Self-Serving Deviations from Standard Behavior: Investigating Income and Relative Return Differentials in Voluntary Contributions Mechanisms

By Bachir Kassas, Marco Palma, and Charles Hall

Invited presentation at the 2018 Southern Agricultural Economics Association Annual Meeting, February 2-6, 2018, Jacksonville, Florida

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Abstract

Using a public goods experiment with heterogeneous income and marginal-per-capita-returns (MPCR), this paper examines the interaction between high- and low-income individuals in voluntary contributions mechanisms (VCMs). While free-riders were present among both income types, the majority of low-income individuals were keen on stimulating higher contributions through cooperation. On the other hand, high-income individuals were more prone to decreasing their contributions in the presence of the low-income type. Based on a finite mixture model, and a thorough analysis of the cross-treatment payoff structure, we argue that the behavior of both income types is driven by self-interest.

Keywords: finite mixture model, income heterogeneity, public goods, varying relative returns

JEL Classifications: C91, H41

I. INTRODUCTION

Public goods are an integral part of any society. Be it a public library, playground for the kids, or street lights in our neighborhood, we all need and often use public goods on a daily basis. Moreover, policy makers place primary interest in questions concerning the level and method of provision of public goods. How much of a public good should be provided, and how should a specific public good be financed, are issues that regularly confront policy makers.

Voluntary contributions mechanisms (VCMs) present a potentially convenient and efficient means of providing a public good. Using those mechanisms, individuals voluntarily pay money into an account to help finance the public good. Despite prominent free-riding tendencies induced by VCMs, there is ample experimental and real world evidence of significant positive contributions under those mechanisms. This fact has shifted interest towards determining the main motivations that drive voluntary contributions to public goods (Andreoni 1995; Sugden 1984; Andreoni 1990; Fehr and Gachter 2002; Palfrey and Prisbrey 1997; Anderson et al. 1998; Keser and van Winden 2000). To this end, this paper investigates the behavior in VCMs of individuals with heterogeneous incomes playing separately and in mixed groups with homogeneous and heterogeneous relative returns from the public good. This investigation will provide a better understanding of the dynamics surrounding the provision of public goods in richer and poorer neighborhoods. It also explains the interaction between higher- and lower-income individuals and changes in their behavior resulting from different expectations regarding their relative gain from the provision of the public good.

The predominant models in the literature explain giving in public goods games to be a result of social preferences, namely altruism, warm glow, inequality aversion, and reciprocity (Bolton and Ockenfels 2000; Andreoni 1989; Becker 1974; Sugden 1984). The first model,

altruism, argues that individuals derive utility from the consumption of others (Becker 1974; Andreoni 1989; Andreoni 1990; Levine 1998). Warm glow is somewhat related to altruism except that it is more concerned with the utility realized from the very act of giving (Kahneman and Knetsch 1992; Andreoni 1990; Andreoni 1995). On the other hand, inequality aversion assumes a fair individual who dislikes inequalities in income and/or consumption (Bolton and Ockenfelds 2000; Fehr and Schmidt 1999; Ashley et al. 2010), while reciprocity perceives fairness as the reciprocal action of mirroring the behavior of others (Sugden 1984; Fischbacher 2001; Croson 2007).

The vast experimental research on VCMs has identified several other factors that affect levels of contribution to public goods. For instance, Isaac et al. (1994) reported that group size is directly proportional to contribution levels. It was also found that contributions might be a result of confusion (Andreoni 1995), are enhanced by the presence of institutions (Kosfeld et al. 2009) and altruistic punishment (Fehr and Gatcher 2002), and are influenced by the particular framing of the task (Andreoni 1995; Park 2000).

Few papers have already considered the effect of income heterogeneity on contributions in VCMs. In fact, the effect of income heterogeneity has been examined using linear (Kachelmeier and Shehata 1997; Isaac and Walker 1988; Buckley and Croson 2006) and nonlinear (Bergstrom et al. 1986; Chan et al. 1996; Chan et al. 1999) public goods settings.[1] In a linear public goods setting, Kachelmeier and Shehata (1997) and Isaac and Walker (1988) studied the effects of monitoring and communication, respectively, on contributions using heterogeneous incomes. However, these papers do not separately report the contributions across different income levels.

[1] We only discuss literature pertaining to linear public goods in this paper. A review of some of the literature on nonlinear public goods is provided in Buckley and Croson (2006)

Buckley and Croson (2006) addressed this by designing an experiment where they used two endowment levels (25 and 50 tokens). By constructing mixed groups, consisting of two members from each endowment level, they were able to show that less wealthy individuals contribute the same as the wealthier in absolute terms, which of course translates to a higher percentage contribution by the less wealthy.

Heterogeneous relative returns, or marginal per capita returns (MPCR), have been theoretically investigated by Kinateder and Merlino (2017), who considered heterogeneity in cost and valuation in settings with endogenous networks. Experimental applications of this heterogeneity have been conducted by Isaac and Walker (1988), Fisher et al. (1995), and Cardenas et al. (2002). They all report a negative correlation between MPCR and contribution levels. However, while Isaac and Walker (1988) and Fisher et al. (1995) varied MPCR by changing the return from the public good, variations in MPCR were introduced in Cardenas et al. (2002) by changing the valuations of the private good.

In this paper, we combine heterogeneity in income and MPCR in order to gain a better understanding of the interactive effects of those two factors. Unlike Buckley and Croson (2006), high- and low-income individuals were placed in separated and mixed income groups. Heterogeneity in MPCR was introduced in the mixed income groups, which consisted of 2 low- and 2 high-income individuals. Specifically, three types of mixed income groups were constructed: 1) homogeneous MPCR; 2) increasing MPCR with income, where high-income individuals benefited more from the public good; and 3) decreasing MPCR with income, where low-income individuals benefited more from the public good. The comparison of separated income groups with mixed income, homogeneous MPCR groups will help us determine any changes in behavior resulting from the mere presence of high- or low-income members in the group. Moreover, the

cross comparison of mixed income groups with each other and with separated income groups will shed light on how differences in the relative gain of high- and low-income individuals from the public good affect their contributions. Analyzing those effects could potentially reveal some of the determining forces that shape contributions in those settings and some of the characteristics of the underlying individuals.

