delta_x U_\omega(c, \cdot)$ is strictly decreasing.

Lemma 2 *$\forall c, G, G' \in \mathbb{R}_+$ and $\forall \omega \in \{0, 1\}$: $G' > G$ only if $\Delta_x U_\omega(c, G') < \Delta_x U_\omega(c, G)$*

Proof. By definition, $\Delta_x U_\omega(c, G) = \int_0^x \left[\frac{\partial U_\omega(c-x, G+z)}{\partial G} - \frac{\partial U_\omega(c-x, G+z)}{\partial c}\right] \mathrm{d}z$. But, if $G < G'$, then $\frac{\partial U_\omega(c-x, G'+z)}{\partial G} < \frac{\partial U_\omega(c-x, G+z)}{\partial G}$ by (A.2) and $\frac{\partial U_\omega(c-z, G')}{\partial c} \geq \frac{\partial U_\omega(c-z, G)}{\partial c}$ by (A.3). □

Given that we restrict our attention to strategies that depend only upon the players' signals, this result enables us to determine some sufficient inequalities for (3) to obtain. To this end, consider first the nominator of the ratio in the middle of (3). Since the players' strategies are functions of their signals and all signals are independent and informative, we have

$$\begin{aligned}
\frac{\Pr\left[X_N - X_n = (N-n)\, x | \vec{\sigma}_n, \omega = 1\right]}{\Pr\left[X_N - X_n = 0 | \vec{\sigma}_n, \omega = 1\right]} &= \frac{\Pr\left[(s_{n+1}, \ldots, s_N) = \mathbf{1} | \omega = 1\right]}{\Pr\left[(s_{n+1}, \ldots, s_N) = \mathbf{0} | \omega = 1\right]} \\
&= \prod_{k=1}^{N-n} \left(\frac{\Pr\left[s_{n+k} = 1 | \omega = 1\right]}{\Pr\left[s_{n+k} = 0 | \omega = 1\right]}\right) > 1
\end{aligned}$$

And as also $\Delta_x U_{n,1}(e_{n-1}, \cdot) > 0$ (Lemma 1),

$$\begin{aligned}
& \Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\, x\right) \\
< \; & \frac{\Pr\left[X_N - X_n = (N-n)\, x | \vec{\sigma}_n, \omega = 1\right]}{\Pr\left[X_N - X_n = 0 | \vec{\sigma}_n, \omega = 1\right]} \Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\, x\right) \\
< \; & \sum_{k=0}^{N-n} \frac{\Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right]}{\Pr\left[X_N - X_n = 0 | \vec{\sigma}_n, \omega = 1\right]} \Delta_x U_{n,1}\left(e_n, X_{n-1} + kx\right)
\end{aligned}$$

which, multiplying the two end-sides by $\Pr\left[X_N - X_n = 0 | \vec{\sigma}_n, \omega = 1\right]$, gives

$$\begin{aligned}
& \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1} + kx\right) \\
> \; & \Pr\left[X_N - X_n = 0 | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\, x\right) \\
= \; & (1-q)^{N-n} \Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\, x\right)
\end{aligned}$$

For the denominator of the ratio in the middle of (3), on the other hand, we have

$$\begin{aligned}
& \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + kx\right) \\
> & \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + (N-n)\, x\right) \\
> & (N-n+1)\, \Delta_x U_{n,0}\left(e_n, X_{n-1} + (N-n)\, x\right)
\end{aligned}$$

where the first inequality is due to Lemma 2 while the second follows from the fact that $\Delta_x U_{n,0}\left(e_n, \cdot\right) < 0$ (Lemma 1). In other words,

$$\begin{aligned}
& -\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + kx\right) \\
< & -(N-n+1)\, \Delta_x U_{n,0}\left(e_n, X_{n-1} + (N-n)\, x\right)
\end{aligned}$$

