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Seeds to succeed? Sequential giving to public projects

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ABSTRACT

The public phase of a capital campaign is typically launched with the announcement of a large seed donation. Andreoni (1998) argues that such a fundraising strategy may be particularly effective when funds are being raised for projects that have fixed production costs. The reason is that when there are fixed costs of production simultaneous giving may result in both positive and zero provision equilibria. Thus absent announcements donors may get stuck in an equilibrium that fails to provide a desirable public project. Andreoni (1998) demonstrates that such inferior outcomes can be eliminated when the fundraiser initially secures a sufficiently large seed donation. We investigate this model experimentally to determine whether announcements of seed money eliminate the inefficiencies that may result under fixed costs and simultaneous provision. To assess the strength of the theory we examine the effect of announcements in both the presence and absence of fixed costs. Our findings are supportive of the theory for sufficiently high fixed costs.

1. Introduction

A rule of thumb commonly followed by fundraisers is that past contributions are announced to future donors. This practice is perhaps most noteworthy in capital campaigns where the announcement of a substantial seed donation is used to launch the public phase of the campaign. The practice of sequential fundraising is intriguing in light of the analysis of voluntary provision of public goods provided by Varian (1994). Examining a model with continuous production of the public good, he compares the contributions that result when donations are made simultaneously versus sequentially. Recognizing that one donor's contribution is a perfect substitute for that of another, he demonstrates that sequential provision enables the initial donor to free ride off of subsequent donors, and as a result the overall provision in the sequential contribution game will be no greater than in the simultaneous one.[1]

This inconsistency between common fundraising practice and theoretical prediction has prompted researchers to identify conditions under which it may be optimal to raise funds sequentially. Andreoni (1998), the first to propose an explanation, showed that a sequential fundraising strategy is preferable when there are fixed production costs. The reason is that, when no individual single-handedly is willing to cover the fixed costs, simultaneous giving may result in both positive and zero provision equilibria. Thus fundraising campaigns that rely on simultaneous giving may get stuck in an equilibrium where donors fail to coordinate on a preferred positive provision outcome. Interestingly, a sequential fundraising strategy helps eliminate such inferior equilibria, as a large initial contribution secures that the fixed costs will be covered and that the good will be provided.

List and Lucking-Reiley (2002) use a field experiment to examine the prediction that followers respond positively to a large initial contribution. Raising funds for a number of $3000 computers, they sent out solicitations in which the initial contribution to the nonprofit institution varied between 10%, 33%, and 67% of the computer's cost. They find that the likelihood of contributing and the average amount contributed is greatest when 67% of the project funding had already been provided.[2] In fact a six-fold increase in contributions is seen when moving from the lowest to the highest seed amount. Qualitatively the results are very much in line with the prediction of

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[1] Experimental investigations of the quasi-linear environment of Varian (1994) confirm the prediction of lower contributions in the sequential game (Andreoni et al., 2002; Gächter et al., 2010). As emphasized by Vesterlund (2003), this prediction relies on the somewhat unrealistic assumption that initial donors can commit to giving only once. Absent this assumption the contribution level is predicted to be the same with simultaneous and sequential moves. Thus the strict preference for sequential giving remains a puzzle in this case.

[2] A series of field experiments also find that giving is influenced by the size of the initial contribution. For example, Frey and Meier (2004) show that contributions to charitable funds at the University of Zurich are affected by information on how many others donated in the past. In a campaign for a public radio station, Croson and Shang (2008) show that donations increase when a donor is informed that others have contributed more than he did in the past. Martin and Randal (2008) change the amount placed in an art gallery's donation box and show that average donations increase when it appears that others have given larger amounts.

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Andreoni's model. However the results are also in line with the predictions made by a number of other models on sequential giving. For example, the increase in giving may also be explained by donors interpreting the initial contribution as a signal of the nonprofit's quality (Vesterlund, 2003).[3]

What distinguishes Andreoni's predictions from alternative models of sequential fundraising is the crucial role played by the presence of fixed production costs. Sequential giving is effective because it eliminates the inefficiencies that may arise as a result of fixed costs. Unfortunately in a field setting it is not straightforward to find a cause for which it is possible to vary the fixed costs while keeping all other characteristics constant. The objective of the present paper is to use laboratory experiments to examine the role of sequential giving in the presence and absence of fixed costs. By using the laboratory we can test a simplified environment and determine if fixed costs play a critical role in the success of sequential giving.

It is important to recognize that the question is not merely one of confirming previous evidence that sequential play improves efficiency in coordination games (see for example Weber et al., 2004). With simultaneous play of the public good game there may be an incentive to contribute in excess of the preferred Nash equilibrium as it improves overall efficiency and alleviates strategic uncertainty, thus in the presence of fixed costs simultaneous play need not give rise to inefficient outcomes which sequential play can improve upon; furthermore absent fixed costs sequential play may in and of itself increase contributions thereby decreasing the likelihood that fixed cost play a critical role in explaining the frequent use of sequential fundraising.

Our study is designed to answer the following research questions. First, do sequential moves increase giving when there are no fixed costs? Second, do fixed costs give rise to inefficient outcomes under simultaneous provision? That is, do contributions decrease when we introduce fixed costs such that no individual has an incentive to single-handedly provide the good? Third, if such inefficient outcomes exist, does sequential play help eliminate these inefficiencies and increase the likelihood of providing the public good? Specifically do initial contributors respond to the coordinating role they hold in the sequential game, and do subsequent donors follow? Finally, to evaluate the extent to which the success of seed money depends on the presence of fixed costs, we ask whether the potential increase in contributions under sequential provision is sensitive to the size or even the presence of fixed costs.

Our results are supportive of the theory for high, but not for low fixed costs. Surprisingly, under simultaneous provision we find that the introduction of small fixed costs increases rather than decreases overall provision. Individuals seem uncertain of which equilibrium will be played and, at the risk of decreasing their payoff, they increase their contributions to ensure that the public good is provided. By facilitating coordination on the positive provision outcome, seed money effectively removes the strategic uncertainty and the risk of under-provision. Sequential contributions decrease to the predicted equilibrium level and fall below the greater-than-expected contributions in the simultaneous game. Consequently, our results show that sequential provision has no role when fixed costs are small. However, when fixed costs are high, contribution behavior is in line with the theoretical prediction: individuals often fail to provide the public good in the simultaneous game, and sequential provision successfully facilitates coordination and eliminates these undesirable outcomes. As a result, when fixed costs are high the likelihood of securing provision of the public good is much greater when contributions are made sequentially. The effect of sequential play on earnings is even greater than that seen absent fixed costs. Thus consistent with Andreoni's model we find that sequential moves play a unique coordinating role when there are (large) fixed costs.

The remainder of the paper is organized as follows. We first describe the theoretical insights in a simple example of Andreoni's model, and explain how the derived hypotheses helped shape our experimental design. The effect of sequential play under three different fixed cost treatments is presented in Section 3. In Section 4 we examine the interaction between sequential play and fixed costs of production. We conclude the paper in Section 5.

2. Experimental design

Andreoni (1998) fully characterizes the equilibria of the contribution game with fixed costs. To demonstrate the insights of interest for this study, we start by presenting a simple two-person example of his model. This example has precisely the characteristics we want for our experiment and will serve as the basis for our design. We complete the section by describing the parameters and procedures used for the study.

2.1. Theory

Consider the following two-person voluntary contribution environment. A donor, $i=1,2$, has an endowment, w_i, which he must allocate between private consumption, x_i, and contributions to a public good, g_i. Let $c(g_i)$ denote i's cost of giving g_i and $r(G)$ i's benefit from a total contribution of $G=g_1+g_2$.[4] Assuming that the price of the private good is 1, let i's quasi-linear utility be given by

$$U_i(x_i, G) = w_i - c(g_i) + r(G).$$

Let the return from the public good equal m per unit contributed to the public good, provided that the total contribution exceeds a fixed cost of FC.

$$r(G) = \begin{cases} 0 & \text{if } G<FC \\ mG & \text{if } G\geq FC \end{cases}.$$

Further assume that costs are convex and piecewise linear of the form

$$c(g_i) = \begin{cases} \alpha g_i & \text{if } g_i\in[0, l_{NE}] \\ \alpha l_{NE} + \beta(g_i - l_{NE}) & \text{if } g_i\in(l_{NE}, l_{PE}] \\ \alpha l_{NE} + \beta(l_{PE} - l_{NE}) + \gamma(g_i - l_{PE}) & \text{if } g_i\in(l_{PE}, \bar{l}] \end{cases}.$$

Thus the marginal cost of contributing is initially α, then β, and finally γ. To secure an interior Nash equilibrium and an interior Pareto optimal outcome with $FC=0$ assume that $0<\alpha<m$, $m<\beta<2m$, $\gamma>2m$, and that $0<l_{NE}<l_{PE}<w_i$.

