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Competition for Status Acquisition in Public Good Games

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Abstract

This paper examines the role of status acquisition as a motive for giving in voluntary contributions to public goods. In particular, every donor's status is given by the difference between his contribution and that of the other donor. Specifically, I show that contributors give more than in standard models where status is not considered, and their donation is increasing in the value they assign to status and, under certain conditions, in the value that their opponents assign to status (reflecting donors' competition to gain social status). Furthermore, I consider contributors' equilibrium strategies both in simultaneous and sequential contribution mechanisms. Then, I compare total contributions in both of these mechanisms. I find that the simultaneous contribution order generates higher total contributions than the sequential mechanism only when donors are sufficiently homogeneous in the value they assign to status. Otherwise, the sequential mechanism generates the highest contributions.

Keywords: Public goods games, Status acquisition, Competition.
JEL classification: C7, H41.

1 Introduction

The effect of status on individuals' consumption of private goods has been extensively analyzed from a theoretical perspective, and confirmed by multiple studies. Indeed, many authors, starting from Smith (1759) and Veblen (1899), have examined agents' incentives to consume certain positional goods (such as luxury cars) for the only purpose of acquiring social status among their neighbors, co-workers or friends; see Frank (1985), Congleton (1989), Fershtman and Weiss (1993), Ball *et al.* (2001) and Hopkins and Kornienko (2004).

Despite the extensive analysis of status in private good settings, there is yet a relatively limited theoretical literature analyzing social status acquisition in public good contexts.[1] Nonetheless, the importance of status as a motive for individual donations to public goods cannot be overemphasized. For example, both *BusinessWeek* and *Slate* magazines recently created rankings of the most generous U.S. philanthropists. More generally, publicizing the list of donors, as well as the size of their contributions to the charity, constitutes a common practice of many charitable organizations, what suggests that many donors are indeed concerned about how their contribution is ranked relative to others'. In the same spirit, recent experimental literature, such as Kumru and Vesterlund (2005) and Duffy and Kornienko (2005), have also confirmed the role of status as an individual incentive affecting donors' giving behavior in different experimental settings.[2]

This paper contributes to this literature by constructing a theoretical model that analyzes how individual (and total) contributions to a charity are affected by players' competition for social status. Intuitively, one may expect every donor's giving decision to be increasing in his value for social status, since this valuation might attenuate his incentives to free-ride on other donors' contributions. This intuitive prediction is indeed confirmed both in the simultaneous solicitation order (where both donors give simultaneously to the charity) and in its sequential version (in which one donor gives first and then the other gives second before the end of the game). Similarly, an individual's contribution should also be increasing in the value that other donors assign to status. Indeed, since an opponent with a higher value for status increases his contribution, individuals need to increase their donation to the charity in order to reduce as much as possible their loss of social status; this is confirmed in our model under certain parameter conditions.

A question of interest is which particular contribution order raises the highest total revenue to the charity. In particular, building on Romano and Yildirim (2001), I provide an answer to this question which can be directly applied by practitioners. Specifically, populations of relatively *homogeneous* donors —in terms of the value they assign to status— induce a higher competition (and contributions) in the simultaneous public good game than in its sequential version. In contrast,

[1] Harbaugh (1998) examines a model where contributions are announced among donors, and every donor gains "prestige" from his donation, although such "prestige" only depends on his own contribution. In this paper we assume, instead, that a donor gains status only if his contribution is higher than those of other donors (so an individual's status depends not only on his individual contribution, but also in those of other donors).

[2] In a linear public good game, Andreoni and Petrie (2004) expermientally test the effect of the identification of participants and the information they receive about other players' contributions on their donations to the public good. They show that individual contributions are significantly affected by subjects' information about the exact contribution of other participants (i.e., information about "who gave what").

groups of contributors with *heterogeneous* values to status submit higher total donations in the sequential contribution game than in its simultaneous counterpart. Hence, this paper contributes to the literature on public good games by analyzing which particular solicitation order raises the highest total revenue to the charity when players compete for social status. Similarly, it provides an explanation of why charities might prefer to organize sequential fund-raising events: their donors are relatively heterogeneous in their concerns for status acquisition. In particular, when some contributors can be regarded as "net free-riders" (because their concerns for status acquisition are relatively low) whereas others can be denoted as "net status-seekers" (because their concerns for status are relatively high), the charity would raise the highest revenue by organizing a sequential fund-raising event.[3]

Finally, I examine the possibility that donors' social status might be acquired from their previous donations to the charity, or from any other sources. This is the case, for example, of famous philanthropists who start their competition for status with previously acquired levels of seniority. In particular, I show that if this previous status enters additively into donors' status concerns, seniority may work as an strategic substitute for the status donors can acquire through current donations, reducing their contributions. In contrast, if currently acquired status emphasizes previously acquired rankings, then status acquired during different periods work as strategic complements, and current donations are increased.

The article is organized as follows. In the next section, I present the model, and sections three and four describe the results in terms of the players' equilibrium contributions in the simultaneous and sequential games, respectively. In section five, given the previous results, I find the contribution mechanism that maximizes the charity's total revenue. Section six presents an extension of the previous results, which considers the effect of seniority on current donations. In section seven, I conclude and offer some extensions of the model.

2 Model

Let us consider a public good game (PGG) where two agents privately contribute to the provision of a public good. Let g_i denote subject i's voluntary contributions to the public good, and let $x_i \geq 0$ represent his consumption of private goods. Additionally, I assume that the marginal utility individual i derives from his consumption of the private good is one. Specifically, the representative contributor's maximization problem is given by

$$\max_{x_i, G} \; x_i + \ln\left[mG + \alpha_i \left(g_i - g_j\right)\right]$$

[3] Note that this result differs from that in Varian (1994), where contributors without concerns for status acquisition give higher total contributions to the charity in the simultaneous than in the sequential public good game.

$$
\begin{aligned}
\text{subject to } x_i + g_i &= w \\
g_i + g_j &= G \\
g_i, g_j &\geqslant 0
\end{aligned}
$$

where $m \in [0, +\infty)$ denotes the return player i obtains from total contributions to the public good, $G = g_i + g_j$, and w represents players' endowment of monetary units that can be distributed between private and public goods consumption.[4] In addition, I assume that the status subject i acquires by contributing g_i is given by the difference between his contribution and that of the other player, $g_i - g_j$. That is, subject i enhances his relative status if his contribution is greater than individual j's; otherwise, subject i perceives himself as an individual with lower status than subject j.[5] In addition, this difference is scaled by α_i, indicating the importance of relative status for subject i, where $\alpha_i \in [0, +\infty)$. As commented in the previous section, this is a game of complete information. Hence, in the equilibrium of the PGG, player i correctly conjectures donor j's contribution, g_j for all $j \neq i$, and as a consequence he knows whether he acquires status through his contribution, $g_i > g_j$, or if he does not, $g_i < g_j$. Furthermore, all the elements of the game, including the particular values of α_i, are assumed to be common knowledge among the players. Using $x_i = w - g_i \geq 0$, we can simplify the above program to

$$
\max_{g_i \geq 0} \quad w - g_i + \ln\left[m(g_i + g_j) + \alpha_i \left(g_i - g_j\right)\right]
$$

In particular, the first term, $w - g_i$, represents the utility derived from the consumption of the remaining units of money that have not been contributed to the public good. The second term denotes, on the one hand, the utility that individual i gets from the consumption of the total contributions to the public good $g_i + g_j$, and on the other hand, the utility derived from relative status acquisition.

Intuitively, note that in our model an increase in player j's contribution, g_j, imposes both a positive and a negative externality on player i's utility level. The *positive* externality from g_j on player i's utility is just the usual one arising from the public good nature of player j's contributions. Player j's donations, however, impose also a *negative* externality on player i since this donation reduces the status perception of player i, i.e., higher g_j decreases $\alpha_i \left(g_i - g_j\right)$, for any given g_i. Finally, note that we do not make any additional assumption on the quasilinear part of player i's utility function in order to guarantee that it is positive for any parameter values. Indeed, as we show in the next sections, this term is never negative in equilibrium, since low contributions by player i correspond to those cases for which α_i is close to zero.