We find a significant increase in the average contributions of low-income individuals when high-income individuals are present, even when the public good bears the same benefit to all members (i.e., the mere presence of high-income individuals causes low-income individuals to contribute more to the public good). On the other hand, there is a significant decline in average contributions of high-income individuals when low-income individuals are present, even when the public good bears the same benefit to all members (i.e., the mere presence of low-income individuals causes high-income individuals to contribute less to the public good). Moreover, while there is evidence of free-riding behavior under both income levels, the percentage of high-income free-riders is significantly lower than the percentage of low-income free-riders. Our framework was analyzed using a structural model with different types of low- and high-income individuals. Low-income individuals were classified as either "free-riders" or "opportunists" (who strategically increase their contributions in the presence of high-income individuals in order to encourage higher contributions and gain access to the resources of high-income members). As for high-income individuals, they were classified as either "free-riders" or "selfists" (who, due to self-centered interests, deliberately decrease their contributions in situations where low-income individuals are present and/or are in advantageous positions). Finally, a tremble parameter was used to account for the possibility of mistakes and/or loss of concentration, thus allowing for a less rigid definition of free-riders.

The significance of this paper stems from its high applicability in the real-world and its role in providing policy makers a deeper understanding of the interaction between high- and low-income individuals and the dominant motivations determining their behavior towards public good provision. People have different occupations and income. They also live in very different neighborhoods ranging from the affluent to the slums. When faced with the potential provision of a certain public good or service, it is reasonable to also believe that people carry different valuations for it. These are significant factors that affect our daily lives, let alone our decisions concerning how much to contribute to a public good. By constructing simplified environments to isolate and examine those effects, we can shed more light on the main drivers of behavior in situations with heterogeneous income levels and relative returns.

The rest of the paper is organized as follows: the experimental design and procedures are described in section II, followed by a simplified theoretical model in section III, which explains potential behavior of both income types. Section IV includes the data analysis and a discussion of the main results, while section V presents the structural regression model, which was constructed based on observed regularities in the behavior of high- and low-income individuals. The last section briefly summarizes the main findings and concludes the paper.

II. EXPERIMENTAL DESIGN

A total of 140 undergraduate students were recruited to participate in the experiment, which consisted of a baseline and three treatment groups. Subjects were paid $5 for their participation plus the amount of any earnings they made during the experiment. Upon arrival to their session, subjects read and signed a consent form, after which they completed the public goods game (which

differed based on the treatment), filled a short questionnaire regarding demographic and socioeconomic characteristics, received their payments, and were escorted out of the session.[2]

Subjects were randomly split into high- and low-income types, where each subject participated in twelve rounds of the public goods game (2 practice and 10 real rounds). High-income type individuals were endowed with 750 tokens in each round, while low-income type individuals were endowed with 250 tokens in each round. Participants were divided into groups of 4 members, where each group played the public goods game separately. In each round, subjects were required to decide how to divide their endowments between two accounts: private and public accounts. Participants were explained that each token allocated to the private account yields 1 cent only to the person who invested it, while each token allocated to the public account yields a return less than one cent to all members of the group.

The return from every token allocated to the public account differed by treatment, as did the group composition. Following each round, each subject was given information regarding their own contribution to the public account, the total contribution of their group to the public account, their earnings from the private and public accounts, and their total earnings for the round. One of the ten real rounds was randomly selected as binding at the end of the experiment and subjects were paid according to their earnings in this binding round. The two practice rounds, along with various examples on how the private and public accounts work, were included in order to avoid confusion and to make sure that everyone had a good understanding of the procedure.

[2] This study was approved by the Institutional Review Board of the University and subjects were told that privacy will be maintained regarding their information and that any data collected will only be used for research purposes. The public goods game and subsequent questionnaire were computerized using z-Tree (Fischbacher 2007).

The instructions made it clear to the participants that the group members will remain anonymous to one another throughout the entire experiment and that at no point will the identity of any of the group members be revealed to the other members of the group. In order to avoid changes in behavior from reputation effects, a stranger design was implemented in which the participants were randomly reassigned to new groups each round. Moreover, subjects had an understanding that their investment decisions will be completely confidential, as will their earnings from each round.

The high- and low-income types played independent of each other in the baseline group, hereafter "*separated groups, homogeneous return*" (SHR). That is, each four-member group was entirely made up of either high-income or low-income individuals. Subjects were aware that each member in their group received the same number of tokens in each round (250 for low-income or 750 for high-income individuals). Also, within each group, every token that any member invests in the public account yielded half a cent to each member of the group (i.e., the MPCR was 0.5 for all members in the baseline treatment).

In the other three treatments, the high- and low-income types were mixed together in the same group, where each group was made up of 2 high-income and 2 low-income individuals. The participants were aware that the group members had different endowments, but they were not given information on the individual endowments of each member in the group. However, they knew their own endowment and the average endowment of the group (including them), which was 500 tokens in all cases. Hence, they were able to classify themselves as belonging to the high- or low-income types.

The first treatment, hereafter "*mixed groups, homogenous return"* (MHR), was identical to the baseline treatment in that the MPCR was equal to 0.5 for all members. The only difference was the group composition. In the second treatment, "*mixed groups, increasing return*" (MIR) the MPCR was directly proportional to the initial endowment, meaning that high-income individuals gained more than low-income individuals from every token invested in the public account. The participants were clearly explained that their return from every token that any of their group members invests in the public account is positively related to their endowments. The instructions also specified the individual MPCR, which was equal to 0.75 for high-income individuals and 0.25 for low-income individuals. Finally, in the third treatment, "*mixed groups, decreasing return*" (MDR), the MCPR was inversely proportional to the initial endowment, meaning that low-income individuals gained more than high-income individuals from every token invested in the public account. Again, this was clearly explained to the subjects and they were given their individual MPCR, which was 0.25 for high-income individuals and 0.75 for low income individuals. Table 1 summarizes the main parameters in each treatment.