In analyzing the game, let us start by characterizing the equilibria of the simultaneous game and describe how these change with the size of the fixed cost. For this purpose it will be beneficial to define the following two fixed cost levels: let FC_1 denote the fixed cost where the return to covering the fixed cost single-handedly equals the cost, i.e., $r(FC_1)=c(FC_1)$, and let FC_2 denote the fixed cost where the return from covering the fixed cost equals the cost of contributing an amount equal to half of the fixed cost, i.e., $r(FC_2)=c(FC_2/2)$.

Absent fixed costs ($FC=0$) the dominant strategy for each individual is to contribute l_{NE}, thus the equilibrium is $(g_1^*, g_2^*)=(l_{NE}, l_{NE})$. This remains the unique equilibrium outcome as long as individuals are willing to single-handedly cover the fixed cost, i.e., $FC<FC_1$. For higher fixed costs, i.e., $FC>FC_1$, a zero provision

[3] See also Potters et al. (2005, 2007), Andreoni (2006), Komai et al. (2007).

[4] The interest in examining public good provision is driven by the classic view that altruistically motivated giving can be viewed as voluntary contributions to a public good (see Becker, 1974). Rather than relying on altruistic preferences we instead follow Andreoni (1993) and induce preferences for a public good through the payoff function described earlier.

equilibrium arises. The reason is that when $FC > FC_1$ the best response to $g_{-i} = 0$ is a contribution of $g_i = 0$; thus for a sufficiently high fixed cost, $(g_1^*, g_2^*) = (0,0)$ is a Nash equilibrium of the simultaneous game. In fact zero provision is the unique equilibrium outcome when $FC > FC_2$. For intermediate value fixed costs, that is, when $FC_1 < FC < FC_2$, there are both zero and positive provision equilibria. Although all players would prefer positive provision, a failure to coordinate may trap contributors at zero provision.

The role of seed money demonstrated by Andreoni (1998) arises when the fixed cost is in the intermediate range where the simultaneous game gives rise to multiple equilibria. He showed that while the simultaneous game may result in zero provision, such inefficiencies are eliminated with sequential play. The reason is that by providing a sufficiently large first donation the first mover can ensure that the second mover is willing to cover the remainder of the fixed cost. Thus for fixed costs in this intermediate range the fundraiser can secure positive provision by announcing the first donor's contribution.

2.2. Experimental parameters

We are interested in examining the effect of sequential giving for fixed costs in the intermediate range described above. In determining the interaction between fixed costs and sequential play we initially considered a simple 2×2 design, comparing simultaneous and sequential giving with and without fixed costs. In choosing the fixed costs we wanted to secure that the fixed cost, while high enough to give rise to positive and zero provision equilibria, was small enough that the positive provision equilibrium of the simultaneous game with fixed cost was the same as that absent fixed cost. However this resulted in a relatively low fixed cost and our investigation of this setting soon revealed that it also was of interest to examine the effect of sequential giving with a higher fixed cost. Thus we added two high-cost treatments resulting in a 3×2 design: (fixed cost: zero, low, high)×(play: simultaneous, sequential).

Our design is based on the example presented above as it captures the critical features of Andreoni's model. Furthermore it is relatively simple and has characteristics that are desirable for our experimental design: an interior Nash equilibrium in dominant strategies and an interior Pareto optimal outcome.[5] Thus in contrast to the classic voluntary contribution mechanism (VCM) where the dominant strategy is to give nothing and the Pareto optimal outcome is to give everything, this design allows for participants not only to over-contribute but also to under-contribute. Furthermore, contributions are not limited to being inefficiently low but may also be inefficiently high. While previous studies have examined environments in which both the Nash and Pareto optimal outcomes are interior, the attraction of our example is that we secure the Nash equilibrium in dominant strategies using piecewise linear payoffs, which are easily explained.[6]

The specific parameters chosen for the study were as follows: Participants interacted in a one-shot manner in groups of two. Provided that the fixed cost is covered, the marginal return per unit invested in the public account was 50 cents. The per unit cost of investing was 40 cents for units 1 to 3, 70 cents for units 4 through 7, and finally $1.10 for units 8 through 10. Thus the experimental parameters were: $m = 0.5$, $\alpha = 0.4$, $\beta = 0.7$, $\gamma = 1.1$, $l_{NE} = 3$, and $l_{PE} = 7$. Absent fixed costs it is a dominant strategy to contribute 3 units, and Pareto efficiency is achieved with each contributing 7 units.

[5] Menietti et al. (2009) examine a similar payoff structure.

[6] See Laury and Holt (2008) for a review of the literature on VCMs with interior Nash equilibria. Our design also differs from the threshold models, be it for contributions or a minimum contributing set, where there is no return from exceeding the threshold, see, for example, Erev and Rapoport (1990), Dorsey (1992), Cooper and Stockman (2007), Coats et al. (2009); as well as the review by Croson and Marks (2000).

Table 1
Equilibrium predictions (g_1^*, g_2^*).

	FC = 0	FC = 6	FC = 8
Simultaneous	(3,3)	(0,0) &(3,3)	(0,0) & (3,5), (4,4), (5,3)
Sequential	(3,3)	(1,5)	(2,6)

As previously noted we selected the fixed cost to be so large that no individual had an incentive to cover the fixed cost single-handedly, yet small enough to secure both positive and zero provision equilibria of the simultaneous game. Furthermore in selecting the cost for the low-fixed-cost treatments we wanted to facilitate an easy comparison across treatments and selected a fixed cost for which the positive provision equilibrium was identical in the simultaneous games with and without fixed cost. A fixed cost of six satisfied these criteria. With $FC = 6$ it remains an equilibrium of the simultaneous game for each individual to contribute 3 units, yet if the other person contributes zero the best response is to contribute zero as well. This is because the cost of covering the fixed cost alone is \$3.30 $(= 3 \times 0.4 + 3 \times 0.7)$ which outweighs the benefit of \$3 $(= 6 \times 0.5)$. Thus with simultaneous play and $FC = 6$ there are two Nash equilibria—one that provides the public good and another that does not. Under sequential provision, however, the zero provision outcome is eliminated. The reason is that the first mover has an incentive to provide just enough to secure that the second mover will cover the remaining fixed costs.[7] Examining the second mover's incentives, we see that the second mover's best response is:

$$g_2(g_1) = \begin{cases} 0 & \text{if} \quad g_1 = 0 \\ 6-g_1 & \text{if} \quad g_1 \in \{1,2\} \\ 3 & \text{if} \quad g_1 \in [3,10] \end{cases}.$$

where g_1 denotes the first mover's contribution and g_2 the second mover's contribution. Thus, the first mover, by contributing 1 unit, can secure completion of the project and maximize her own payoff.

For the high fixed cost treatments we increased the cost to 8 units. Once again the fixed costs give rise to both zero and positive provision under simultaneous move. However in increasing the fixed cost beyond 6 units we also increase the number of positive provision equilibria of the simultaneous game. In particular there are now three Nash equilibria that secure provision: (3,5), (4,4) and (5,3). Introducing sequential play leads to a unique subgame perfect equilibrium of (2,6), thus sequential play not only eliminates the inefficient (0,0) equilibrium, it also eliminates the coordination problem associated with selecting one of the positive provision equilibria. The implications of the high-cost treatments are discussed in greater detail in Section 3.3.

Our 3×2 design – $(FC = 0, FC = 6, FC = 8) \times$ (simultaneous play, sequential play) – gives rise to the predictions in Table 1.

Of course, various forms of other-regarding preferences may give rise to deviations from the predicted equilibria.[8] Altruism may cause contributions to exceed the predicted contributions. The attraction of the fair and Pareto superior outcome may be so strong that we observe no inefficiencies in the simultaneous game with fixed costs. Reciprocity and inequality aversion may cause deviations in the sequential game where small initial contributions can be punished, while large contributions can be rewarded. In light of the many behavioral factors that may cause deviations from the equilibrium prediction, we refrain from assessing the model's predictive power by examining adherence to the predicted equilibria; instead we focus on the predicted comparative statics. Needless to say the role of

[7] The characteristic of this subgame perfect equilibrium is similar to that of the ultimatum game where the proposer offers the smallest *nonzero* amount possible and the responder accepts. The equilibrium also resembles the quasi-linear settings by Andreoni et al. (2002) and Gächter et al. (2010), where there is a substantial first mover advantage.