[4] Allowing for asymmetric monetary endowments, $w_i \neq w_j$, would not change our results, since players' utility function is quasilinear in w. Furthermore, we assume that w is sufficiently large.

[5] Note that this public good game could be generalized to N players. In such setting, every donor measures the status he acquires by comparing his contribution and that of the other $N-1$ players. The outcome of each of these comparisons can then be added up (or scaled in a weighted average) in order to evaluate player i's acquired status. For simplicity, however, we focus on the case of two players.

2.1 Best response function

In order to gain a clearer intuition of our results, let us analyze player i's best response function. Henceforth, all proofs are relegated to the appendix.

Lemma 1. *In the contribution game, player i's best response contribution level, $g_i(g_j)$, is*

$$g_i(g_j) = \begin{cases} 1 + \frac{\alpha_i - m}{\alpha_i + m} g_j & \text{if } g_j \in \left[0, \frac{m+\alpha_i}{m-\alpha_i}\right], \text{ and} \\ 0 & \text{if } g_j > \frac{m+\alpha_i}{m-\alpha_i} \end{cases}$$

if $\alpha_i < m$. And in the case that $\alpha_i > m$, $g_i(g_j) = 1 + \frac{\alpha_i - m}{\alpha_i + m} g_j$ for all g_j.

Clearly, when $\alpha_i < m$, player i's best response function is decreasing in g_j, while $\alpha_i > m$ implies a positively sloped best response function, as the following figures indicate.

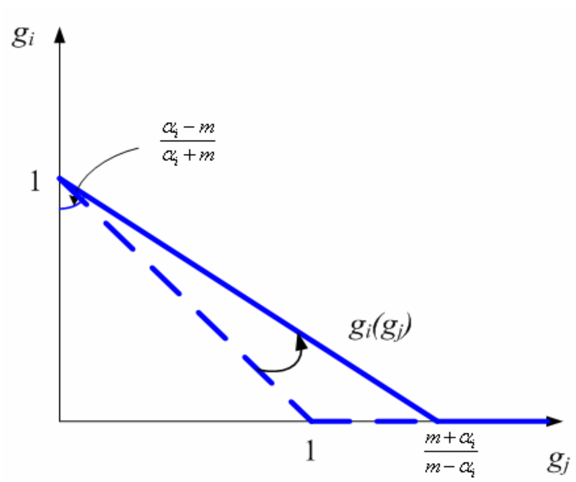

Figure 1(a): $g_i(g_j)$ when $\alpha_i < m$ (net free-rider).

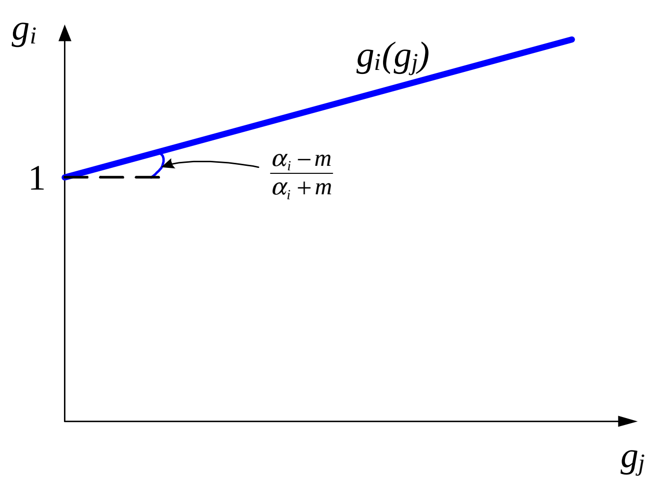

Figure 1(b): $g_i(g_j)$ when $\alpha_i > m$ (net status-seeker).

In particular, when $\alpha_i < m$ the positive externality that player j's donations impose on player i's utility dominates the negative one, and player i considers player j's contributions as strategic *substitutes* of his own (i.e., he is a net free-rider), as in the usual PGG models without status. On the other hand, when $\alpha_i > m$ the negative externality resulting from player j's contributions is higher than the positive externality originated from the public good nature of his contributions. In this case, player i considers player j's donations as strategic *complements* to his own (i.e., he is a net status-seeker), which leads to the positively sloped best response function depicted in figure 1(b). In addition, from the above lemma and discussion, it is easy to infer that the slope of player i's best response function increases in his value to status, α_i. Indeed, from the above figures, $g_i(g_j)$ pivots upward, with center at $g_i = 1$, as α_i increases: from a negative slope when $\alpha_i < m$ to a positive slope when $\alpha_i > m$.

3 Simultaneous contributions

After analyzing player i's best response function and its interpretation, we can now examine player i's optimal contribution in this simultaneous-move game.

Proposition 1. *In the simultaneous contribution game, player $i = \{1, 2\}$ submits the following Nash equilibrium contribution level*

$$g_i^{Sm} = \begin{cases} 1 \;\; if \;\; \alpha_i > 0 \; and \; \alpha_j = 0 \\ \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m} \;\; if \;\; \alpha_i > 0 \; and \; \alpha_j > 0 \\ 0 \;\; if \;\; \alpha_i = 0 \; and \; \alpha_j > 0 \end{cases}$$

and $g_i^{Sm} + g_j^{Sm} = 1$ if $\alpha_i = \alpha_j = 0$

Figure 2 illustrates the set of parameter values that support the above different contribution levels. In particular, $g_i^{Sm} = 1$ on the vertical axis of the figure where $\alpha_j = 0$; $g_i^{Sm} = 0$ on the horizontal axis, where $\alpha_i = 0$; and $g_i^{Sm} = \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m}$ when α_i,$\alpha_j > 0$. Intuitively, player i submits $g_i^{Sm} = 1$ when he assigns a value to status and player j does not; submits a zero contribution when he does not assign any value to status, $\alpha_i = 0$, and player j does, $\alpha_j > 0$;[6] and finally he submits $g_i^{Sm} = \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m}$ when both players assign a value to status.

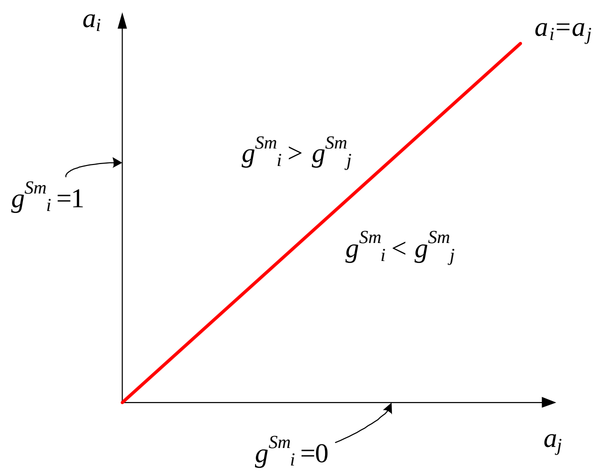

Figure 2: g_i^{Sm} and g_j^{Sm}

In addition, figure 2 includes the 45^0- line, where $\alpha_i = \alpha_j$, which divides equilibrium contribution levels into two parts: an upper region where $\alpha_i > \alpha_j$ and as a consequence $g_i^{Sm} > g_j^{Sm}$, and a lower region where $\alpha_i < \alpha_j$ and $g_i^{Sm} < g_j^{Sm}$. This result originates in the fact that players' equilibrium strategies are symmetric up to their individual value to status. Hence, in this simultaneous

[6]Note that zero donations can be alternatively interpreted as players who decide not to participate in the contribution mechanism.

game, the player who assigns the highest value to status submits the highest donation. Next, the following lemma presents the comparative statics of player i's equilibrium donation.

Lemma 2. *In the simultaneous contribution game, player i's equilibrium contribution,* g_i^{Sm}, *is weakly increasing in his value to status acquisition,* α_i, *for all parameter values, and is weakly increasing in player j's value,* α_j, *if* $\alpha_i \geq m$. *Furthermore,* g_i^{Sm} *is weakly decreasing in the return,* m, *that every donor obtains from total contributions.*

That is, a player who values status competes more ferociously when he becomes more concerned about the status he can acquire through his contributions. When his opponent becomes more concerned about status, however, he becomes more competitive only if he is a net status-seeker, i.e., $\alpha_i \geq m$. Indeed, since his opponent increases his donation, player i must increase his own as well if he pretends to maintain his level of social status unchanged.