[Insert Table 1 approximately here]

III. THEORETICAL FRAMEWORK

This section presents the main theoretical framework that explains potential changes in the behavior of high- and low-income individuals when heterogeneities in income and relative returns are introduced. The model presented here will be based on the well-established evidence of positive contributions to public goods and on the fact that individual contributions are positively correlated with group average contributions (Bardsley 2000; Fischbacher and Gatcher 2010). By incorporating those elements, we can write the payoff individual i realizes from the VCM in the following form:

$$u_i = (w_i - g_i) + ag_i + a\sum_{j=1}^{3} g_j(\bar{g}) \quad (1)$$

where w_i is the initial endowment for individual i, g_i is his/her contribution to the public account, a is the MPCR, the first term on the right-hand side represents the payoff from the amount he/she places in the private good, the second term is his/her payoff from own contribution to the public good, and the third term is his/her payoff from the contributions of other members to the public good. The dependency of individual contributions on group average contributions is captured by writing g_j as a function of $\bar{g}$, thus assuming that individual i is aware of, or alternatively believes in, this proportional relationship when deciding how much to invest in the public account. The positive correlation is captured by the assumption $\frac{\partial g_j}{\partial \bar{g}} > 0$.

Following this framework, we can represent the payoff of a low-income individual playing in a separated income group by:

$$u_i^P = (w_i^P - g_i^P) + ag_i^P + a\sum_{j=1}^{3} g_j^P(\bar{g}). \quad (2)$$

On the other hand, his/her payoff when playing in a mixed income group is given by:

$$v_i^P = (w_i^P - g_i^P) + ag_i^P + a\delta g_j^P(\bar{g}) + a\gamma\sum_{k=1}^{2} g_k^R(\bar{g}) \quad (3)$$

where δ and γ are reaction factor parameters, which capture how the low- and high-income individuals react to the general presence of members from the opposite income type. The idea behind those parameters is that, *ceteris paribus*, individuals might choose to change their general behavior in a public goods game merely because they find themselves playing with individuals from a different income class. For instance, the presence of high-income individuals might increase or decrease the low-income type's general aptitude for giving compared to what they would have done when playing in a separated income group. Over the course of the game, it is reasonable to

assume that those parameters will depend positively on own MPCR and group average contributions. Hence, we can write the parameters as $\delta(a, \bar{g})$ and $\gamma(a, \bar{g})$, with positive partial derivatives. If high- and low-income individuals are not responsive to the presence of the opposite income type, then γ and δ will take a value of one. On the other hand, if they react positively (negatively) with a general increase (decrease) in contributions, then γ and δ will be greater (less) than one.

Given this structure, we can consider the three possible behavioral changes a low-income individual can decide on as a result of playing with individuals from the opposite income type. Relative to what they would have done in a separated income group, low-income individuals can either increase or decrease their contributions or keep them unchanged. We start with the change in payoff resulting from an increase in contributions, which we calculate by assuming the individual contributes g_{oi}^{P} in the separated income group and g_{Hi}^{P} in the mixed income group (with $g_{Hi}^{P} > g_{oi}^{P}$) and subtracting equation (2) from (3) to get

$$\Delta u_i^P = \left(g_{oi}^P - g_{Hi}^P\right) + a\left(g_{Hi}^P - g_{oi}^P\right) + a\left[\delta g_j^P(\bar{g}_H) - g_j^P(\bar{g}_o)\right] + a\left[\gamma \sum_{k=1}^{2} g_k^R(\bar{g}_H) - \sum_{l=1}^{2} g_l^P(\bar{g}_o)\right] \quad (4)$$

The first term on the right hand side is the loss in payoff resulting from the decreased investment in the private account, while the second term is the gain resulting from the increased investment in the public account. This is straightforward since increasing one's contributions to the public good necessitates withdrawing that amount from the private account. The third term captures the gain or loss from the change in the behavior of the other low-income individual between separated and mixed income groups. Finally, the fourth term represents the gain or loss resulting from the difference in the contributions of the two remaining high-income individuals in the mixed income group and the two remaining low-income individuals in the separated income group.

Similarly, we can write the change in the payoff of low-income individuals if they decrease their contribution from g_{oi}^P to g_{Li}^P in the mixed income group as

$$\Delta u_i^P = \left(g_{oi}^P - g_{Li}^P\right) + a\left(g_{Li}^P - g_{oi}^P\right) + a\left[\delta g_j^P(\bar{g}_L) - g_j^P(\bar{g}_o)\right] + a\left[\gamma \sum_{k=1}^{2} g_k^R(\bar{g}_L) - \sum_{l=1}^{2} g_l^P(\bar{g}_o)\right] \quad (5)$$

while the change in their payoff resulting from a no change in contribution can be written as

$$\Delta u_i^P = a\left[\delta g_j^P(\bar{g}_o) - g_j^P(\bar{g}_o)\right] + a\left[\gamma \sum_{k=1}^{2} g_k^R(\bar{g}_o) - \sum_{l=1}^{2} g_l^P(\bar{g}_o)\right]. \quad (6)$$

A payoff maximizing agent will select the strategy that provides him/her with the most favorable change in outcome. While the sum of the first two terms is clearly negative in equation (4) and positive in equation (5), the outcome of the third and fourth terms depend on how the individual perceives δ and γ. However, it is straightforward to see that those terms are positively correlated with own contribution. Hence, they are higher in equation (4) than (5). This creates the tradeoff that defines the change in behavior. If individuals believe the benefits gained by increasing the contribution from g_{oi}^P to g_{Hi}^P (the last two terms in equation 4) outweigh the losses realized from the lower payoff generated by their own investments (the first two terms in equation 4) then they are better off increasing contributions in the mixed relative to the separated income group. If the opposite is true, then they are better off decreasing contributions. Finally, if they think the changes offset each other, then they are better off not changing their behavior. Similar logic can be applied to high-income individuals.[3]

Hypothesis 1: the individual's perception of δ and γ dictates their preferred change in behavior when playing with members from the opposite income type. They will select the strategy that maximizes their payoff.