[8] See Cooper and Kagel (forthcoming) for a review of other-regarding preferences.

You \ Other Group Member	0	1	2	3	4	5	6	7	8	9	10
0	4.0 / 4.0	4.5 / 4.1	5.0 / 4.2	5.5 / 4.3	6.0 / 4.1	6.5 / 3.9	7.0 / 3.7	7.5 / 3.5	8.0 / 2.9	8.5 / 2.3	9.0 / 1.7
1	4.1 / 4.5	4.6 / 4.6	5.1 / 4.7	5.6 / 4.8	6.1 / 4.6	6.6 / 4.4	7.1 / 4.2	7.6 / 4.0	8.1 / 3.4	8.6 / 2.8	9.1 / 2.2
2	4.2 / 5.0	4.7 / 5.1	5.2 / 5.2	5.7 / 5.3	6.2 / 5.1	6.7 / 4.9	7.2 / 4.7	7.7 / 4.5	8.2 / 3.9	8.7 / 3.3	9.2 / 2.7
3	4.3 / 5.5	4.8 / 5.6	5.3 / 5.7	5.8 / 5.8	6.3 / 5.6	6.8 / 5.4	7.3 / 5.2	7.8 / 5.0	8.3 / 4.4	8.8 / 3.8	9.3 / 3.2
4	4.1 / 6.0	4.6 / 6.1	5.1 / 6.2	5.6 / 6.3	6.1 / 6.1	6.6 / 5.9	7.1 / 5.7	7.6 / 5.5	8.1 / 4.9	8.6 / 4.3	9.1 / 3.7
5	3.9 / 6.5	4.4 / 6.6	4.9 / 6.7	5.4 / 6.8	5.9 / 6.6	6.4 / 6.4	6.9 / 6.2	7.4 / 6.0	7.9 / 5.4	8.4 / 4.8	8.9 / 4.2
6	3.7 / 7.0	4.2 / 7.1	4.7 / 7.2	5.2 / 7.3	5.7 / 7.1	6.2 / 6.9	6.7 / 6.7	7.2 / 6.5	7.7 / 5.9	8.2 / 5.3	8.7 / 4.7
7	3.5 / 7.5	4.0 / 7.6	4.5 / 7.7	5.0 / 7.8	5.5 / 7.6	6.0 / 7.4	6.5 / 7.2	7.0 / 7.0	7.5 / 6.4	8.0 / 5.8	8.5 / 5.2
8	2.9 / 8.0	3.4 / 8.1	3.9 / 8.2	4.4 / 8.3	4.9 / 8.1	5.4 / 7.9	5.9 / 7.7	6.4 / 7.5	6.9 / 6.9	7.4 / 6.3	7.9 / 5.7
9	2.3 / 8.5	2.8 / 8.6	3.3 / 8.7	3.8 / 8.8	4.3 / 8.6	4.8 / 8.4	5.3 / 8.2	5.8 / 8.0	6.3 / 7.4	6.8 / 6.8	7.3 / 6.2
10	1.7 / 9.0	2.2 / 9.1	2.7 / 9.2	3.2 / 9.3	3.7 / 9.1	4.2 / 8.9	4.7 / 8.7	5.2 / 8.5	5.7 / 7.9	6.2 / 7.3	6.7 / 6.7

Fig. 1. Payoff table with FC = 0.

sequential giving relies critically on inefficiencies arising with simultaneous giving, and when examining the comparative statics of sequential giving we therefore assume that there is a positive probability that simultaneous moves result in zero provision.

In examining the comparative statics between and within the no fixed cost and fixed cost treatments we can answer the questions of interest. First, do sequential moves absent fixed cost increase contributions? Second, does the introduction of fixed cost gives rise to inefficiencies and decrease contributions. Third, comparing treatments (simultaneous versus sequential play) with fixed cost, do we find evidence that sequential play increases contributions and the likelihood of provision? Fourth, does sequential play have a unique coordinating role in the presence of fixed costs, and is such a role sensitive to the level of fixed costs?

2.3. Experimental procedures

The sessions were conducted at the Pittsburgh Experimental Economics Laboratory at the University of Pittsburgh. Three sessions were conducted for each of the initial four treatments (FC = 0 and FC = 6), and two sessions were conducted for each of the subsequent high fixed cost treatments (FC = 8). With 14 participants per session a total of 224 undergraduate students participated in the study. Each session proceeded as follows: First instructions and a payoff table were distributed.[9] Care was taken to make the payoff table as clear as possible. The payoffs to the participant and her group member are distinguished by color and location in each cell (see Fig. 1 for an example of the payoff table when FC = 0). The instructions were read out loud and a short quiz was given to gauge the participants' understanding. The quiz asked participants to use the payoff table to determine the payoffs earned by a participant and her group member for several combinations of contribution levels above and below the fixed cost level. To avoid priming the participants, the examples did not include focal outcomes, such as the Nash equilibrium and Pareto optimal outcome. The quiz questions were the same for all treatments, though the answers varied with the size of the fixed costs.

Once all participants had completed the quiz a solution key was distributed. The quiz answers were explained by an experimenter using a projection of the payoff table. Screen shots of the experimental software were shown and explained. The payoff table was displayed on all decision screens. Participants then began the portion of the experiment that counted for payment. They played 14 rounds of the public goods game. In each round each participant was randomly paired with another participant, was given a $4 endowment and the opportunity to invest any number of units between zero and ten in a public account.[10]

Contributions were either made "simultaneously" or "sequentially." Effectively decisions were made sequentially in both treatments with half the participants called "first movers" and the other half "second movers." However only in the sequential treatment was the second mover informed of the first mover's contribution before making her decision. The variation in information for the second mover was the only difference between the sequential and simultaneous treatments, which resulted in minimal variations in instructions and procedures between the two treatments.[11] The experiment

[9] See the online Appendix, http://www.pitt.edu/~vester/BMVappendix.pdf, for the instructions and payoff tables.

[10] A consequence of our design is that a participant's cost can exceed their endowment; in effect they borrow against earnings from the group account. We made this clear in the instructions, and participants did not express any concerns about this aspect of the design. Throughout the experiment participants relied on the payoff table when making decisions. Thus their decisions appeared to be determined solely by final payoffs. Only one participant asked how purchases could exceed his endowment. The participant appeared satisfied with the explanation that the cost was taken out of his earnings from the group account. While we think it is unlikely, we cannot rule out that limited endowments rather than decreasing payoffs, restrained contributions.

[11] This procedure allows us to directly test the informational effect of sequential play and eliminates the possibility that sequencing alone can explain the results (see e.g., Cooper et al., 1993). Potters et al. (2005, 2007) use a similar approach.

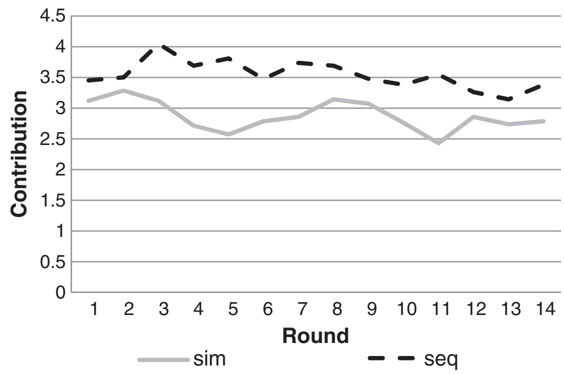

Fig. 2. Fixed costs of zero mean individual contributions.

was programmed and conducted using the software z-Tree (Fischbacher, 2007).

When the 14 rounds were completed, we randomly selected three rounds to count for payment.[12] Participants were then asked to complete a short questionnaire, following which they were paid in private and in cash. Sessions lasted approximately one hour and average earnings were $22, including a $5 show-up fee.

3. The effect of sequential giving with and without fixed costs

Our experiment is designed to examine the role of sequential fundraising in eliminating inefficient outcomes that may arise in the presence of fixed costs and simultaneous play. In reporting the results we first determine the effect sequential play may have absent fixed costs, we then see if the introduction of a fixed cost of six gives rise to inefficient outcomes when contributions are made simultaneously, and whether sequential moves may help overcome such inefficiencies. We conclude the section by determining whether the answers to these questions are robust to an increase in the fixed cost.

3.1. Contributions with zero fixed costs

Absent fixed costs the unique equilibrium prediction of both the sequential and simultaneous game is for each member of the two-person group to contribute three units. Hence the first hypothesis is:

H1. With zero fixed costs, sequential play has *no effect* on contributions.