And putting the last two inequalities together, gives

$$\begin{aligned}
& \frac{\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1} + kx\right)}{-\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + kx\right)} \\
> & \left(\frac{(1-q)^{N-n}}{N-n+1}\right) \left(\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1} + (N-n)\, x\right)}{-\Delta_x U_{n,0}\left(e_n, X_{n-1} + (N-n)\, x\right)}\right)
\end{aligned}$$

establishing the first part of the claim. For the second part, we have

$$\begin{aligned}
& \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega\right] \Delta_x U_{n,\omega}\left(e_n, X_{n-1} + kx\right) \\
< & \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega\right] \Delta_x U_{n,\omega}\left(e_n, X_{n-1}\right)
\end{aligned}$$

for $\omega \in \{0, 1\}$ (Lemma 2). And, by Lemma 1,

$$\begin{aligned}
& \sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1}\right) & < & (N-n+1)\, \Delta_x U_{n,1}\left(e_n, X_{n-1}\right) \\
& -\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1}\right) & > & \\
& -\Pr\left[X_N - X_n = (N-n)\, x | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1}\right) & = & -(1-q)^{N-n}\, \Delta_x U_{n,0}\left(e_n, X_{n-1}\right)
\end{aligned}$$

That is,

$$\begin{aligned}
& \frac{\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1} + kx\right)}{-\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + kx\right)} \\
< & \left(\frac{N-n+1}{(1-q)^{N-n}}\right) \left(\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1}\right)}{-\Delta_x U_{n,0}\left(e_n, X_{n-1}\right)}\right)
\end{aligned}$$

as required.

Claim 2 *The Limits of Altruism.*
If $MRS_{\max}(X_{n-1}) \leq \frac{1}{\mu_{1,n}} - 1$, a no-contributions cascade starts in the nth period.

Proof. For the nth player, we have

$$\begin{aligned}
& -\frac{\mathbb{E}_{\mathbf{x}_n}\left[\Delta_x U_{n,1}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)\vec{\sigma}_n, \omega = 1\right]}{\mathbb{E}_{\mathbf{x}_n}\left[\Delta_x U_{n,1}\left(e_n, X_{n-1} + \sum_{i=n+1}^{N} x_i\right)\vec{\sigma}_n, \omega = 0\right]} \\
= & -\frac{\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 1\right] \Delta_x U_{n,1}\left(e_n, X_{n-1} + kx\right)}{\sum_{k=0}^{N-n} \Pr\left[X_N - X_n = kx | \vec{\sigma}_n, \omega = 0\right] \Delta_x U_{n,0}\left(e_n, X_{n-1} + kx\right)} \\
< & -\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1}\right)}{\Delta_x U_{n,0}\left(e_n, X_{n-1}\right)} \leq \mathrm{MRS}_{\max}\left(X_{n-1}\right) \leq \frac{1}{\mu_{1,n}} - 1
\end{aligned}$$

As (5) is violated (and $\frac{1}{\mu_{1,n}} < \frac{1}{\mu_{0,n}}$), she will not contribute, regardless of her signal and whatever her belief about the strategies of her successors. But this means also that her action conveys no information upon which her successor can condition his own prior belief. That is, $\pi_{n+1} = \pi_n$ and, consequently, $\mu_{s,n+1} = \mu_{s,n}$ for all $s \in \{0, 1\}$. For the $n+1$th agent then

$$\begin{aligned}
& -\frac{\mathbb{E}_{\mathbf{x}_{n+1}}\left[\Delta_x U_{n+1,1}\left(e_{n+1}, X_n + \sum_{i=n+2}^{N} x_i\right)\vec{\sigma}_{n+1}, \omega = 1\right]}{\mathbb{E}_{\mathbf{x}_{n+1}}\left[\Delta_x U_{n+1,1}\left(e_{n+1}, X_n + \sum_{i=n+2}^{N} x_i\right)\vec{\sigma}_{n+1}, \omega = 0\right]} \\
< & -\frac{\Delta_x U_{n+1,1}\left(e_{n+1}, X_n\right)}{\Delta_x U_{n+1,0}\left(e_{n+1}, X_n\right)} \\
\leq & -\frac{\Delta_x U_{n+1,1}\left(e_{n+1}, X_{n-1}\right)}{\Delta_x U_{n+1,0}\left(e_{n+1}, X_{n-1}\right)} \leq \mathrm{MRS}_{\max}\left(X_{n-1}\right) \leq \frac{1}{\mu_{1,n}} - 1 = \frac{1}{\mu_{1,n+1}} - 1
\end{aligned}$$