[3] An elaborate discussion of the potential changes in the behavior of a high-income individual is presented in the appendix.

Based on this model, we can now investigate the effects of changing the a to understand potential changes in behavior in the treatments with heterogeneous MPCR. Looking at equation (4), we can see that as a increases, the first two terms become less negative (more positive in equation 5) while the third and fourth terms are scaled up. Moreover, considering the experimental design, we can note that $\delta(a, \bar{g})$ and $\gamma(a, \bar{g})$ move in opposite direction. This is because they are both positively correlated with a, which either increases for low- and decreases for high-income individuals or vice versa. Hence, the change in the individual's behavior when heterogeneity in MPCR is introduced depends on their perception of the potential changes in outcome resulting from alterations in $\delta(a, \bar{g})$ and $\gamma(a, \bar{g})$. This leads us to our second hypothesis.

Hypothesis 2: Changes in MPCR can stimulate further changes in contribution through their impact on δ and γ.

IV. RESULTS AND DISCUSSION

A breakdown of average total contributions and average percent contributions by treatment and income type is presented in Figure 1 and Table 2. The average total contributions, and average percent contributions, of low-income individuals are significantly higher in the MHR and MDR compared to the SHR and MIR treatments. In fact, besides the comparison between MHR and MIR, which was marginally significant (t-test, P=0.09), all cross comparisons of MHR and MDR with SHR and MIR were significant at the 95% confidence level (t-test, P<0.05). This is taken as evidence that lower-income individuals contribute more towards the public good when high-income individuals are present and the public good bears equal or more benefit to them. More importantly, the result indicates that the mere presence of high-income individuals causes low-income individuals to increase their contributions to the public good even when MPCR is left

unchanged. This kind of behavior might stem from a self-centered interest to maximize one's return. Perhaps this increase in contribution levels in the presence of high-income individuals represents a deliberate attempt by low-income individuals to signal low free-riding tendencies to the high-income type, thus encouraging them to put forward generous contributions to the public good. By pooling in the resources of the high-income type, low-income individuals can increase their overall return by reaping the benefits generated from the public good.

[Insert Table 2 approximately here]

[Insert Figure 1 approximately here]

Table 3, which presents the payoffs for each treatment and endowment type that would result from the two extreme strategies *FC* and *FR*, adds perspective to this conclusion and helps explain the lack of change in contributions between the SHR and MIR treatments. Here, *FC* refers to the fully cooperative strategy where all members contribute their full endowments to the public good and *FR* refers to the Nash equilibrium strategy where all members free-ride and contribute nothing to the public good. As we can see, the cooperative outcome carries the same return to low-income individuals in the SHR and MIR treatments. It is important to highlight that following our previous reasoning, low-income individuals are only keen on encouraging higher contributions from high-income individuals when the presence of those individuals provides an added benefit that could potentially be realized from the public good. In other words, low-income individuals should only contribute more in the MHR and MDR treatments since the presence of high-income individuals in those two treatments inflates their potential gain from the public good to $10 and $15 respectively. This is exactly what we observe in the data.

[Insert Table 3 approximately here]

For high-income individuals, it is clear that average total contributions, and average percent contributions, are significantly lower in the MHR and MDR compared to the SHR and MIR treatments. In fact, the effects are somewhat more pronounced than those of the low-income type. Besides the comparison between SHR and MHR, which was significant at the 95% confidence level (t-test, P=0.024), all cross comparisons of MHR and MDR with SHR and MIR were significant at the 99% confidence level (t-test, P=0.000). This result indicates that high-income individuals contribute less towards the public good when low-income individuals are present and the public good bears equal or less benefit to them. More importantly, it implies that the mere presence of low-income individuals causes high-income individuals to decrease their contributions to the public good even when MCRP is left unchanged. This can be explained by a combination of self-centered interest and a precautionary tendency that becomes more prominent in the presence of the low-income type. Again, the payoff matrix for high-income individuals in Table 3 provides more insight to this hypothesis. Under altruism and inequality aversion, it would be expected that high-income individuals would not change or even increase their contributions in the MHR and MDR treatments, since that would benefit low-income individuals and help decrease the earnings gap between the two types. However, the fact that contributions by high-income individuals significantly decreased in those treatments implies that even though altruism and/or inequality aversion might still be operating, they are overshadowed by motivations of self-interest and mistrust.

From the perspective of high-income individuals, the probability of free-riding is higher when the low-income type is present. This is because it is more likely that someone with a low-income would be inclined to free-ride and depend on high-income individuals to contribute to the public good. Therefore, driven by a self-centered interest not to be taken advantage of, high-

income individuals decrease their contributions to the public good. The fact that the contribution levels of the high-income type are lowest in the MDR treatment favors self-interest as the dominant force driving the behavior of high-income individuals. Here, the public good carries a bigger reward to low-income individuals, which significantly decreases their free-riding motivations since they have more reason to invest in the public good. Generous contributions by high-income individuals in this treatment can only be explained by altruism and/or inequality aversion, since the high-income type is better off with the *FR* scenario in this case. However, the sharp decrease in average contributions by the high-income type to a mere 18% supports the hypothesis regarding the significance of self-interest and its role as one of the main motivations driving the behavior of the high-income type.

The results are further analyzed for low- and high-income individuals in panels a and b of Figure 2, respectively. The left side of the panels separates percent contribution into 10 categories ranging from 0-100% and shows the fraction of the overall low- and high-income samples in each category. This result is broken down by treatment on the right side of the panels. The clustering of observations in the 0-0.1 interval for both income types under all treatments is indicative of the presence of free-riding behavior, at least among some individuals. However, it is also important to note the clustering at the 0.9-1 interval in most cases. For low-income individuals, we observe a slight rightward shift in the histogram of contributions under the MHR and MDR treatments (K-S test, $P<0.027$). On the other hand, we also observe a leftward shift in the histogram of contributions for high-income individuals under those treatments (K-S test, $P<0.013$). This further supports the notion concerning the motivations that determine the behavior of low- and high-income individuals in those scenarios.