Finally, note that individual donations are decreasing in the return that every donor obtains from total contributions to the public good. That is, for a given value of status among donors, individual contributions decrease as his benefits from total contributions to the public good (free-riding effects) dominate his benefits from an increase in his individual contribution (status effects). These results might be specifically vivid in the case of donors helping charities with low returns from total contributions, such as those operating in distant countries. Indeed, according to our previous results, a donor would donate *more* to charities with goals he does not directly benefit from (low returns) than from those he does (high returns), for a given value of the status he acquires from his donations to either charity. As a consequence of the above individual giving decision from players i and j, total contributions are the following.

Lemma 3. *In the simultaneous contribution game total donations induced from Nash equilibrium play,* G^{Sm}, *are*

$$G^{Sm} = \begin{cases} 1 \ \ \textit{if} \ \ \alpha_j = 0 \ \textit{and} \ \alpha_i > 0 \\ 1 + \frac{2\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m} \quad \textit{if} \ \ \alpha_i > 0 \ \textit{and} \ \alpha_j > 0 \\ 1 \ \ \textit{if} \ \ \alpha_i = 0 \ \textit{and} \ \alpha_j \geq 0 \end{cases}$$

where G^{Sm} *is weakly increasing in both* α_i *and* α_j, *and maximized for* (α_i, α_j) *pairs such that* $\alpha_i = \alpha_j = \alpha$.

Figure 3(a) represents total contributions in this simultaneous PGG for any α_i and α_j; and figure 3(b) illustrates the three areas in which total contributions can be divided. In particular, figure 3(b) shows that: (1) when player i assigns no importance to status but player j does, on the horizontal axis of figure 3(b), player j submits $g_j^{Sm} = 1$; (2) when the opposite happens, $\alpha_j = 0$ and $\alpha_i > 0$ on the vertical axis, it is player i who submits $g_i^{Sm} = 1$; and (3) when both players are positively concerned about status, α_i,$\alpha_j > 0$ in the interior points of the figure, both players give positive amounts and their total contributions are $1 + \frac{2\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m}$.

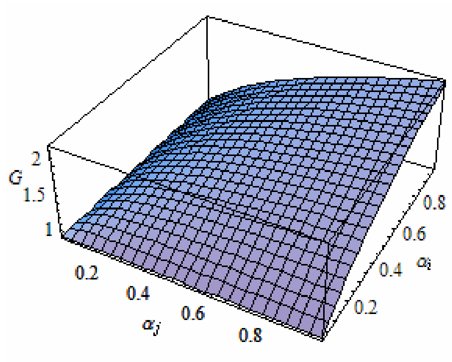

Figure 3(a): G^{Sm}

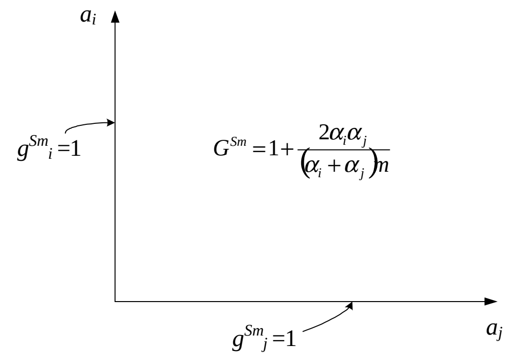

Figure 3(b)

Finally, note that players' total contributions when *either* of them does not value status coincides with total contributions when *none* of them does, $G^{Sm} = 1$. Alternatively, increasing the status concerns of a single individual does no raise total contributions. Furthermore, G^{Sm} is higher when players' value of status acquisition are relatively homogeneous ($\alpha_i = \alpha_j = \alpha$, in the main diagonal) than when they are heterogeneous ($\alpha_i \neq \alpha_j$, away from the main diagonal). Finally, note that total contributions are increasing in both α_i and α_j, even in rays $\frac{\alpha_i}{\alpha_j}$ of figure 3(b) for which $\alpha_i \neq \alpha_j$.

4 Sequential contributions

Let us next examine donors' contributions in the sequential PGG, where player i is the first donor solicited to contribute (and he can only give once).[7] Observing his contribution, player j (the follower) determines his donation.

Proposition 2. *In the sequential contribution game in which player i moves first, equilibrium contributions are given by*

$$g_i^{Seq} = \begin{cases} 0 \quad \text{if} \quad \alpha_i \in [0, \bar{\alpha}_i]\,, \text{ and} \\ \frac{\alpha_i\alpha_j + 3\alpha_i m + \alpha_j m - m^2}{2m(\alpha_i+\alpha_j)} \quad \text{if} \ \ \alpha_i \in (\bar{\alpha}_i, +\infty) \end{cases}$$

for player i, where $\bar{\alpha}_i = \frac{m(m-\alpha_j)}{3m+\alpha_j}$. *Similarly, for player j (second mover)*

$$g_j^{Seq} = \begin{cases} 1 \quad \text{if} \quad \alpha_i \in [0, \bar{\alpha}_i)\,, \\ \frac{1}{2}\left(\frac{\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m} + \frac{m}{\alpha_i+\alpha_j} + \frac{4\alpha_j}{\alpha_j+m} - 1\right) \ \text{if} \ \ \alpha_j < m \text{ and } \alpha_i \in [\bar{\alpha}_i, \hat{\alpha}_i)\,, \\ \qquad \text{or if} \ \ \alpha_j > m \text{ and } \alpha_i \in [\bar{\alpha}_i, +\infty), \text{ and} \\ 0 \quad \text{if} \ \ \alpha_j < m \text{ and } \alpha_i \in [\hat{\alpha}_i, +\infty) \end{cases}$$

[7] In section six we examine how our results would be modified if players are allowed to contribute to the charity more than once.

where $\hat{\alpha}_i = \frac{m(3\alpha_j^2+m^2)}{-\alpha_j^2-4\alpha_j m+m^2}$.

Let us first analyze player i's decision about contributing positive amounts. From the above proposition, we know that player i submits a strictly positive contribution if and only if $\alpha_i > \bar{\alpha}_i$. Figure 4(a) represents player i's equilibrium contribution for different values of α_i and α_j, and figure 4(b) illustrates cutoff level $\bar{\alpha}_i$ for different values of m.

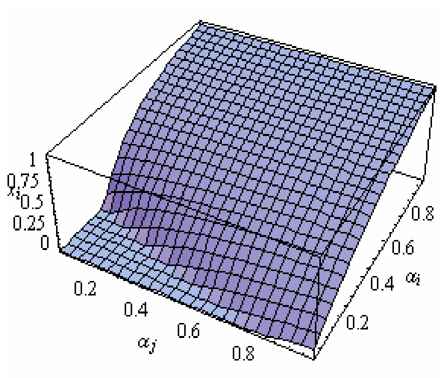

Figure 4(a): g_i^{Seq}

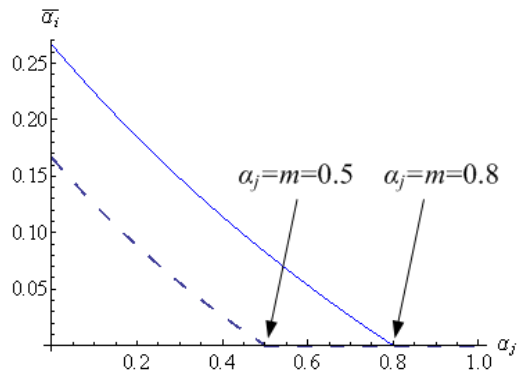

Figure 4(b): $\bar{\alpha}_i$ for $m = 0.5$ and $m = 0.8$.