The average contributions for the simultaneous and sequential games with zero fixed costs are shown by round in Fig. 2. Focusing first on the simultaneous game, we note that average contributions are very close to the three-unit equilibrium prediction. With a mean contribution of 2.87 units we cannot reject that participants contribute the predicted amount ($p=0.382$).[13] Furthermore we do not see a substantial decrease in contributions over the course of the experiment — a sharp contrast to the behavior in the classic VCM game where contributions initially exceed the dominant strategy of zero giving and decrease over time.[14] Our data does however resemble that of previous VCMs in that the frequency of equilibrium play increases over the course of the experiment — from 57% during the first half of the experiment to 66% during the second half of the experiment. The unusually high frequency of equilibrium play is most likely driven by the fact that we use a very simple piecewise linear cost function to secure an interior dominant strategy.[15]

Table 2
GLS random effects regression dependent variable: individual contribution, FC = 0.

	All rounds 1–14	First seven 1–7	Last seven 8–14
Sequential	0.668	0.752	0.585
	(0.001)	(0.002)	(0.002)
Round	−0.030	−0.031	−0.060
	(0.001)	(0.238)	(0.017)
Constant	3.103	3.048	3.486
	(0.000)	(0.000)	(0.000)
N	1176	588	588
Participants	84	84	84

Note: *p*-values are in parentheses.

While contributions in the simultaneous game are consistent with the equilibrium prediction, we see greater-than-predicted giving in the sequential game. In every round of the sequential game average contributions exceed the predicted contribution of 3. Indeed the mean contribution of 3.54 differs significantly from the prediction ($p=0.00$). Note however that 73% of all decisions are at the predicted contribution of 3.

In describing the experimental design we hypothesized that reciprocity might cause behavior in the sequential game to deviate from the equilibrium prediction, and our data are consistent with this explanation. While our results do not show evidence of negative reciprocity there is some evidence of positive reciprocity.[16] When the first mover's contribution ranges between 0 and 3 units, second movers opt for the dominant strategy and contribute an average of 2.99 units. However the average second mover contribution increases to 3.80 units when first movers give more than their dominant strategy. To assess the return from increasing first contributions by 1 unit, we use random effects to regress second mover contributions on that of the first mover. When first mover contributions range from 3 to 7 units we find that a one-unit increase in first mover contributions increases the second mover's contribution by 0.29 units. Although the positive coefficient is consistent with reciprocity the response is not large enough to make it payoff maximizing for first movers to deviate from their dominant strategy.[17] Nonetheless the incentive for first movers to give is greater with sequential play and average first mover contributions are found to be significantly higher in the sequential than simultaneous game (3.85 vs. 2.96, $p=0.005$).

Comparing the sequential and simultaneous treatments with zero fixed costs we find a significant effect of sequential moves.[18] Using

[12] This differs from the common approaches where either all or only one round count for payments. However we see no reason why this approach should be inferior and it allows us to keep the average payments in line with those commonly seen, and secures a transparent payoff table.

[13] To account for fact that each individual makes 14 decisions, the reported test statistics in our paper refer the results from random effects regressions. Exceptions will be noted.

[14] A random effects regression of individual contributions on round shows that contributions decrease significantly over time, but the coefficient is small (−0.028, $p=0.042$) in the simultaneous game and corresponds to no more than a one percent decrease in giving per round. See Ledyard (1995) for a review of commonly observed contribution patterns in the classic VCM.

[15] Previous examinations of interior equilibria in dominant strategies use the more complicated quadratic cost function and fail to see substantial equilibrium play (see Keser, 1996; Sefton and Steinberg, 1996; Van Dijk, et al., 2002; and Laury and Holt, 2008 for a review). Menietti et al. (2009) use a linear payoff structure similar to that examined here and find substantial equilibrium play.

[16] As noted by Charness and Rabin (2005) the experimental evidence of negative reciprocity is substantial whereas that on positive reciprocity is more limited. As demonstrated by Andreoni et al. (2003) the degree of both negative and positive reciprocity is however sensitive to the examined environment and the perceptions individuals have of a particular action. A contribution below the dominant strategy equilibrium is costly to the individual and may not be perceived as unkind.

[17] The net cost of contributing in the 4–7 unit range is 20 cents; thus it is payoff maximizing to increase first mover contributions by 1 unit if it generates an increase in second mover contributions of more than 0.4 units.

[18] This result is likely to be sensitive to the environment examined. In our study the equilibrium is symmetric and is predicted to be the same under sequential and simultaneous moves. In sharp contrast Andreoni et al. (2002) and Gächter et al. (2010) examine quasi-linear environments where contributions are predicted to decrease with sequential moves and where the asymmetric subgame perfect equilibrium predicts a substantial first-mover advantage. Both studies find evidence of lower sequential than simultaneous giving.

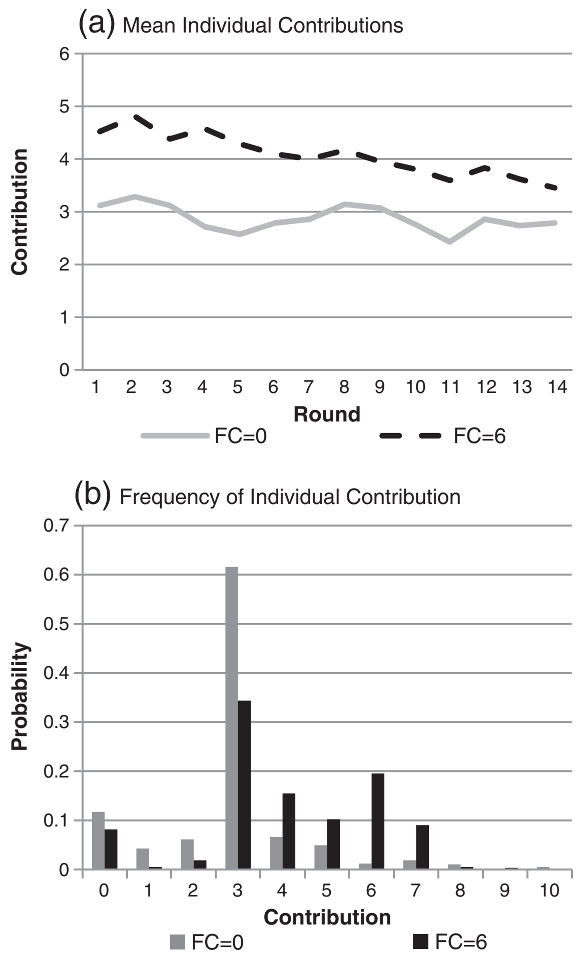

Fig. 3. Simultaneous moves with fixed costs of zero and six.

random effects Table 2 reports the results from regressing individual contributions on a “sequential” dummy that takes a value of 1 if the game is sequential and 0 otherwise, and a round number variable “round” which controls for changes in contributions over time, be it due to learning or changes in preferences.

Table 2 shows that when pooling the sequential and simultaneous data we continue to see a slight decrease in contributions with round. While the decrease is significant overall and in the last seven rounds, it is not significantly different from zero during the first seven rounds. As expected from Fig. 2 sequential play is found to cause a significant and substantial 20% increase in contributions. This implies a 32 cent or 6% increase in earnings.[19] This positive effect is robust to breaking the data into the first-seven and last seven rounds. Hence we reject hypothesis H1.[20] When fixed costs are zero, sequential play *increases* contributions.[21]

3.2. Contributions with low fixed costs

Having found that sequential play increases contributions in our zero-fixed-cost treatments, we continue our analysis to determine how behavior responds to the introduction of fixed costs. The primary question of interest is whether in the presence of fixed costs, sequential play causes an even greater increase in giving as it eliminates inefficient outcomes. Outcomes that may arise as a result of fixed costs in the simultaneous game. We begin by examining the response in our low-cost treatments where the fixed cost is six.

To evaluate the potential role of sequential play we start by examining whether the introduction of low fixed costs causes coordination failure and zero provision outcomes in the simultaneous game. We compare contributions under simultaneous play when fixed costs are zero and six. As shown earlier, with fixed costs of six the simultaneous game admits two Nash equilibria: $(g_1^*, g_2^*) \in \{(0,0), (3,3)\}$. That is, an inefficient equilibrium with zero contribution emerges along with the previous equilibrium of three-unit contributions by each of the group members. Although the existence of an additional and inefficient equilibrium does not guarantee it will be played, this is an implicit assumption in Andreoni's argument for the role of sequential fundraising. If the inefficient equilibrium is played with some positive probability, average contributions are predicted to be lower with fixed costs of six. This comparative static prediction is summarized in the second hypothesis:

H2. Average contributions in the simultaneous game with fixed costs of six are *smaller* than with fixed costs of zero.