[Insert Figure 2 approximately here]

The effects of the different treatments on percent contribution were estimated in Table 4 using several Tobit regression specifications in order to ensure robustness of the above results. The specification in column 1 investigates the treatment effects leaving out any other potential explanatory variables. Learning effects are examined in column 2 by including the variable period, which represents the round number, while the demographic effects of gender and school year are controlled for in column 3.

[Insert Table 4 approximately here]

Firstly, our results are consistent with the universal finding in the literature concerning the presence of a learning effect. We observe a significant, albeit small, downward trend across periods as shown by the negative coefficient on the variable period in column 2. More importantly, looking at the treatment effects for high- and low-income individuals, it is clear that the results in Table 4 strongly support our conclusions. Low-income individuals contribute significantly more in the MHR and MDR treatments, while high-income individuals contribute significantly less in those treatments under all specifications. This bolsters our confidence regarding the hypothesized opportunistic and self-centered motivations of low- and high-income individuals respectively. Finally, concerning demographic effects, the results indicate a slightly higher contribution rate among males compared to females and among upper- compared to lower-school year students.

V. STRUCTURAL MODEL OF INDIVIDUAL BEHAVIOR

The robust findings presented in the previous section allow for the structural modeling of various types of high- and low-income individuals. Specifically, the high- and low-income types were each classified into two categories based on the observed behavior across treatments.[4] Given the

[4] The model used in this analysis is similar to the one in Bardsley and Moffatt (2007).

observed clustering of observations on the lower and upper limits, it is appropriate to consider a two-limit censored model, where we define the latent variable y^* as desired contribution. Low-income individuals were modeled as either *"free-riders"* or *"opportunists"*. Although free-riders are typically individuals who always contribute zero to the public good, the term was used more loosely here to allow for the possibility of mistakes and/or loss of concentration. Thus, instead of restricting this category to individuals who strictly contribute zero on every occasion, a tremble parameter was used to include individuals who contribute very low amounts on most occasions among free-riders. As for opportunists, they are defined as individuals who contribute more in the presence of the high-income type, but only when this presence carries potential benefits to them. Hence, while the desired contribution of free-riders is consistently near zero and is not related to other variables, the desired contribution of opportunists was assumed to depend linearly on a set of explanatory variables as follows:

$$y^*_{opp} = \beta_0 + \beta_1 * RWB + \beta_2 * period + \beta_3 * male + \beta_4 * schoolyr + \varepsilon \qquad (7)$$

Where y^*_{opp} is the desired contribution of opportunists, RWB stands for rich-with-benefit and is a dummy variable that takes the value one if the high-income type are present and the situation is beneficial for low-income individuals (i.e., it takes the value one in the MHR and MDR treatments), and $\varepsilon \sim N(0, \sigma^2)$. The other explanatory variables are as described in the previous section and are included for the same reasons they were included in the Tobit regression specifications.

The high-income type was also modeled as belonging to one of two categories, *"free-riders"* and "*selfists"*. Here, selfists are defined as individuals who contribute less in the presence of low-income individuals, when this presence brings a potential disadvantage to them. Again, the

less rigid definition of free-riders was adopted here and their desired contribution was assumed not to depend on other variables. On the other hand, the desired contribution of selfists was specified linearly as follows:

$$y^*_{slf} = \beta_0 + \beta_1 * PWD + \beta_2 * period + \beta_3 * male + \beta_4 * schoolyr + \varepsilon \quad (8)$$

Where y^*_{slf} is the desired contribution of selfists, PWD stands for poor-with-disadvantage and is a dummy variable that takes the value one if the low-income type are present and the situation is disadvantageous for high-income individuals (i.e., it takes the value one in the MHR and MDR treatments), and $\varepsilon \sim N(0, \sigma^2)$.

While the latent variable y^* can take any value on the real numbers line, the observed actual contribution y is restricted to values within the allowable range $[0, \text{endowment}]$. The relationship between actual contribution y and desired contribution y^* is as follows:

For opportunists and selfists:

$$\text{y} = \begin{cases} 0 & \text{if } y^* \leq 0 \\ y^* & \text{if } 0 \leq y^* \leq \bar{\text{y}} \\ \bar{\text{y}} & \text{if } y^* \geq \bar{\text{y}} \end{cases} \quad (9a)$$

For free-riders:

$$\text{y} = 0 \quad (9b)$$

where $\bar{\text{y}}$ is 750 tokens for high-income individuals and 250 tokens for low-income individuals.

In order to incorporate the less rigid definition of a free-rider, a tremble parameter ω was introduced to account for possible loss of concentration. On any round, there is a probability ω that the individual will lose concentration and choose his/her contribution randomly. The tremble

parameter has already been used in the literature (Bardsley and Moffatt 2007, Loomes et al. 2002) and is specified similarly here, where it is allowed to decay throughout the experiment as follows:

$$\omega = \omega_0 * \exp\left[\omega_1 * (\text{period} - 1)\right] \tag{10}$$

With this specification, ω_0 represents the tremble at the beginning of the experiment, before any experience was accumulated, while ω_1 represents the rate of decay in the tremble parameter as experience accumulates throughout the experiment. Hence, we expect ω_0 to be positive and ω_1 to be negative.