Corollary 1. *In the sequential contribution game,* $g_i^{Seq} > 0$ *when* $\alpha_i = 0$*, if and only if* $\alpha_j > m$*. Furthermore,* $g_i^{Seq} > 0$ *when* $\alpha_i > m$ *for any* α_j*.*

That is, when the first mover does not assign any value to status, $\alpha_i = 0$, he submits a positive contribution when the second donor is a net status-seeker ($\alpha_j > m$) since the second mover will be tempted to significantly increase his donation. Otherwise, when the second donor is a net free-rider ($\alpha_j < m$), a first mover with no value for status contributes zero, as in sequential PGGs without considerations about status. Figure 4(b) illustrates the above intuition, in particular at the α_j-axis (horizontal axis), where $\alpha_i = 0$. Note that for any value at the α_j-axis where $\alpha_j < m$, player i's optimal contribution is zero, while for any $\alpha_j > m$, player i submits positive donations.

On the other hand, the second result of corollary 1 specifies that when player i is a net status-seeker, $\alpha_i > m$, he submits positive contributions regardless of the value that the second mover may assign to status acquisition, α_j. Graphically, this result is depicted in figure 4(b). In particular, any (α_i, α_j)-pair satisfying $\alpha_i > m$, lies to the right-hand side of the solid line, leading to strictly positive contributions from the first mover. Let us next examine comparative statics about g_i^{Seq} in this sequential game.

Lemma 4. *In the sequential contribution game,* g_i^{Seq} *is weakly increasing both in his own value for status acquisition,* α_i*, and in player* j*'s value,* α_j*, for any parameter values.*

Let us finally analyze the charity's total revenues in this sequential solicitation mechanism.

Lemma 5. *In the sequential PGG total contributions induced from the subgame perfect Nash equilibrium of the game, G^{Seq}, are*

$$G^{Seq} = \begin{cases} 1 \quad if \quad \alpha_i \in [0, \bar{\alpha}_i) \\ \frac{2\alpha_j}{\alpha_j+m} + \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m} \; if \; \alpha_j < m \; and \; \alpha_i \in [\bar{\alpha}_i, \hat{\alpha}_i), \; or \; if \; \alpha_j > m \; and \; \alpha_i \in [\bar{\alpha}_i, +\infty) \\ \frac{\alpha_i\alpha_j+3\alpha_i m+\alpha_j m-m^2}{2m(\alpha_i+\alpha_j)} \; if \; \alpha_j < m \; and \; \alpha_i \in [\hat{\alpha}_i, +\infty) \end{cases}$$

Interestingly, when player i assigns a sufficiently low value to status acquisition, $\alpha_i < \bar{\alpha}_i$, he does not contribute and player j responds by contributing one. In this case, $G^{Seq} = 1$, and the results resemble those in sequential PGG models without status considerations, $\alpha_i = \alpha_j = 0$. In contrast, when player i assigns a sufficiently high value to status, $\alpha_i \in [\bar{\alpha}_i, \hat{\alpha}_i)$, and $\alpha_j > m$, he contributes positive amounts which are then reciprocated by the positive contributions of player j (who is a net status-seeker). Finally, if $\alpha_i > \hat{\alpha}_i$ and player j is a net free-rider ($\alpha_j < m$), player i contribution crowds-out all donations by player j, and he is the only donor contributing to the charity.

5 Comparing contribution mechanisms

Different questions naturally arise from the above results. For example, given a particular pair of players' values for status, (α_i, α_j), under what contribution order does player i (or player j) contribute more? Or, what contribution order maximizes total donations received by the charity? Let us first compare individual contributions, and then extend our results to the total revenues received by the charity.

Lemma 6. *Player i's equilibrium donations in the simultaneous and sequential contribution game satisfy $g_i^{Sm} > g_i^{Seq}$ if and only if either both players are net status-seekers ($\alpha_i > m$ and $\alpha_j > m$), or both are net free-riders ($\alpha_i < m$ and $\alpha_j < m$). Player j's equilibrium donations satisfy $g_j^{Sm} > g_j^{Seq}$, if and only if player i is a net status-seeker ($\alpha_i > m$).*

That is, when players' value of status is relatively *homogenous* (both players are net status-seekers or both are net free-riders), the first mover contributes more in the simultaneous PGG than in its sequential version. This result is indicated in figure 5(a) below for those quadrants in which $g_i^{Sm} > g_i^{Seq}$. If, on the contrary, players' value of status is relatively *heterogeneous*, i.e., if $\alpha_i > m$ and $\alpha_j < m$ for all $j \neq i$ (one player is a net status-seeker while the other is a net free-rider), then the above inequality is reversed, i.e., $g_i^{Sm} < g_i^{Seq}$.

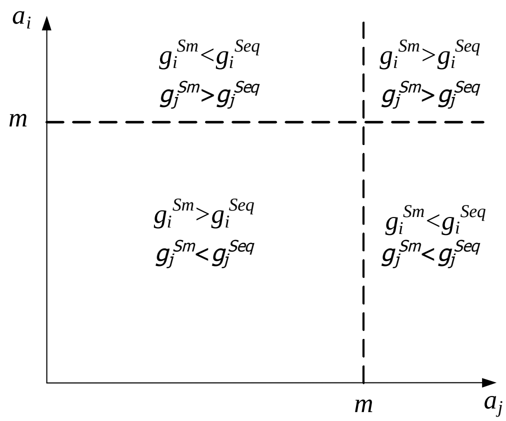

Figure 5(a): Individual comparisons.

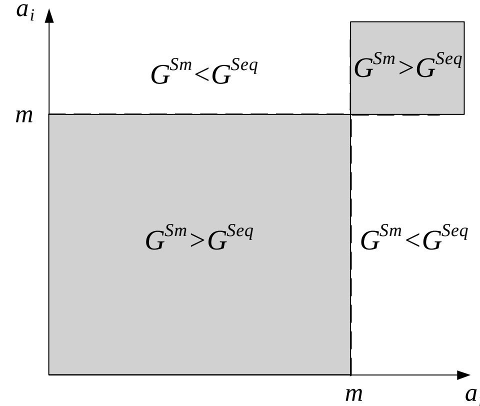

Figure 5(b): Revenue comparisons.

In the case of player j, note that $g_j^{Sm} > g_j^{Seq}$ if player i is a net status-seeker. Intuitively, when $\alpha_i > m$ player i (the first mover in the sequential game) induces player j to "give-up" from the competition for social status by submitting a sufficiently high donation. In contrast, when $\alpha_i < m$ player i "tempts" player j to win the competition for social status by submitting a sufficiently low contribution which can be easily exceeded. After describing the ranking of individual contributions, let us now rank total contributions.

Proposition 3. *Total donations under the simultaneous contribution game are higher than under the sequential game, $G^{Sm} > G^{Seq}$, if and only if either both players are net status-seekers ($\alpha_i > m$ and $\alpha_j > m$), or both are net free-riders ($\alpha_i < m$ and $\alpha_j < m$).*

The results from this proposition are graphically illustrated in figure 5(b) above. Shaded areas indicate sets of parameters values for which the simultaneous contribution mechanism provides higher revenues to the charity than the sequential game, $G^{Sm} > G^{Seq}$, whereas unshaded areas support the contrary, i.e., $G^{Sm} < G^{Seq}$.

Let us first elaborate on those parameter values supporting $G^{Sm} > G^{Seq}$, where both donors are net status-seekers ($\alpha_i > m$ and $\alpha_j > m$) or both are net free-riders ($\alpha_i < m$ and $\alpha_j < m$). In the first case, competition for social status is so intense in the simultaneous version of the game that $G^{Sm} > G^{Seq}$. In the second case, when both players are net free-riders, we find equilibrium predictions resembling those in PGGs where players do not care about status. In particular, since both players consider each others' contributions as strategic substitutes, the first mover reduces his contribution anticipating that the second donor will increase his, what he then free-rides. Since, in addition, the second mover does not increase his donation enough to compensate for such a decrease, we observe $G^{Sm} > G^{Seq}$.

Let us now analyze those parameter values for which $G^{Sm} < G^{Seq}$, which occurs when only one donor is a net status-seeker while the other is a net free-rider, i.e., $\alpha_i > m$ and $\alpha_j < m$ for all $i = \{1,2\}$ and $j \neq i$. As described in the previous section, when the first donor is the only status-seeker, he induces the second mover (a net free-rider) to "give up" from the competition by submitting a sufficiently high contribution, which cannot be exceeded by the second donor.