Fig. 3 panel (a) demonstrates the mean contributions by round in the two simultaneous treatments (FC = 0 and FC = 6). With fixed cost the contribution pattern is in sharp contrast to the prediction. Rather than decreasing contributions, the introduction of low fixed costs is found to significantly increase contributions.[22] A random effects regression of individual contribution on round and a dummy variable (FC = 6) that takes a value of 1 for observations with fixed costs of six and 0 for observations with zero fixed cost reveals a positive and significant coefficient for the fixed cost dummy. All else equal, in the simultaneous game introducing a fixed cost of six *increases* individual contributions by 1.20 units.[23] Thus we reject H2.

To better understand the deviation from the predicted comparative static we examine the probability distribution of individual contributions. As seen in Fig. 3 panel (b) the distribution with a fixed cost of six first-order stochastically dominates the distribution with a fixed cost of zero. Relative to the zero-fixed-cost treatment, we see a decrease in the number of contributions of less than 3 units and an increase in contributions between 4 and 7 units. Contributions in excess of the dominant strategy account for 26% of play when there are no fixed costs and increase to 55% when the fixed cost increases to six. Perhaps most importantly, and contrary to expectations, the presence of fixed costs is not found to increase the frequency of zero unit contributions.

We conjecture that strategic uncertainty is the primary cause for the increase in contributions. Contributing all of the fixed costs happens to be a best response for a wide range of beliefs over the partner's contribution. Consider beliefs that only place weight on the partner selecting an action associated with the two Nash equilibria: contributing 0 or 3 units. If the subject is very certain to be matched with someone contributing zero, the individual's best response is

[19] For rounds 1–14 we get a constant of 5.67 ($p = 0.00$), coefficients of 0.32 (0.00) on sequential play, and −0.01 (0.10) on round. For rounds 1–7 the constant is 5.68 ($p = 0.00$), and the coefficients are 0.35 (0.00) on sequential play and −0.02 (0.30) on round. Finally, for rounds 8–14 the constant is 5.78 ($p = 0.00$) and the coefficients are 0.29 (0.00) on sequential play, and −0.017 (0.23) on round.

[20] Session level analysis generates the same result. Mean contributions in the three sequential sessions systematically exceed those of the three simultaneous sessions.

[21] Our results are robust to controlling for the correctness of the answers provided on the quiz. However the coefficient on the correctness of the quiz is never significant and including it has no qualitative (and most often no quantitative) effect on the estimated coefficients. An explanation for why a participant's initial ability to read the payoff table has no significant effect on behavior may be that the experimenter carefully reviewed and explained the quiz answers prior to the decision phase of the experiment.

[22] Session level data reveal the same contribution pattern: the simultaneous treatments with fixed costs of six systematically generate larger session averages than that observed with fixed costs of zero.

[23] A random effects regression of individual contributions for rounds 1–14 reveals coefficients of 1.20 on a FC = 6 dummy, −0.06 on round, and 3.32 as the constant. For rounds 1–7 the coefficient is 1.46 on FC = 6, −0.10 on round, and 3.31 as the constant. Finally, for rounds 8–14 the coefficient is 0.95 on FC = 6, −0.08 on round, and 3.70 as the constant. All p-values are smaller than 0.01.

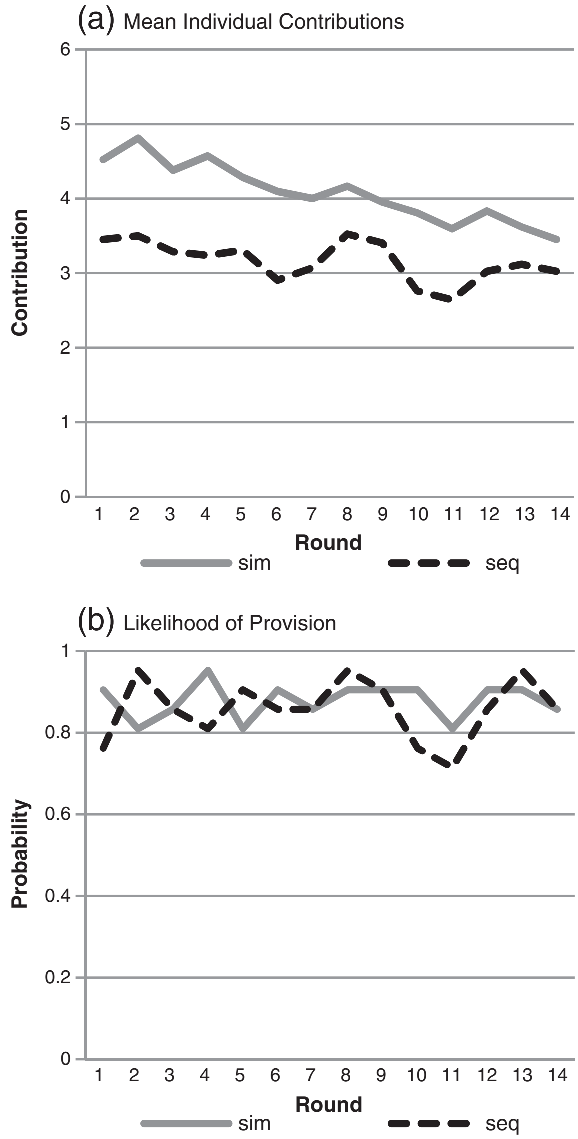

Fig. 4. Fixed costs of six.

instead to contribute zero as well. Similarly, if she is very certain to be matched with someone contributing 3 units, the best response is to contribute three. However, if the likelihood of being matched with a zero contributor lies in the range of 40 to 80%, the best response is to contribute 6 units. Thus absent the ability to coordinate on one of the two Nash equilibria, individuals may benefit from single-handedly securing provision of the project. There are other examples in which a contribution of 6 units is a best response due to the tradeoff between risk of coordination failure and contribution costs. In fact there are a number of symmetric mixed strategy Nash equilibria that require that the individual contributes six with a positive probability.[24]

Table 3
GLS random effects regression dependent variable: individual contribution, FC = 6.

	All rounds 1–14	First seven 1–7	Last seven 8–14
Sequential	−0.917	−1.129	−0.704
	(0.000)	(0.000)	(0.008)
Round	−0.064	−0.097	−0.082
	(0.000)	(0.004)	(0.002)
Constant	4.560	4.767	4.678
	(0.000)	(0.000)	(0.000)
N	1176	588	588
Participants	84	84	84

Note: *p*-values are in parentheses.

If the strategic uncertainty argument is correct, one would expect equilibrium play to increase as uncertainty about the strategies being employed diminishes. The data is consistent with an increase in equilibrium play. The effect of fixed costs is found to decrease from the first to the second half of the experiment, and over the course of the experiment the number of six-unit contributions decrease while the number of three-unit contributions increase. During the first seven rounds of the game, three- and six-unit contributions each account for 25% of all play. These numbers change for the latter half of the experiment, with 44% of all contributions at three and only 14% at six. Interestingly the frequency of zero contributions also decreases slightly over the course of the experiment. During the first and second half of the experiment a contribution of zero accounts for, respectively, 9 and 7% of overall contributions.

We complete our analysis of the low-fixed-cost treatments by examining the effect of sequential play. With fixed costs of six the subgame perfect Nash equilibrium of the sequential game is $(g_1^*, g_2^*) = (1,5)$: the first mover gives 1 unit while the second mover gives the remaining amount to cover the fixed cost, i.e., 5 units. From a theoretical viewpoint, the sequential game eliminates the inefficient Nash equilibrium outcome of zero provision, potentially increasing contributions (to an average of 3 units). This is summarized in the third hypothesis:

H3. With fixed cost of six, sequential play *increases* contributions.

Our results from the simultaneous game leave one skeptical that support for H3 will be found in the low-fixed-cost environment. The limited evidence of inefficient outcomes in the simultaneous game with fixed costs leaves little room for sequential play to improve on the simultaneous outcomes. Furthermore, we argued that uncertainty with regard to the partner's play helped explain why fixed costs increased contributions in the simultaneous game. As this uncertainty is reduced in the sequential game, contributions may instead decrease to the equilibrium level. Fig. 4 panel (a) shows the mean individual contributions by round in the sequential and simultaneous game with low fixed costs.