Given the above assumptions, we can write the conditional probabilities of y on each behavioral category as follows:

Low-income individuals

For $y = 250$:

$$P(y = 250|op) = (1 - \omega) * \left[1 - \Phi\left(\frac{250 - \beta_0 - \beta_1 * RWB - \beta_2 * period - \beta_3 * male - \beta_4 * schoolyr}{\sigma}\right)\right] + \frac{\omega}{251} \ ] \tag{11}$$

$$P(y = 250|fr) = \frac{\omega}{251} \tag{12}$$

For $0 < y < 250$:

$$f(y|op) = (1 - \omega) * \frac{1}{\sigma} * \Phi\left(\frac{y - \beta_0 - \beta_1 * RWB - \beta_2 * period - \beta_3 * male - \beta_4 * schoolyr}{\sigma}\right) + \frac{\omega}{251} \tag{13}$$

$$f(y|fr) = \frac{w}{251} \tag{14}$$

For $y = 0$:

$$P(y = 0|op) = (1 - \omega) * \Phi\left(\frac{\beta_0 + \beta_1 * RWB + \beta_2 * period + \beta_3 * male + \beta_4 * schoolyr}{\sigma}\right) + \frac{\omega}{251} \tag{15}$$

$$P(y = 0|fr) = 1 - \frac{250\omega}{251} \quad (16)$$

High-income individuals

For $y = 750$:

$$P(y = 750|slf) = (1 - \omega) * \left[1 - \Phi\left(\frac{750 - \beta_0 - \beta_1 * PWD - \beta_2 * period - \beta_3 * male - \beta_4 * schoolyr}{\sigma}\right)\right] + \frac{\omega}{751} \quad (17)$$

$$P(y = 750|fr) = \frac{\omega}{751} \quad (18)$$

For $0 < y < 750$:

$$f(y|slf) = (1 - \omega) * \frac{1}{\sigma} * \Phi\left(\frac{y - \beta_0 - \beta_1 * PWD - \beta_2 * period - \beta_3 * male - \beta_4 * schoolyr}{\sigma}\right) + \frac{\omega}{751} \quad (19)$$

$$f(y|fr) = \frac{w}{751} \quad (20)$$

For $y = 0$:

$$P(y = 0|slf) = (1 - \omega) * \Phi\left(\frac{\beta_0 + \beta_1 * PWD + \beta_2 * period + \beta_3 * male + \beta_4 * schoolyr}{\sigma}\right) + \frac{\omega}{251} \quad (21)$$

$$P(y = 0|fr) = 1 - \frac{750\omega}{751} \quad (22)$$

Using this model allows not only the estimation of the parameters in the above equations, but also the estimation of the fraction of opportunists among low-income individuals and the fraction of selfists among high-income individuals.

The estimated parameters for low- and high-income individuals are presented in Table 5. As expected, the coefficient on RWB was positive for opportunists and the coefficient on PWD was negative for selfists. This proves the dominance of the hypothesized motivations on the behavior of high- and low-income individuals. Based on these results, we are more confident about

the conclusion that a substantial proportion of low-income individuals are behaving opportunistically by trying to tempt the high-income type to submit generous contributions to the public good. Also, it is clear that the overruling majority of high-income individuals are behaving in a self-centered manner by keeping the bulk of their endowment rather than sharing it with the low-income type. It is worth noting that this result implies that low-income individuals were optimistic about the potential returns from increased contributions (they placed higher values on δ and γ), while high-income individuals were pessimistic about those prospects (they placed lower values on δ and γ). Moreover, it seems there are far more free-riders among low-income compared to high-income individuals. Whereas about a third of low-income individuals were estimated as free-riders, only 3% of high-income individuals were classified into this category. This implies that the self-interest exhibited by high-income individuals in the MHR and MDR might be justified by the significant free-riding tendencies of the low-income type.

[Insert Table 5 approximately here]

The two tremble parameters were significant for both income types and carried signs as expected. While there is a significant probability that individuals will lose focus at the beginning of the experiment and contribute randomly, this probability consistently declines over the course of the experiment as subjects start gaining experience with the task. Also, it seems that low-income individuals are not only more prone to losing focus at the start of the experiment, they also acquire experience slower than high-income individuals. It is highly probable that this difference is due to the task being somewhat more complicated for the low-income type. This is illustrated by considering that the dominant motivation of high-income individuals pushes them towards the Nash equilibrium of acting in a more self-interested way and contributing less, while the dominant motivation of low-income individuals pushes them away from the Nash equilibrium by acting

opportunistically and contributing more to the public good. Thus, it is reasonable to think that a low-income individual might have a higher tendency to contribute randomly; perhaps in the spirit of exploration.

The coefficient on the variable period conforms to the universal finding that contributions decay across rounds. Although small, this coefficient was negative and significant for both income types, which suggests a consistent decline in contributions as individuals gain more experience with the task during the experiment. As for the coefficients on the demographic variables male and school year, they conform to the previous estimates in that they are positive and significant for both income types. Again, this suggests that there is a higher tendency to contribute for males than females and for upper- than lower-school year students.

VI. CONCLUSION

Voluntary contributions mechanisms (VCMs) present a convenient and potentially efficient provision method for public goods. The vast evidence of sizeable contributions under those mechanisms has directed interest towards determining the underlying motivations for this behavior. This paper investigates the interplay between income and relative marginal per capita return (MPCR) and their role in determining contribution levels in public goods games.

A control and three treatments were constructed, where high- and low-income individuals were allowed to play separately and in mixed groups with homogenous and heterogeneous MPCRs. Subjects completed 12 rounds of a public goods game, consisting of 2 practice and 10 real rounds, and were paid using a randomized lottery incentive design in order to encourage more concentration in each round.

On average, low-income subjects displayed more cooperative behavior in the presence of the high-income type, but only in situations where this presence carried potential advantages to them. On the other hand, high-income subjects displayed more self-centered behavior in the presence of the low-income type when this presence carried potential disadvantages to them. Moreover, there was evidence of free-riding behavior among both income types, which stimulated the structural modeling of different behavioral categories within each income type and the estimation of the main characteristics of those categories.

The overall behavior of low-income individuals can be well explained by the presence of free-riders, who in most cases contribute very small amounts to the public good, and opportunists, who strategically try to attract and benefit from higher contributions by the high-income type. As for high-income individuals, their behavior was explained by the presence of free-riders and selfists, who deliberately try to segregate from the low-income type mainly due to a self-centered interest coupled with a sense of caution. However, it seems that the low-income type has a substantially higher propensity to free-ride than the high-income type, which might justify the inclination towards self-interest exhibited by high-income individuals.