On the other hand, when the second mover is the only net status-seeker, $\alpha_i < m$ and $\alpha_j > m$, the first donor (net free-rider) submits a low contribution, that "tempts" the second mover with the chance to win the competition by contributing a higher donation to the charity. Finally, note that when both players assign the same value to status acquisition, $\alpha_i = \alpha_j$, as illustrated in the 45^0-line of figure 5(b), total contributions satisfy $G^{Sm} > G^{Seq}$, for any parameter values. This result extends that of Varian (1994), who determines that $G^{Sm} > G^{Seq}$ when $\alpha_i = \alpha_j = 0$ in the standard public good game where players do not assign any value to status acquisition.

6 Extensions

6.1 Seniority in status

Previous sections considered that individuals can only acquire status through their donations while playing the PGG. Donors, however, were not allowed to start the voluntary contribution game with some previous status arising, for example, from their prior donations to the charity during past solicitation mechanisms or from any other source (generally, what we henceafter refer "seniority" in status). In this section, I analyze how our results would change when allowing for such seniority in status. In particular, assuming that players i and j start the PGG with previous seniority levels of S_i and S_j respectively, their utility function becomes

$$U_i = w - g_i + \ln\left[m\left(g_i + g_j\right) + \alpha_i\left(S_i + g_i - g_j\right)\right]$$

Let us first examine players' individual contributions in both the simultaneous and the sequential-move game.

Proposition 4. *In the simultaneous and sequential contribution game, player i's equilibrium contribution is weakly decreasing in his own seniority in status, S_i, for any parameter values; but weakly increasing in the other player's seniority in status, S_j, if and only if $\alpha_i < m$.*

That is, the seniority player i acquires in previous rounds of the game works as a substitute of the status that he can acquire today by raising his contribution to the charity.[8] Nonetheless, a greater seniority of player j, S_j, leads player i to increase his contribution only if he is a net free-rider. In particular, an increase in player j's seniority, S_j, reduces her own contribution today,

[8] This result is a consequence of how seniority in status enters into players' utility function. If seniority entered scaling up the difference between individual contributions, i.e., $\alpha_i\left(g_i - g_j\right)S_i$, an increase in S_i would have the same effect in player i's equilibrium donations as a raise in α_i. That is, status acquired during previous and current time periods would work as a strategic complement of status acquired today, and an increase in S_i would lead player i to *raise* her contribution g_i. More empirical research is needed, however, to determine how seniority in status enters into donors' preferences.

thus increasing that of player i, since the latter's best response function is negatively sloped (i.e., $\alpha_i < m$ as he is a net free-rider). Let us finally determine which solicitation order generates the highest revenue for the charity. Since our results from section six are not modified, we refer to that section and to figure 5(b) for a discussion of their intuition.

Proposition 5. *Total contributions under the simultaneous game are higher than under the sequential game, $G^{Sm} > G^{Seq}$, if and only if either both players are net status-seekers ($\alpha_i > m$ and $\alpha_j > m$), or both are net free-riders ($\alpha_i < m$ and $\alpha_j < m$).*

6.2 What if players could donate more than once?

We assumed that charities only allow donors to give once. This assumption is equivalent to considering that charities allow players to contribute many times, but donations are not revealed until the end of the game. Indeed, this interpretation generates the same individual and total contributions. If, instead, contributions are revealed in-between periods, it can be shown that the above one-period simultaneous contributions $\left(g_i^{Sm}, g_j^{Sm}\right)$ are the unique equilibrium of the game when players are relatively homogeneous in their concerns for status, i.e., $\alpha_i > m$ and $\alpha_j > m$ or if $\alpha_i < m$ and $\alpha_j < m$.[9] This provides an interesting implication to our results, since in these cases the introduction of new stages in the game (in which players could modify their initial contributions to the charity) would not modify the equilibrium donations identified in this paper, maintaining our ranking results as well.

7 Conclusions

Recent experimental evidence (as well as casual observation) support status acquisition as an individual incentive for charitable giving. Nonetheless, and despite its interest, relatively few studies have analyzed this topic from a theoretical approach. We find that, under certain parameter conditions, contributors' giving decisions are increasing both in their own concerns for status, α_i, and that of the other donor, α_j. This pattern clearly reflects donors' competition in their contributions with the objective of acquiring higher social status, which is confirmed both in the simultaneous and sequential solicitation mechanisms. In addition, I identify what parameter values induce the charity to choose a simultaneous over a sequential contribution order. In particular, I show that the charity prefers simultaneous PGGs when players are sufficiently homogeneous in the relative value they assign to status acquisition.[10] Otherwise, the charity prefers the sequential mechanism.

In an extension, I analyze how the above results would be modified if we allow donors to start their competition for status acquisition with previously acquired "stocks" of status, i.e., seniority in status. In particular, the results in terms of what contribution mechanism is more profitable for the charity are not changed. However, several insights about the role of seniority in status

[9] Otherwise, multiple contribution profiles can be supported in the equilibrium of the repeated game.

[10] This result is similar to that of Dixit (1987) for contests where players expend effort to win a certain prize.

are obtained. Specifically, I demonstrate that when previous status enters additively into donors' concerns, seniority may work as an strategic substitute for the status that donors can acquire through current donations, reducing their contributions. In contrast, if currently acquired status emphasizes previously acquired rankings, then status acquired during different periods works as strategic complements, and current donations are increased.

Different extensions of this paper would enhance our understanding of the role of status acquisition in PGG. First, it would be interesting to analyze how a charity can influence donors' concerns about status, by inducing on them higher or lower preferences for status acquisition. Second, we could extend this model by considering status acquisition in PGGs with incomplete information. In such settings contributors do not know each other's preferences for status, which is closer to many real-life situations, where donors may have a common understanding of the return from the public good, but may not know each others' preferences for status acquisition. Further research in this area can certainly provide additional insights about donors' incentives to contribute to charities, how status acquisition affects their giving decisions and, finally, how does it lead them to compete in their contributions.

8 Appendix

8.1 *Proof of Lemma 1*

Both players are asked to simultaneously submit their voluntary contributions to the public good. Fixing subject j's contribution, g_j, we have that

$$g_i(g_j) = \begin{cases} 1 \text{ if } g_j = 0 \\ 1 + \frac{\alpha_i - m}{\alpha_i + m} g_j \text{ if } g_j \in \left(0, \frac{m+\alpha_i}{m-\alpha_i}\right] \\ 0 \text{ if } g_j \in \left(\frac{m+\alpha_i}{m-\alpha_i}, +\infty\right) \end{cases}$$

if $\alpha_i < m$. Note that $0 \geq 1 + \frac{\alpha_i - m}{\alpha_i + m} g_j \Longleftrightarrow g_j \geq \frac{m+\alpha_i}{m-\alpha_i}$ and this threshold is positive if $\alpha_i < m$, see figure 1(a). In contrast, when $\alpha_i > m$ this threshold is never binding for any positive g_j, i.e., g_i does not become zero or negative for any positive value of g_j, see figure 1(b). The corresponding best response function for player i in this case is

$$g_i(g_j) = \begin{cases} 1 \text{ if } g_j = 0 \\ 1 + \frac{\alpha_i - m}{\alpha_i + m} g_j \text{ if } g_j > 0 \end{cases}$$

■

8.2 *Proof of Proposition 1*

First, take a given player i's best response function, $g_i(g_j)$. Then, $g_i^{Sm} = 1$ only when: (1) the slope of player j's best response function, $g_j(g_i)$, is smaller than -1, and (2) the horizontal intercept of player i's best response function, $g_i(g_j)$, is higher than 1. Otherwise, both players' best response functions would cross each other in an interior point. That is, $g_i^{Sm} = 1$ if and only if $\frac{\alpha_j - m}{\alpha_j + m} \leq -1 \iff \alpha_j \leq 0$. And $\frac{m+\alpha_i}{m-\alpha_i} \geq 1$ if and only if $\alpha_i > 0$

Since $\alpha_i, \alpha_j \geq 0$, the above conditions on player i and j's concerns about status are $\alpha_i \geq 0$ and $\alpha_j = 0$. Hence, $g_i^{Sm} = 1$ if and only if $\alpha_i \geq 0$ and $\alpha_j = 0$. Secondly, $g_i^{Sm} = 0$ only when the opposite happens. That is, when $\alpha_i = 0$ and $\alpha_j \geq 0$. Finally, when none of the above cases is satisfied, i.e., when $\alpha_i > 0$ and $\alpha_j > 0$, then we have an interior solution. Solving for g_i and g_j in a system of two equations, we obtain $g_i^{Sm} = \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m}$, as the interior Nash equilibrium contribution level.