In contrast to the predicted comparative statics we see that mean contributions are lower with sequential play than with simultaneous play. Table 3 presents a random effects regression analysis of individual contributions for FC = 6. As before, the dependent variable is individual contribution and the explanatory variables are whether the game is sequential or simultaneous and the number of rounds. The effect of sequential play is found to be negative and significant. All else equal sequential play reduces individual contributions by almost 1 unit. Thus we reject H3: with fixed costs of six, sequential play *decreases* the mean contribution.[25]

The rejection of H3 is not caused by behavior in the sequential game. In fact we cannot reject that the average contribution of 3.16 in the sequential game equals the predicted three-unit mean

[24] To see this formally, Appendix III (http://www.pitt.edu/~vester/BMVappendix.pdf) presents the inequalities which determine whether or not contributing six is a best response. The set of inequalities contains 6 inequalities, which together define whether the strategy of contributing 6 units is a best response. The set of symmetric mixed strategy NE is {(0,3,6) with probability (0.4, 0.2, 0.4); (0,1,5,6) with probability (0.08, 0.36, 0.048, 0.512); (0,2,4,6) with probability (0.2, 0.15, 0.075, 0.575); (0,1,3,5,6) with probability (0.08, 0.24, 0.06, 0.036, 0.584); (0,2,3,4,6) with probability (0.2, 0.12, 0.024, 0.072, 0.584); (0,1,2,4,5,6) with probability (0.08, 0.096, 0.138, 0.0228, 0.02736, 0.63584); (0,1,2,3,4,5,6) with probability (0.08, 0.096, 0.1152, 0.01824, 0.021888, 0.026266, 0.642406)}.

[25] Session level data reveal the same contribution pattern, with the sequential treatments systematically generating lower session averages than those observed with simultaneous moves.

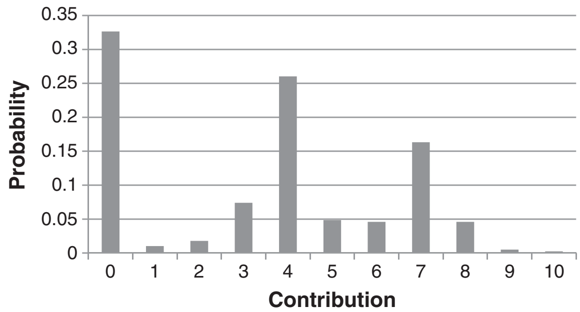

Fig. 5. Probability density function of individual contributions simultaneous play and FC = 8.

contribution ($p = 0.380$). Instead the deviation from the predicted comparative static (H3) is driven by the higher-than-expected contributions in the simultaneous game.

Before we draw any conclusions on the relative advantages of sequential versus simultaneous play, we should however examine the actual provision of the public good. After all, donors benefit from provision rather than contribution, thus contributions may be misleading when selecting between fundraising techniques. For example, it is possible that an individual gift of 5 units in the simultaneous game is matched with a contribution of zero causing the public good not to be provided. Fig. 4 panel (b) presents the fraction of cases in which the public good was provided, by round and by treatment (simultaneous versus sequential). The provision rate is high and in excess of 80% in both treatments. Despite the coordination problem associated with simultaneous giving, the 30% of contributions that are large enough to guarantee public good provision in the simultaneous game help secure similar provision rates in the two treatments. The high provision rate combined with the larger average contributions in the simultaneous treatment implies that individual earnings are slightly lower with sequential than simultaneous play. Using random effects to regress individual round earnings on a sequential treatment dummy and round number we find that sequential play reduces participant earnings by about 25 cents per round.[26] While this difference is significant it only corresponds to a 4% decrease in earnings. Contrary to the expectations we do not find evidence to suggest that participants on average get higher earnings in the sequential treatment when the fixed cost equals six.

3.3. Contributions with high fixed costs

Our analysis of contributions with a six-unit fixed cost did not show the expected increase in contributions from sequential play. This result was driven by the larger than expected contributions in the simultaneous game. We argued that strategic uncertainty and the associated risk of coordination failure could help explain this behavior. To illustrate this point we used an example of an individual who believes that her partner either contributes nothing or covers half of the fixed cost, and found that single-handedly covering the fixed cost is a best response for this individual as long as she believes the probability of the other group member contributing nothing is between 40 and 80%. The substantial probability range (40 to 80) makes the risk of coordination failure a real concern, and reduces the attractiveness of contributing less than six. For instance if the individual gives 3 units and the threshold is not met she will incur a loss of 1.2; however if she contributes 6 units herself, the worst that can happen is the partner contributing zero yielding a loss of 0.3. Accounting for this type of strategic uncertainty renders contributions of six a best response.

In this section we examine if behavior may be more in line with theory in a fixed-cost treatment where this type of strategic uncertainty does not make it a best response to single-handedly cover the cost. Specifically we examine an environment with an eight-unit fixed cost where, given the belief that the other group member either contributes nothing or covers half the fixed cost, it is not a best response to contribute eight.[27] Recall that with a fixed cost of eight there is a unique subgame perfect equilibrium at (2,6), and four Nash equilibria of the simultaneous game: (3,5), (4,4), (5,3) and (0,0). As noted in Section 2, with fixed costs of eight there are two ways in which sequential play may increase contributions: first through the elimination of the zero contribution equilibrium, and second by alleviating the coordination problem associated with selecting one of the positive provision equilibria. If participants in the simultaneous game play the zero contribution equilibrium with some positive probability, then the comparative static of the low-fixed-cost treatment should still hold. Thus we test the following fourth hypothesis:

H4. With an eight-unit fixed cost, sequential play *increases* contributions.

We first examine if there is coordination failure in the simultaneous game. The contribution distribution in the simultaneous game is shown in Fig. 5. As with fixed costs of six, a substantial fraction of contributions are found to cover half of the fixed cost (four), and a fair number of contributions are at the efficient level (seven). However, in sharp contrast to our earlier findings with fixed costs of six it is rare to see individual contributions that cover the fixed costs, and the modal choice now is to contribute nothing.[28] A third of all contributions are at zero units.[29] Thus behavior in the simultaneous game suggests that there is room for sequential play to improve outcomes.

Fig. 6 panel (a) compares the mean individual contributions in the sequential and simultaneous game by round. Despite the high frequency of zero unit contributions in the simultaneous game, the mean contributions are found to be quite similar. The similarity in mean contributions is further supported by a random effects regression of individual contributions on a sequential dummy and rounds. The coefficient on the sequential dummy is found to be small and insignificant whether it is examined overall, or during the first or second half of the experiment.[30] Thus contrary to hypothesis H4, sequential play *does not significantly increase* individual contributions.

While sequential play is not found to increase mean contributions, the likelihood of providing the public good does increase substantially. As Fig. 6 panel (b) illustrates, the difference in provision rates is large and persistent across the fourteen rounds of play. On average, sequential play almost doubles the likelihood of providing the public

[26] For rounds 1–14 we get a constant of 5.97 ($p = 0.00$), coefficients of −0.25 (0.00) on sequential play, and −0.02 (0.03) on round. For rounds 1–7 the constant is 6.02 ($p = 0.00$), and the coefficients are −0.28 (0.01) on sequential play and −0.03 (0.25) on round. Finally, for rounds 8–14 the constant is 6.01 ($p = 0.00$) and the coefficients are −0.22 (0.00) on sequential play, and 0.02 (0.32) on round.

[27] If the agent assigns a probability p to the opponent playing 0 and the probability 1-p to the opponent playing 4, then it is easily seen that there is no positive probability for which the agent would prefer giving 8 rather than either 0 or 4. Specifically if given only the choice of 0, 4 or 8, the agent will never give 8, and will give 0 when the probability that the opponent gives zero is more than 0.525, and will give four otherwise. Note that with a probability of 0.525 both 0 and 4 will give an expected payoff of 4, whereas the expected payoff from 8 is 3.85.

[28] A reviewer suggested that this need not result from differences in earnings, but may be a consequence of the low initial endowment. As noted in footnote 11 we are skeptical that participants used the costs rather than the final payoffs to make decisions. However if participants felt restricted by the costs then the comparative statics nonetheless shed light on the effect of sequential contributions in situations where budget constraints prevent donors from covering the fixed costs of a public project.

[29] The frequency of zero contributions increases from 31 to 35% between the first and second half of the experiment.

[30] The sequential coefficient equals −0.051 ($p = 0.91$) over all 14 rounds, 0.240 ($p = 0.61$) for the first seven rounds, and −0.342 ($p = 0.49$) for the last seven rounds.