In conclusion, this paper provides insights on the motivations driving the behavior of high- and low-income individuals in VCMs. The value of this paper derives from its relevance to real-world situations and its usefulness to policy makers considering public good provisions in neighborhoods with varying income levels. While more work might be necessary to provide a better understanding of the forces that govern behavior in situations with heterogeneous income levels and relative returns, this article serves as a first step in uncovering important ways of targeting the critical elements that can help enhance efficiency of VCMs in those settings.

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VIII. TABLES AND FIGURES

TABLE 1.
Summary of Treatments

Treatment	Group Composition	MPCR
Separated Groups, Homogeneous Return (SHR)	4 high-income or 4 low-income	0.5 for all members
Mixed Groups, Homogenous Return (MHR)	2 high-income and 2 low-income	0.5 for all members
Mixed Groups, Increasing Return (MIR)	2 high-income and 2 low-income	0.25 for low- and 0.75 for high-income
Mixed Groups, Decreasing Return (MDR)	2 high-income and 2 low-income	0.75 for low- and 0.25 for high-income

TABLE 2.
Average Contributions and Percent Contributions by Treatment and Income Type

Separated Groups, Homogeneous Return (SHR)		
	High-Income	*Low-Income*
Contribution	279.7	104.9
Percent Contribution	0.37	0.42

Mixed Groups, Homogeneous Return (MHR)		
	High-Income	*Low-Income*
Contribution	224.5	124.6
Percent Contribution	0.30	0.50

Mixed Groups, Increasing Return (MIR)		
	High-Income	*Low-Income*
Contribution	424.5	107.8
Percent Contribution	0.57	0.43

Mixed Groups, Decreasing Return (MDR)		
	High-Income	*Low-Income*
Contribution	132.4	131.2
Percent Contribution	0.18	0.52

TABLE 3.
Payoff Summary by Treatment and Endowment Type

Separated Groups, Homogeneous Return (SHR)		
	FC	*FR*
Low-Income	$5	$2.5
High-Income	$15	$7.5

Mixed Groups, Homogeneous Return (MHR)		
	FC	*FR*
Low-Income	$10	$2.5
High-Income	$10	$7.5

Mixed Groups, Increasing Return (MIR)		
	FC	*FR*
Low-Income	$5	$2.5
High-Income	$15	$7.5

Mixed Groups, Decreasing Return (MDR)		
	FC	*FR*
Low-Income	$15	$2.5
High-Income	$5	$7.5

Notes: FC refers to the strategy where every member in the group contributes all of his/her endowment to the public good and FR is the strategy where every member in the group completely free-rides and contributes nothing to the public good.

TABLE 4.
Tobit Model Capturing Average Treatment Effects for High- and Low-Income Types

	[1]	[2]	[3]
Variable	Parameter	Parameter	Parameter
Constant	0.398	0.506	0.262
	(0.037)	(0.044)	(0.047)
Rich	-0.073	-0.073	-0.066
	(0.052)	(0.052)	(0.052)
MHR	0.121	0.120	0.081
	(0.050)	(0.050)	(0.041)
MIR	-0.008	-0.007	-0.045
	(0.052)	(0.051)	(0.052)
MDR	0.160	0.160	0.137
	(0.053)	(0.052)	(0.053)
MHR*Rich	-0.197	-0.197	-0.195
	(0.071)	(0.070)	(0.070)
MIR*Rich	0.291	0.290	0.312
	(0.073)	(0.072)	(0.073)
MDR*Rich	-0.407	-0.408	-0.409
	(0.075)	(0.075)	(0.074)
Period	-	-0.020	-
		(0.004)	
Male	-	-	0.049
			(0.026)
School Year	-	-	0.049
			(0.012)
Sigma	0.460	0.456	0.456
	(0.011)	(0.011)	(0.011)
Observations	1,400	1,400	1,400
Log Likelihood	-1068.572	-1058.503	-1057.96

Notes: The data contained a total of 258 left-censored and 175 right-censored observations. Considering the significance of sigma under all specifications, a Tobit regression generates significantly different estimates compared to an OLS regression.

TABLE 5.
Finite Mixture, Two-Limit Tobit Model with Tremble

	High-Income Individuals		Low-Income Individuals	
Variable	Parameter	Std. Error	Parameter	Std. Error
Constant	56.60	(38.96)	405.63	(50.79)
RWB/PWD	136.53	(35.11)	-233.58	(39.78)
Period	-7.94	(3.89)	-16.73	(3.73)
Male	116.37	(26.26)	63.90	(33.64)
School Year	43.54	(12.78)	12.54	(11.20)
Sigma	84.61	(13.24)	299.15	(17.95)
w0	0.62	(0.04)	0.19	(0.11)
w1	-0.03	(0.01)	-0.37	(0.19)
P_opp/P_slf	0.65	(0.03)	0.97	(0.04)
Observations	840		840	
Log Likelihood	-3774.4507		-4684.7204	

FIGURE 1.