where the second inequality follows from the fact that $-\frac{\Delta_x U_{n+1,1}(e_{n+1},\cdot)}{\Delta_x U_{n+1,0}(e_{n+1},\cdot)}$ is strictly decreasing. That is, it is optimal also for the agent who acts in period $n+1$ to not contribute whatever his signal, and irrespectively of the strategies of his successors. Proceeding inductively, for any $n' \in \{n, \ldots, N\}$, we have $\pi_{n'} = \pi_n$ and $\mu_{s,n'} = \mu_{s,n}$ for all $s = 0, 1$. And as

$$\begin{aligned}
& -\frac{\mathbb{E}_{\mathbf{x}_{n'}}\left[\Delta_x U_{n',1}\left(e_{n'}, X_{n'-1} + \sum_{i=n'+1}^{N} x_i\right)\vec{\sigma}_{n'}, \omega = 1\right]}{\mathbb{E}_{\mathbf{x}_{n'}}\left[\Delta_x U_{n',1}\left(e_{n'}, X_{n'-1} + \sum_{i=n'+1}^{N} x_i\right)\vec{\sigma}_{n'}, \omega = 0\right]} \\
< & -\frac{\Delta_{x_{n'}} U_{n',1}\left(e_{n'}, X_{n'-1}\right)}{\Delta_{x_{n'}} U_{n',0}\left(e_{n'}, X_{n'-1}\right)} \\
\leq & -\frac{\Delta_{x_{n'}} U_{n',1}\left(e_{n'}, X_{n-1}\right)}{\Delta_{x_{n'}} U_{n',0}\left(e_{n'}, X_{n-1}\right)} \leq \mathrm{MRS}_{\max}\left(X_{n-1}\right) \leq \frac{1}{\mu_{1,n}} - 1 = \frac{1}{\mu_{1,n'}} - 1
\end{aligned}$$

it is a dominant strategy for each player to not contribute, irrespectively of the signal she receives.

Corollary 3 *As $N \to +\infty$, a contributions cascade cannot be an equilibrium.*

Proof. Suppose otherwise and let a contribution cascade equilibrium start in the nth period. By this, we mean that all players from the nth onwards contribute irrespective of their signals. For any $n' \geq n$, therefore, the amount of the public good at the beginning of the n'th period, $X_{n'-1}$, is increasing in n' while the priors, the posteriors, and the condition for the preceding lemma to apply remain π_n, $\mu_{s,n}$, and $\mathrm{MRS}_{\max}(X_{n'-1}) \leq \frac{1}{\mu_{1,n}} - 1$, respectively. Recall, however, that $-\frac{\Delta_x U_{n,1}(e_n,\cdot)}{\Delta_x U_{n,0}(e_n,\cdot)}$ is strictly decreasing for all n. So must be $\mathrm{MRS}_{\max}(\cdot)$. And as $X_{n'-1} = X_{n-1} + (n'-n)\,x$, for large enough n', the condition for the preceding lemma to apply will be met. That is, from this n' onwards, the unique subgame outcome will be a no contribution cascade. Which is absurd, though, given our initial premise that a contributions cascade takes place for all $n' \geq n$.

Claim 4 *The Limits of Egoism*
Define the public good amount G_n by $-\frac{\Delta_x U_{n,1}(e_n,G_n)}{\Delta_x U_{n,0}(e_n,G_n)} = \frac{1}{\mu_{0,n}} - 1$. If $X_{n-1} \leq G_n$, a no contributions cascade starting with the nth player cannot be an equilibrium.

Proof. Suppose, to the contrary, that a no contributions starting in the nth period is indeed an equilibrium. On this equilibrium path, the nth player expects a payoff

$$\mu_{s,n} U_{n,1}(e_n - x, x) + (1 - \mu_{s,n})\, U_{0,n}(e_n - x, x)$$

if she contributes, and

$$\mu_{s,n} U_{n,1}(e_n, 0) + (1 - \mu_{s,n})\, U_{n,0}(e_n, 0)$$

if she doesn't, if she receives the signal s, and given that the strategy of all subsequent players is to not contribute, irrespectively of their own signals. But since $-\frac{\Delta_x U_{n,1}(e_1,\cdot)}{\Delta_x U_{n,0}(e_1,\cdot)}$ is decreasing and $X_n \geq G_n$, we ought to have

$$-\frac{\Delta_x U_{n,1}(e_n, X_n)}{\Delta_x U_{n,0}(e_n, X_n)} \geq -\frac{\Delta_x U_{n,1}(e_n, G_n)}{\Delta_x U_{1,0}(e_n, G_n)} \geq \frac{1}{\mu_{0,n}} - 1 > \frac{1}{\mu_{1,n}} - 1$$

The nth player will find it, therefore, optimal to contribute, whatever her signal. Which contradicts her part of the assumed equilibrium profile.