Sufficiency

Let us now check that the second order conditions of incentive compatibility are satisfied. Suppose all but player i submit a contribution to the public good according to the above equilibrium prediction. I next show that, for any α_i, contributor i maximizes his utility by following g_i^{Sm}. Let

$$U(g, \alpha_i) = w - g_i + \ln\left[m(g_i + g_j^{Sm}) + \alpha_i\left(g_i - g_j^{Sm}\right)\right]$$

be the utility level of player i when contributing g to the public good, and having a concern α_i about status acquisition. We must now show that the derivative $U_g(g, \alpha_i) \geq 0$ for all $g < g_i^{Sm}$, and $U_g(g, \alpha_i) \leq 0$ for all $g > g_i^{Sm}$, which imply that $U(g, \alpha_i)$ is indeed maximized at exactly $g = g_i^{Sm}$. Differentiating $U(g, \alpha_i)$ with respect to g,

$$U_g(g, \alpha_i) = -1 + \frac{\alpha_i + m}{\alpha_i\left(g - g_j^{Sm}\right) + m(g + g_j^{Sm})}$$

Let us now suppose that $g < g_i^{Sm}(\alpha_i)$, and denote $\tilde{\alpha}_i$ to be the concern about status for which the equilibrium contribution is exactly g, i.e., $g_i^{Sm}(\tilde{\alpha}_i) = g$. Since $g_i^{Sm}(\alpha_i)$ is strictly increasing in α_i (as one can check from the suggested equilibrium contribution g_i^{Sm}, and confirmed in lemma 4) this implies that $g_i^{Sm}(\alpha_i) > g_i^{Sm}(\tilde{\alpha}_i)$ if and only $\alpha_i > \tilde{\alpha}_i$. Then, $U_g(g, \tilde{\alpha}_i) \leq U_g(g, \alpha_i)$. Since by definition, $g_i^{Sm}(\tilde{\alpha}_i) = g$, it implies that $U_g(g, \tilde{\alpha}_i) = 0$. Hence, $U_g(g, \alpha_i) \geq 0$ for all $g < g_i^{Sm}$. By a similar argument, $U_g(g, \alpha_i) \leq 0$ for all $g > g_i^{Sm}$. Therefore, $U(g, \alpha_i)$ is maximized at $g = g_i^{Sm}$. ■

8.3 *Proof of Lemma 2*

Differentiating g_i^{Sm} with respect to α_i, we obtain

$$\frac{\partial g_i^{Sm}}{\partial \alpha_i} = \begin{cases} 0 \text{ if } \alpha_i > 0 \text{ and } \alpha_j = 0 \\ \frac{\alpha_j(\alpha_j+m)}{(\alpha_i+\alpha_j)^2 m} \text{ if } \alpha_i > 0 \text{ and } \alpha_j > 0 \\ 0 \text{ if } \alpha_i = 0 \text{ and } \alpha_j > 0 \end{cases}$$

which is weakly positive for all parameter values. On the other hand, differentiating g_i^{Sm} with respect to

α_j, we obtain

$$\frac{\partial g_i^{Sm}}{\partial \alpha_j} = \begin{cases} 0 \text{ if } \alpha_i > 0 \text{ and } \alpha_j = 0 \\ \frac{\alpha_i(\alpha_i - m)}{(\alpha_i+\alpha_j)^2 m} \text{ if } \alpha_i > 0 \text{ and } \alpha_j > 0 \\ 0 \text{ if } \alpha_i = 0 \text{ and } \alpha_j > 0 \end{cases}$$

which is weakly positive for all parameter values if $\alpha_i \geq m$. Finally, differentiating g_i^{Sm} with respect to α_j, we obtain

$$\frac{\partial g_i^{Sm}}{\partial \alpha_j} = \begin{cases} 0 \text{ if } \alpha_i > 0 \text{ and } \alpha_j = 0 \\ -\frac{\alpha_i \alpha_i}{(\alpha_i+\alpha_j) m^2} \text{ if } \alpha_i > 0 \text{ and } \alpha_j > 0 \\ 0 \text{ if } \alpha_i = 0 \text{ and } \alpha_j > 0 \end{cases}$$

which is weakly negative for all parameter values. ■

8.4 *Proof of Lemma 3*

If $\alpha_i > 0$ and $\alpha_j = 0$, then from proposition 1 we know that $g_i^{Sm} = 1$ and $g_j^{Sm} = 0$. Hence, $G^{Sm} = 1$. If, on the contrary, $\alpha_i = 0$ and $\alpha_j \geq 0$, then from proposition 1 we also know that $g_i^{Sm} = 0$ and $g_j^{Sm} = 1$. Hence, $G^{Sm} = 1$ as well. Finally, if $\alpha_i > 0$ and $\alpha_j = 0$, then $g_i^{Sm} = \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m}$, and similarly for player j, what leads to $G^{Sm} = 1 + \frac{2\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m}$.

Note that if status concerns (α_i, α_j) are chosen in order to maximize G^{Sm}, $\max\limits_{\alpha_i,\alpha_j \geq 0} G^{Sm}$, we obtain the following first order condition for every α_i, $\frac{2\alpha_j^2}{(\alpha_i+\alpha_j)^2 m} \leq 0$, and for α_j, $\frac{2\alpha_i^2}{(\alpha_i+\alpha_j)^2 m} \leq 0$. This gives a continuum of (α_i, α_j) pairs for which G^{Sm} is maximal at $\alpha_i = \alpha_j = \alpha$, and increasing both in α_i and in α_j. ■

8.5 *Proof of Proposition 2*

Operating by sequential rationality, player i inserts the follower's best response function into his utility function, $U_i = w - g_i + \ln\left[m(g_i + g_j(g_i)) + \alpha_i\left(g_i - g_j(g_i)\right)\right]$, which is maximized at

$$g_i^{Seq} = \begin{cases} 0 \;\text{ if }\; \alpha_i \in [0, \bar{\alpha}_i] \\ \frac{\alpha_i\alpha_j + 3\alpha_i m + \alpha_j m - m^2}{2m(\alpha_i+\alpha_j)} \text{ if } \alpha_i \in (\bar{\alpha}_i, +\infty) \end{cases}$$

where $\bar{\alpha}_i = \frac{m(m-\alpha_j)}{3m+\alpha_j}$ Given the above contribution of the first donor and $g_j(g_i)$ specified above, player j submits

$$g_j^{Seq} = \begin{cases} 1 \;\text{ if }\; \alpha_i \in [0, \bar{\alpha}_i) \\ \frac{1}{2}\left(\frac{\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m} + \frac{m}{\alpha_i+\alpha_j} + \frac{4\alpha_j}{\alpha_j+m} - 1\right) \text{ if } \alpha_i \in [\bar{\alpha}_i, \hat{\alpha}_i) \\ 0 \text{ if } \alpha_i \in [\hat{\alpha}_i, +\infty) \end{cases}$$

if $\alpha_j < m$. Clearly, note that when player j's best response function is negative, i.e., $\alpha_j < m$, player j submits no positive contribution if $1 - \frac{\alpha_i - m}{\alpha_i + m} g_j \geq \frac{m+\alpha_j}{m-\alpha_j}$, or in equilibrium, when $\alpha_i \geq \hat{\alpha}_i$, where $\hat{\alpha}_i = \frac{m\left(3\alpha_j^2+m^2\right)}{-\alpha_j^2 - 4\alpha_j m + m^2}$ On the other hand, if player j's best response function is positive, $\alpha_j > m$, player j

submits

$$g_j^{Seq} = \begin{cases} 1 \text{ if } \alpha_i \in [0, \bar{\alpha}_i) \\ \frac{1}{2}\left(\frac{\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m} + \frac{m}{\alpha_i+\alpha_j} + \frac{4\alpha_j}{\alpha_j+m} - 1\right) \text{ if } \alpha_i \in [\bar{\alpha}_i, +\infty) \end{cases}$$