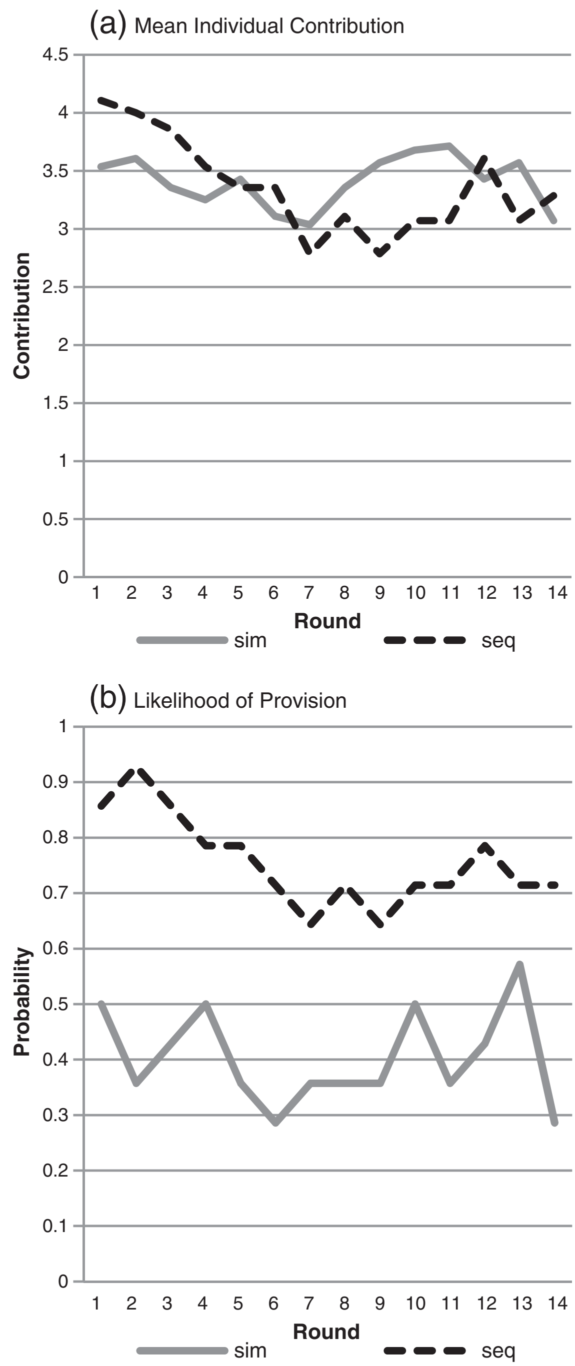

Fig. 6. Fixed costs of eight.

good from 40% when contributions are simultaneous, to 76% when contributions are sequential. Donors accrue substantial benefits from the increase in provision. Using random effects to regress round payoffs on a sequential dummy, we find that sequential play increases round earnings by approximately $1.20, a 27% increase.[31]

[31] A random effects regression of individual earnings reveals for rounds 1–14 a constant of 4.41 ($p=0.00$), coefficients of 1.18 (0.00) on sequential play, and −0.01 (0.39) on round. For rounds 1–7 the constant is 4.56 ($p=0.00$), and the coefficients are 1.34 (0.00) on sequential play and −0.07 (0.10) on round. Finally, for rounds 8–14 the constant is 4.07 ($p=0.00$) and the coefficients are 1.02 (0.00) on sequential play, and 0.03 (0.54) on round.

4. The role of sequential moves with and without fixed cost

Our results demonstrate that the response to sequential play is rather sensitive to the presence and level of fixed costs of production. While sequential play decreased giving in the low-fixed-cost treatment, it increased giving in both the zero and high fixed cost treatments. With high fixed cost, sequential play increased earnings by 27%. By comparison, sequential play increased earnings by 6% when there were no fixed costs and decreased it by 4% when the fixed costs were low.[32] Thus our results confirm that sequential play is particularly effective under high fixed costs.

The differences in return from sequential play are largely driven by the larger than expected contributions in the simultaneous game with low fixed cost. In both the zero and high fixed cost treatment behavior of the simultaneous game was very much in line with equilibrium predictions. Absent fixed costs participants on average made the predicted 3 unit contribution, and under high fixed costs many individuals opted to not contribute which resulted in frequent failure to provide the public good. By contrast when the fixed cost was low individuals instead overcame strategic uncertainty by increasing contribution and single-handedly covering the fixed costs. Under low fixed costs simultaneous play only rarely resulted in zero provision outcomes.

While the emphasis has been on the surprising behavior under simultaneous play, it is important to note that adherence to equilibrium also is sensitive to the fixed cost when contributions are made sequentially. Fig. 7 illustrates the behavior under the three sequential games reporting the observed combinations of first and second mover contributions. Panel (a) shows contributions in the no fixed cost treatment. Absent fixed cost there is substantial adherence to the highlighted subgame perfect equilibrium at (3, 3). The few deviations from equilibrium suggest that contributions below the dominant strategy of 3 are not punished, whereas contributions in excess of 3 are sometimes rewarded. One reason why first mover contributions below three are not punished may be that it is costly for the first mover to give less than her dominant strategy, and in doing so she does not influence the second mover's payoff from giving. Introducing fixed costs gives rise to an asymmetric subgame perfect equilibrium with a substantial first mover advantage. This inequality may help explain why in panel (b) and (c) the fixed-cost-treatments result in greater deviations from the subgame perfect equilibrium. As predicted, contributions in the fixed-cost treatments generally cover the fixed cost. Provision rates are 86% with a fixed cost of six and 76% with a fixed cost of eight. However, there are large differences in the manner in which provision is secured. With a six-unit fixed cost, participants shy away from the highlighted subgame perfect equilibrium (1,5). Instead, the modal outcome is for the first and second mover to each contribute 3 units. In contrast, with fixed costs of eight the modal outcome is the highlighted subgame perfect equilibrium of (2,6). The difference in the frequency of equilibrium play is intriguing as in both cases the subgame perfect equilibrium involves the first player free riding off of the second player's desire to secure provision of the public good.[33]

Two factors may help explain the difference between the two sequential fixed-cost conditions (FC = 6, FC = 8): one is reciprocity and the other is trust. Reciprocity could be a factor since second movers may view contribution of one out of six as more unfair relatively to contribution of two out of eight; it may be easier for the

[32] A random effects regression reveals that the effect of sequential play is significant at the 0.02 level in each of the 3 fixed cost treatments; in addition the difference in response to sequential play is significant at the 0.00 level.

[33] Examining sequential public goods games, Andreoni et al. (2002), Cooper and Stockman (2007) and Gächter et al. (2010) also find that free riding by a first mover causes subsequent subjects to not give, even when it is a dominant strategy to do so. The asymmetric payoff outcome under high fixed cost may help explain why the likelihood of provision decreases in the high fixed cost treatment.

second mover to accept the inequality associated with the subgame perfect equilibrium in the case of fixed costs of eight.[34] Indeed, with a fixed cost of six and an initial contribution of one, there is a 40% chance that the second mover selects a contribution which is insufficient to secure provision. By contrast, with a fixed cost of eight and an initial contribution of two there is only a 20% chance that the project fails to be provided. Despite the prediction that fixed cost gives rise to a first mover advantage, such an advantage only emerges in the high fixed cost treatments. Trust may also be a factor in explaining the difference in behavior across the fixed cost conditions: giving 1 unit risks 40 cents or 10% of the endowment, while contributing 2 units risk 80 cents or 20% of the endowment. Hence, it is possible that second movers interpret a two-unit contribution by the first mover as a stronger signal of trust compared with 1 unit contribution.

We investigate the difference in first mover advantage in Table 4. Pooling the earnings data from the three sequential treatments we note first that absent fixed cost there is a significant disadvantage to being a first mover, with first movers on average earning 53 cents less per round. Despite the prediction that fixed cost will introduce a first mover advantage, as seen by the first mover and the interaction term, we do not see such an effect under low fixed cost. With fixed cost of six first movers earn 7 cents less than second movers, however this difference is not significant ($p=0.60$). A significant and substantial first mover advantage is however seen when the fixed cost is eight, as the earnings of first movers on average exceed those of the second movers by 87 cents ($p=0.00$). The advantage to the first mover is relatively robust over the first and second half of the experiment.