Claim 5 *A Basis for Altruism.*[38]
If $MRS_{\min}\left(X_{n-1}+(N-n)\,x\right) \geq \frac{1}{\mu_{0,n}}-1$*, a contributions cascade starting with the* n*th player is an equilibrium.*

Proof. We will show that it is an equilibrium, starting with the nth player, for every player in the subsequent sequence to contribute, irrespective of her signal. Consider first the nth agent. Given that the strategy of all subsequent players is to contribute, irrespectively of their own signals, her expected payoff under the signal $s \in \{0,1\}$ is given by

$$\mu_{s,n}U_{n,1}\left(e_n-x, X_{n-1}+(N-n+1)\,x\right)+\left(1-\mu_{s,n}\right)U_{n,0}\left(e_n-x, X_{n-1}+(N-n+1)\,x\right)$$

if she contributes, and

$$\mu_{s,n}U_{n,1}\left(e_n, X_{n-1}+(N-n)\,x\right)+\left(1-\mu_{s,n}\right)U_{n,0}\left(e_n, X_{n-1}+(N-n)\,x\right)$$

if she doesn't. But

$$\begin{aligned} -\frac{\Delta_x U_{n,1}\left(e_n, X_{n-1}+(N-n)\,x\right)}{\Delta_x U_{n,0}\left(e_n, X_{n-1}+(N-n)\,x\right)} &\geq \\ \mathrm{MRS}_{\min}\left(X_{n-1}+(N-n)\,x\right) &\geq \frac{1}{\mu_{0,n}}-1>\frac{1}{\mu_{1,n}}-1 \end{aligned}$$

The player will find it optimal, therefore, to contribute, whatever her signal.

But if the action of the nth player is independent of her signal, the prior of her immediate successor remains the same, $\pi_{n+1}=\pi_n$, and so do his posterior beliefs, $\mu_{s,n+1}=\mu_{s,n}$ for $s=0,1$. Moreover, given that his predecessor has contributed, the public good endowment of the $n+1$th agent will be $X_n=X_{n-1}+x$. And under the assume strategy profile of all subsequent players, his expected payoff, under either signal, is identical to that of the nth agent. In other words, the decision problem of the player who is called upon to act in the $n+1$ period is identical to that of the player who acted in the n period. Clearly, he will also contribute whatever the signal he receives. Proceeding inductively leads to the conclusion that all players will contribute, irrespectively of their signals.

Corollary 6 *Suppose that initially there is no social endowment of the public good* ($X_0=0$)*. As* $x\to 0$*, a contributions cascade starting with the first agent in the sequence is an equilibrium.*

[38] As a remark, notice that the respective conditions for the Claims 2 and 5 to apply cannot hold simultaneously. For the ratio $-\frac{\Delta_x U_{n,1}(c,\cdot)}{\Delta_x U_{n,0}(c,\cdot)}$ is strictly decreasing while $\mu_{1,n}>\mu_{0,n}$ as the signal is informative.

Proof. Observe first that the condition for the preceding claim to apply in the first period is $\mathrm{MRS}_{\min}\left(X_0 + (N-1)\,x\right) \geq \frac{1}{\mu_{0,1}} - 1 = \left(\frac{q}{1-q}\right)\left(\frac{1}{\pi} - 1\right)$. Recall, moreover, that $-\frac{\Delta_x U_{n,1}(c,\cdot)}{\Delta_x U_{n,0}(c,\cdot)}$ is strictly decreasing. In particular, for all n, $-\frac{\Delta_x U_{n,1}(e_n,G)}{\Delta_x U_{n,0}(e_n,G)}$ tends to $+\infty$ as $G \to 0$. It must also be, therefore, $\lim_{G\to 0} \mathrm{MRS}_{\min}(G) = +\infty$. And, since $\lim_{x\to 0}(N-1)\,x = 0$, for small enough x (and fixed N), the condition for the preceding claim to apply in the first period will be met.