Clearly, the above two expressions for g_j^{Seq} can be simplified to

$$g_j^{Seq} = \begin{cases} 1 \text{ if } \alpha_i \in [0, \bar{\alpha}_i) \\ \frac{1}{2}\left(\frac{\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m} + \frac{m}{\alpha_i+\alpha_j} + \frac{4\alpha_j}{\alpha_j+m} - 1\right) \text{ if } \alpha_j < m \text{ and } \alpha_i \in [\bar{\alpha}_i, \hat{\alpha}_i)\text{, or if } \alpha_j > m \text{ and } \alpha_i \in [\bar{\alpha}_i, +\infty) \\ 0 \text{ if } \alpha_j < m \text{ and } \alpha_i \in [\hat{\alpha}_i, +\infty) \end{cases}$$

8.6 *Proof of Corollary 1*

First result: From proposition 2, we know that player i submits strictly positive contributions if and only if $\alpha_i > \frac{m(m-\alpha_j)}{3m+\alpha_j}$. Then, if $\alpha_i = 0$, the former condition can only be satisfied if $0 > \frac{m(m-\alpha_j)}{3m+\alpha_j} \iff \alpha_j > m$.

Second result: Since $\bar{\alpha} = \frac{m(m-\alpha_j)}{3m+\alpha_j} < m$, for any $\alpha_j \geq 0$, then if $m < \alpha_i$ we must have $\bar{\alpha} < m < \alpha_i$ for any $\alpha_j \geq 0$. Therefore, $\bar{\alpha} < \alpha_i$, and player i submits a strictly positive contribution for any concern about status player j may have, $\alpha_j \geq 0$. ■

8.7 *Proof of Lemma 4*

Differentiating g_i^{Seq} with respect to α_i, we obtain

$$\frac{\partial g_i^{Seq}}{\partial \alpha_i} = \begin{cases} 0 \text{ if } \alpha_i \in [0, \bar{\alpha}_i] \\ \frac{(\alpha_j+m)^2}{2(\alpha_i+\alpha_j)^2 m} \text{ if } \alpha_i > \bar{\alpha}_i \end{cases}$$

which is weakly positive for any parameter values. On the other hand, differentiating g_i^{Seq} with respect to α_j, we obtain$\frac{(\alpha_i-m)^2}{2(\alpha_i+\alpha_j)^2 m}$

$$\frac{\partial g_i^{Seq}}{\partial \alpha_j} = \begin{cases} 0 \text{ if } \alpha_i \in [0, \bar{\alpha}_i] \\ \frac{(\alpha_i-m)^2}{2(\alpha_i+\alpha_j)^2 m} \text{ if } \alpha_i > \bar{\alpha}_i \end{cases}$$

which is weakly positive for any parameter values. ■

8.8 *Proof of Lemma 5*

When $\alpha_i < \bar{\alpha}_i$, we know from proposition 2 that player i does not contribute, but player j responds submitting a contribution of $g_j^{Seq} = 1$. This is valid both when $\alpha_j < m$ and when $\alpha_j < m$. Then, $G^{Seq} = 1$.

In contrast, when $\alpha_i \in [\bar{\alpha}_i \hat{\alpha}_i)$ and $\alpha_j < m$ (or when $\alpha_i \in [\bar{\alpha}_i + \infty)$ and $\alpha_j > m$) from proposition 2 we know that player i submits $g_i^{Seq} = \frac{\alpha_i\alpha_j + 3\alpha_i m + \alpha_j m - m^2}{2m(\alpha_i+\alpha_j)}$ while player j responds by submitting

$$g_j^{Seq} = \frac{1}{2}\left(\frac{\alpha_i\alpha_j}{(\alpha_i+\alpha_j)m} + \frac{m}{\alpha_i+\alpha_j} + \frac{4\alpha_j}{\alpha_j+m} - 1\right)$$

Then, the total contributions when $\alpha_i > \bar{\alpha}_i$ adds up to $G^{Seq} = \frac{2\alpha_j}{\alpha_j+m} + \frac{\alpha_i(\alpha_j+m)}{(\alpha_i+\alpha_j)m}$ Finally, if $\alpha_i \in [\bar{\alpha}_i + \infty)$ and $\alpha_j < m$, from proposition 2 we know that player i submits $g_i^{Seq} = \frac{\alpha_i\alpha_j+3\alpha_i m+\alpha_j m-m^2}{2m(\alpha_i+\alpha_j)}$ and player j does not submit any positive contribution (since his best response function is positively sloped and, for these parameter values, it crosses the g_i-axis), what implies $G^{Seq} = \frac{\alpha_i\alpha_j+3\alpha_i m+\alpha_j m-m^2}{2m(\alpha_i+\alpha_j)}$. ■

8.9 *Proof of Lemma 6*

Regarding player i, the difference between his equilibrium contribution in the simultaneous and sequential game is $\frac{(\alpha_i-m)(\alpha_j-m)}{2(\alpha_i+\alpha_j)m}$ which is positive if either $\alpha_i > m$ and $\alpha_j > m$, or if $\alpha_i < m$ and $\alpha_j < m$. Hence, if $\alpha_i > m$ and $\alpha_j > m$ (or if $\alpha_i < m$ and $\alpha_j < m$), then $g_i^{Sm} > g_i^{Seq}$. Regarding player j, the difference between his equilibrium contribution in the simultaneous and sequential game is $\frac{(\alpha_i-m)(\alpha_j-m)^2}{2(\alpha_i+\alpha_j)m(\alpha_j-m)}$ which is positive if and only if $\alpha_i > m$. Hence, if $\alpha_i > m$, $g_j^{Sm} > g_j^{Seq}$. ■

8.10 *Proof of Proposition 3*

Applying proposition 1 of Romano and Yildirim (2001), we know that whenever $1 + \frac{\partial g_j(g_i)}{\partial g_i} > 0$, the sign of $\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i}$ and $G^{Seq} - G^{Sm}$ coincide. Let us then first find $1 + \frac{\partial g_j(g_i)}{\partial g_i}$. In particular, $1 + \frac{\partial g_j(g_i)}{\partial g_i} = 1 + \frac{\alpha_j-m}{\alpha_j+m}$which is positive for any $\alpha_j > 0$. On the other hand, from corollary 1, we know that for any $i, j = \{1, 2\}$ where $j \neq i$

$$\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i} = \begin{cases} > 0 \text{ if } \alpha_i < m \text{ and } \alpha_j > m, \\ < 0 \quad \text{otherwise} \end{cases}$$

Therefore, if $\alpha_i < m$ and $\alpha_j > m$, for all $i, j = \{1, 2\}$ and $j \neq i$, then $\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i} > 0$ and $G^{Seq} > G^{Sm}$and if $\alpha_i > m$ and $\alpha_j > m$ (or if $\alpha_i < m$ and $\alpha_j < m$), then $\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i} < 0$ and $G^{Seq} < G^{Sm}$ ■

8.11 *Proof of Proposition 4*

First, take a given player i's best response function, $g_i(g_j)$. Then, $g_i^{Sm,Sen} = 1 - \frac{\alpha_i S_i}{\alpha_i+m}$ only when: (1) the slope of player j's best response function, $g_j(g_i)$, is smaller than -1, and (2) the horizontal intercept of player i's best response function, $g_i(g_j)$, is higher than $1 - \frac{\alpha_j S_j}{\alpha_j+m}$. Otherwise, both players' best response functions would cross each other in an interior point. Therefore, $g_i^{Sm,Sen} = 1 - \frac{\alpha_i S_i}{\alpha_i+m}$ if and only if

$$\begin{aligned} \frac{\alpha_j - m}{\alpha_j + m} &\leq -1 \Longleftrightarrow \alpha_j \leq 0, \text{ and} \\ \frac{\alpha_i S_i - \alpha_i - m}{\alpha_i - m} &\geq 1 - \frac{\alpha_j S_j}{\alpha_j + m} \Longleftrightarrow \alpha_i \geq \frac{\alpha_j S_j m}{\alpha_j (S_i + S_j - 2) + (S_i - 2) m} \end{aligned}$$