To summarize in the no and high fixed cost treatments behavior in both the sequential and simultaneous games is broadly consistent with the equilibrium predictions, however in the low-cost treatments we see substantial deviations in both the sequential and simultaneous games. On one hand strategic uncertainty appears to cause greater than predicted simultaneous giving when the fixed cost is low; on the other hand the tension associated with the substantial first mover advantage appears to move behavior away from the asymmetric subgame perfect equilibrium. Interestingly this asymmetry is more readily accepted when the fixed cost is high. The sensitivity to the size of the seed relative to the total fixed cost may suggest that fundraisers and initial donors should use caution when trying to exploit a potential first mover advantage.

5. Conclusions

Our study was designed to examine whether the frequent use of sequential fundraising and seed money contributions may be explained by the presence of fixed production costs. We find support for this claim for sufficiently high fixed costs, but not for low fixed costs.

More specifically, the theoretical argument made by Andreoni (1998) is that in the presence of fixed costs, giving simultaneously to a public good may result in both positive and zero provision equilibria. Thus absent information on what others give, donors may get stuck in an inefficient equilibrium with zero provision of the public good. The attraction of sequential giving is that it eliminates such inefficient outcomes and guarantees provision of desirable public projects. Thus sequential fundraising is predicted to increase giving and individual payoffs.

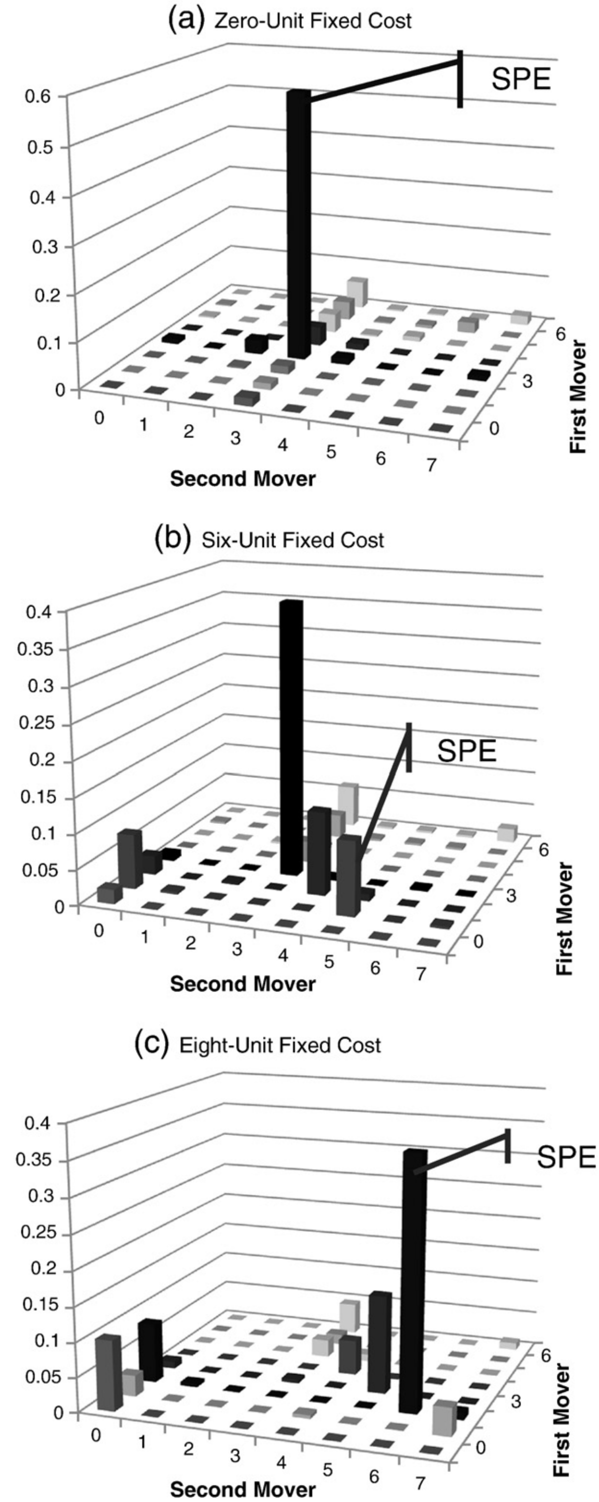

Fig. 7. Contribution frequency.

For small fixed costs we do not find support for this claim; instead sequential play is shown to decrease both contributions and individual payoffs. The reason for this deviation from the predicted comparative statics is found in the simultaneous game where, surprisingly, the introduction of fixed costs increases rather than decreases contributions. The explanation for the larger than expected contributions is due to the coordination difficulties of the

[34] Note that it is not only the perceived fairness of the equilibrium that may change when moving from a subgame perfect equilibrium of (1,5) to one of (2,6). The cost of punishing is also higher in the (2,6) equilibrium. Most games where distributional concerns may play a role have the characteristic that an improvement in fairness also increases the costs of punishment. Andreoni et al. (2003) is an exception as they keep the cost of punishment and rewards constant while allowing the distribution of payoffs to vary.

Table 4
GLS random effects regression dependent variable: individual earnings.

	All rounds 1–14	First seven 1–7	Last seven 8–14
FC = 6	−0.526	−0.526	−0.527
	(0.000)	(0.001)	(0.000)
FC = 8	−1.091	−0.986	−1.091
	(0.000)	(0.000)	(0.000)
First mover	−0.453	−0.545	−0.362
	(0.001)	(0.001)	(0.011)
FC = 6 x (First mover)	0.385	0.389	0.381
	(0.039)	(0.086)	(0.049)
FC = 8 x (First mover)	1.322	1.272	1.372
	(0.000)	(0.000)	(0.000)
Round	−0.174	−0.029	−0.0136
	(0.006)	(0.127)	(0.432)
Constant	6.148	6.229	6.067
	(0.000)	(0.000)	(0.000)
N	1568	784	784
Participants	112	112	112

Note: *p*-values are in parenthesis.

simultaneous game combined with the relatively low fixed costs. Interestingly, uncertainty over which equilibrium the partner is playing often makes it a best response to contribute an amount large enough to single-handedly cover the fixed cost. The sequential game, however, alleviates the coordination problem and participants can “safely” contribute less and still secure provision of the public good. Thus for low fixed costs we find that contributions in the simultaneous game exceeded those in the sequential game. While this result was not anticipated, it is not difficult to envision a case where the cost from contributing is so low and the benefit from provision is so high that individuals in a simultaneous move game will contribute an inefficiently large amount in order to secure the good.[35]

In the case of large fixed costs, behavior was found to be more in line with the theory. Although sequential play did not increase contributions, it did increase the likelihood of provision and individual earnings. As predicted, with simultaneous play many participants did not contribute to the public good, or failed to coordinate to meet the fixed costs level which is necessary to provide the good. With high fixed cost sequential play improved upon the simultaneous outcome through two channels: not only did it eliminate the zero contribution outcomes, it also eliminated the inefficiencies that result when participants fail to coordinate on one of the simultaneous game's multiple positive-contribution equilibria. Thus the success of sequential play with large fixed costs may partly be explained by the fact that the coordination problem is greater in this case.

While sequential play helps donors coordinate on positive provision outcomes, one needs to be wary of the risk associated with allowing for too low an initial contribution. The presence of fixed costs enables the first contributor to free ride off of the second contributor, and to fully extract the second mover's benefit from provision. Full exploitation of this advantage may cause second contributors to object to the unequal division of the burden and result in a failure to provide the public good. Examining the sequential game with both low and high fixed costs, we found evidence to suggest that the success of the sequential play in our case was sensitive to the share of funds provided by the first contributor.

Research has proposed several explanations for why fundraisers rely on sequential solicitation strategies. Many of these explanations reduce the first contributor's inherent ability to free ride off of second contributors in a public good game.[36] By contrast, the introduction of fixed costs increases the first mover advantage inherent in the public good game, and a potential risk of sequential play is that provision may fail unless the fundraiser is successful in convincing initial contributors to donate a fair share. Perhaps this concern for equity helps explain why fundraisers have specific goals for how large seed money contributions need to be as a share of the overall fundraising goal.[37]

Acknowledgments

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Appendix A. Supplementary data

Supplementary data to this article can be found online at doi:10.1016/j.jpubeco.2010.10.007.

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[35] Perhaps the excessive contributions seen in connections with the September 11 attacks in 2001 and the Asian tsunami in 2004 would have been smaller if donations had been made in a more sequential manner.

[36] For example, to signal that a charity is of high quality the first player will have to contribute an amount which is larger than what would have been needed had the charity been known to be of high quality.

[37] As noted in Andreoni (2006); Lawson, 2007 states “the lead gift should be at least 10% of the overall goal” (p. 756). Hartsook (1994) advises that “the leadership commitment . . . should represent no less than 20% of the capital campaign goal” (p. 32).

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