Since $\alpha_i, \alpha_j \geq 0$, the above conditions on player i and j's concerns about status are $\alpha_i \geq \frac{\alpha_j S_j m}{\alpha_j(S_i+S_j-2)+(S_i-2)m}$ and $\alpha_j = 0$. Secondly, $g_i^{Sm,Sen} = 0$ when the opposite happens. That is, when $\alpha_i = 0$ and $\alpha_j \geq \frac{\alpha_i S_i m}{\alpha_i(S_j+S_i-2)+(S_j-2)m}$. Finally, when both $\alpha_i \geq \frac{\alpha_j S_j m}{\alpha_j(S_i+S_j-2)+(S_i-2)m}$ and $\alpha_j \geq \frac{\alpha_i S_i m}{\alpha_i(S_j+S_i-2)+(S_j-2)m}$, we have an interior solution. Solving for g_i and g_j in a system of two equations, we obtain interior solutions, and therefore,

$$g_i^{Sm,Sen} = \begin{cases} 1 - \frac{\alpha_i S_i}{\alpha_j + m} \text{ if } \alpha_i \geq \tilde{\alpha}_i \text{ and } \alpha_j \geq 0 \\ \frac{\alpha_j S_j m - \alpha_i[\alpha_j(S_i+S_j-2)+m(S_i-2)]}{2(\alpha_i+\alpha_j)m} \text{ if } \alpha_i \geq \tilde{\alpha}_i \text{ and } \alpha_j \geq \tilde{\alpha}_j \\ 0 \text{ if } \alpha_i \geq 0 \text{ and } \alpha_j \geq \tilde{\alpha}_j \end{cases}$$

where $\tilde{\alpha}_i = \frac{\alpha_j S_j m}{\alpha_j(S_i+S_j-2)+(S_i-2)m}$ and $\tilde{\alpha}_j = \frac{\alpha_i S_i m}{\alpha_i(S_j+S_i-2)+(S_j-2)m}$. Differentiating $g_i^{Sm,Sen}$ with respect to S_i, $\frac{\partial g_i^{Sm,Sen}}{\partial S_i} = -\frac{\alpha_i(\alpha_j+m)}{2(\alpha_i+\alpha_j)m}$ which is negative for all parameter values. Similarly, differentiating $g_i^{Sm,Sen}$ with respect to S_j, we have $\frac{\partial g_i^{Sm,Sen}}{\partial S_j} = \frac{\alpha_j(m-\alpha_i)}{2(\alpha_i+\alpha_j)m}$ which is negative if and only if $m < \alpha_i$. Using the second mover's best response function, $g_j(g_i)$, from lemma 10, we know that

$$g_i(g_j) = \begin{cases} 1 - \frac{\alpha_j S_j}{\alpha_j + m} \text{ if } g_i = 0 \\ 1 - \frac{\alpha_j S_j}{\alpha_j + m} + \frac{\alpha_j - m}{\alpha_j - m} g_j \text{ if } g_i \in [0, \frac{\alpha_j S_j - \alpha_j - m}{\alpha_j - m}] \\ 0 \text{ if } g_i > \frac{\alpha_j S_j - \alpha_j - m}{\alpha_j - m} \end{cases}$$

Regarding player i, we know that he inserts the above best response function into his utility function, $U_i = w - g_i + \ln\left[m(g_i + g_j(g_i)) + \alpha_i\left(S_i + g_i - g_j(g_i)\right)\right]$ and differentiating with respect to g_i, and solving for g_i we obtain the following optimal contribution

$$g_i^{Seq,Sen} = \begin{cases} 0 \text{ if } \alpha_i \in [0, \alpha_i^A] \\ \frac{(\alpha_j+\alpha_j S_j - m)m - \alpha_i[\alpha_j(S_i+S_j-1)+(S_i-3)m]}{2(\alpha_j+\alpha_j)m} \text{ if } \alpha_i > \alpha_i^A \end{cases}$$

where $\alpha_i^A = \frac{(\alpha_j+\alpha_j S_j-m)m}{\alpha_j(S_i+S_j-1)+(S_i-3)m}$. Given the above contribution of the first mover, we can now use $g_j(g_i)$ to find player j's equilibrium contribution.

$$g_j^{Seq,Sen} = \begin{cases} 1 - \frac{\alpha_j S_j}{\alpha_j + m} \text{ if } \alpha_i \in [0, \alpha_i^A] \\ \frac{1}{2}\left[\frac{m}{\alpha_i+\alpha_j} + \frac{4\alpha_j}{\alpha_j+m} - \frac{\alpha_i+\alpha_j-\alpha_i S_i+\alpha_j S_j}{(\alpha_i+\alpha_j)m} - \frac{\alpha_i\alpha_j(S_i+S_j-4)}{\alpha_i+\alpha_j}\right] \text{ if } \alpha_i \in \left[\alpha_i^A, \alpha_i^B\right] \\ 0 \text{ if } \alpha_i > \alpha_i^B \end{cases}$$

where $\alpha_i^A = \frac{(\alpha_j+\alpha_j S_j-m)m}{\alpha_j(S_i+S_j-1)+(S_i-3)m}$ and $\alpha_i^B = \frac{m\left(m^2-(S_j-3)\alpha_j^2-\alpha_j S_j m\right)}{\alpha_j^2(S_i+S_j-1)+m\alpha_j(S_j-4)-m^2(S_i-1)}$. Differentiating $g_i^{Seq,Sen}$ and $g_j^{Seq,Sen}$ with respect to S_i and S_j, respectively, we obtain

$$\frac{\partial g_i^{Sm,Sen}}{\partial S_i} = -\frac{\alpha_i\left(\alpha_j+m\right)}{2\left(\alpha_i+\alpha_j\right)m}, \text{ and } \frac{\partial g_j^{Sm,Sen}}{\partial S_j} = -\frac{\alpha_j\left(\alpha_i+m\right)}{2\left(\alpha_i+\alpha_j\right)m}$$

which are negative for all parameter values. Similarly, differentiating $g_i^{Seq,Sen}$ and $g_j^{Seq,Sen}$ with respect to S_j and S_i, respectively, we have

$$\frac{\partial g_i^{Sm,Sen}}{\partial S_j} = \frac{\alpha_j\left(m-\alpha_i\right)}{2\left(\alpha_i+\alpha_j\right)m}, \text{ and } \frac{\partial g_j^{Sm,Sen}}{\partial S_i} = \frac{\alpha_i\left(m-\alpha_j\right)}{2\left(\alpha_i+\alpha_j\right)m}$$

which are negative if and only if $m < \alpha_i$ and $m < \alpha_j$ respectively. ■

8.12 *Proof of Proposition 5*

Applying Romano and Yildirim (2001), we know that whenever $1 + \frac{\partial g_j(g_i)}{\partial g_i} > 0$, the sign of $\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i}$ and $G^{Seq} - G^{Sm}$ coincide. Let us then first find $1 + \frac{\partial g_j(g_i)}{\partial g_i}$. In particular, $1 + \frac{\partial g_j(g_i)}{\partial g_i} = 1 + \frac{\alpha_j - m}{\alpha_j + m}$ which is positive for any $\alpha_j > 0$. On the other hand, $\frac{\partial U_i}{\partial g_j} = \frac{-\alpha_i + m}{\alpha_i(S_i + g_i - g_j) + m(g_i + g_j)}$ which is negative if and only if $\alpha_i > m$. Then, from corollary 1, we know that for any $j \neq i$

$$\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i} = \begin{cases} > 0 \text{ if } \alpha_i < m \text{ and } \alpha_j > m, \\ < 0 \quad \text{otherwise} \end{cases}$$

Therefore, if $\alpha_i < m$ and $\alpha_j > m$, for all $j \neq i$, then $\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i} > 0$ and $G^{Seq} > G^{Sm}$ and if $\alpha_i > m$ and $\alpha_j > m$ (or if $\alpha_i < m$ and $\alpha_j < m$), then $\frac{\partial U_i}{\partial g_j}\frac{\partial g_j(g_i)}{\partial g_i} < 0$ and $G^{Seq} < G^{Sm}$ ■

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