Breakdown of average contributions by treatment and endowment type

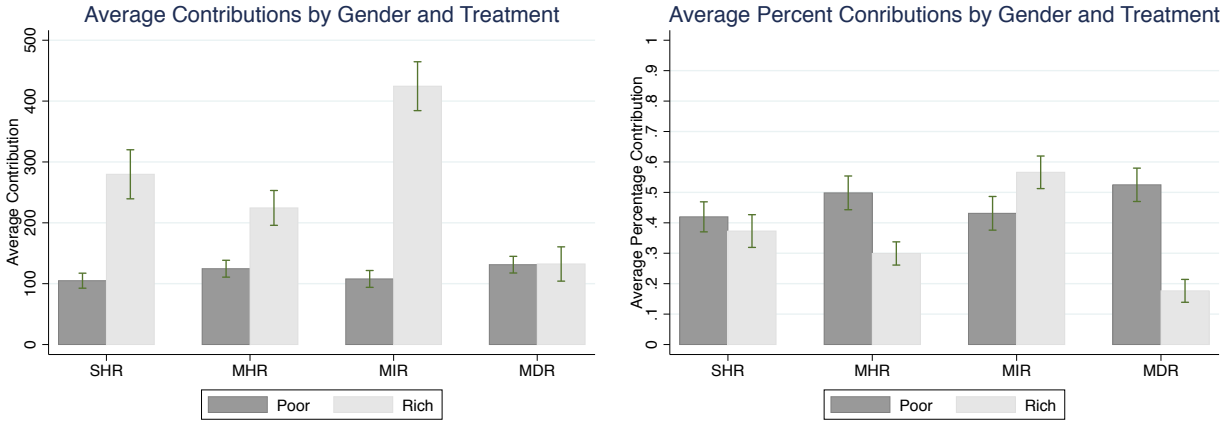
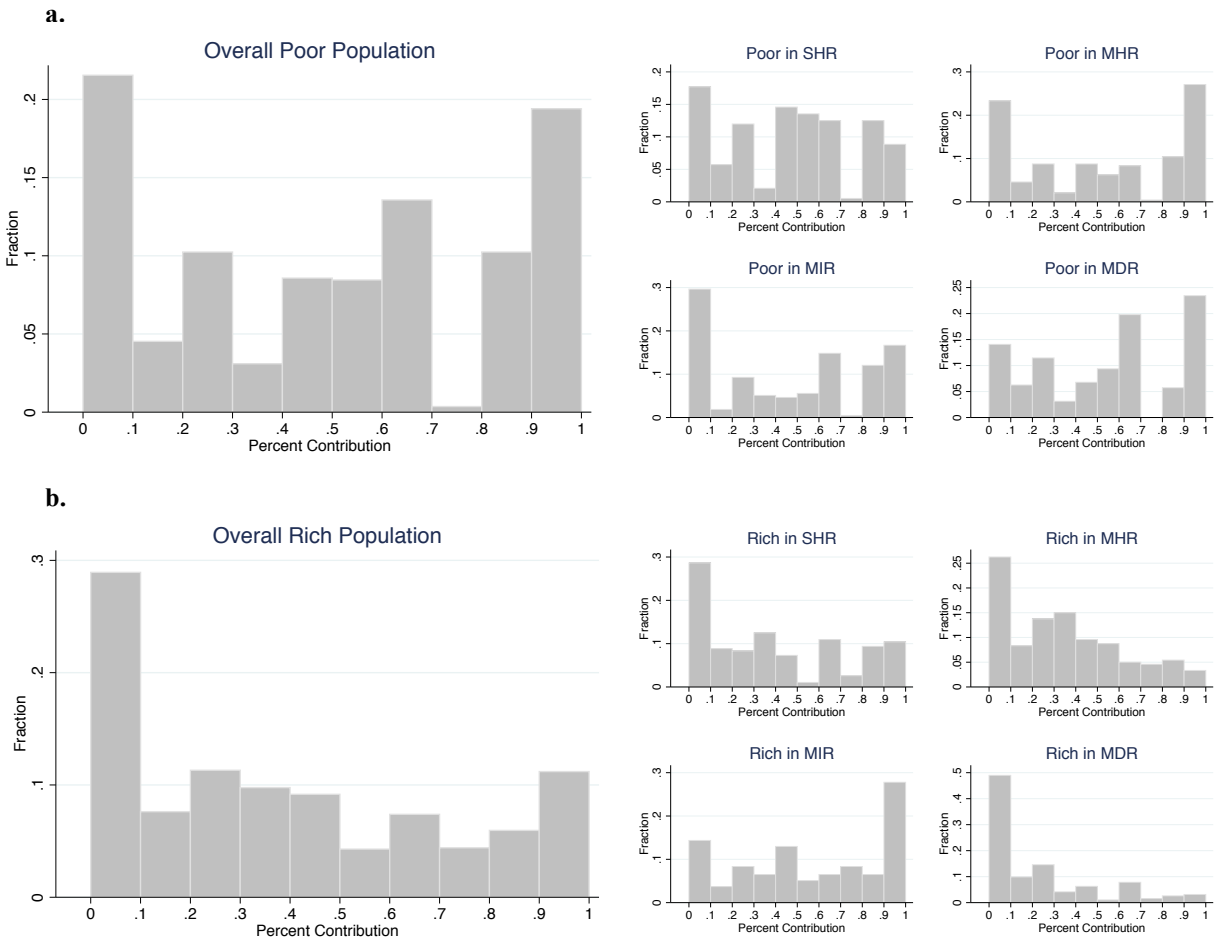


FIGURE 2.
Histograms of percent contribution by treatment and endowment type



APPENDIX

Theoretical Model of High-Income Individuals:

This section applies similar reasoning to the one adopted in the theoretical framework section to explain potential changes in the behavior of high-income individuals resulting from the introduction of heterogeneity in income and relative return. The payoff of a high-income individual playing in a separated income group can be written as

$$u_i^R = (w_i^R - g_i^R) + ag_i^R + a\sum_{j=1}^{3} g_j^R(\bar{g}) \quad (23)$$

while his payoff when in a mixed income group is given by

$$v_i^R = (w_i^R - g_i^R) + ag_i^R + a\gamma g_j^R(\bar{g}) + a\delta \sum_{k=1}^{2} g_k^P(\bar{g}). \quad (24)$$

Hence, we can represent the change is his payoff if he increases his contribution from g_{oi}^R in the separated income group and g_{Hi}^R in the mixed income group by the following equation:

$$\Delta u_i^R = \left(g_{oi}^R - g_{Hi}^R\right) + a\left(g_{Hi}^R - g_{oi}^R\right) + a\left[\gamma g_j^R(\bar{g}_H) - g_j^R(\bar{g}_o)\right] + a[\delta \sum_{k=1}^{2} g_k^P(\bar{g}_H) - \sum_{l=1}^{2} g_l^R(\bar{g}_o)] \quad (25)$$

Similarly, the change in his payoff if he/she decreases his contribution from g_{Mi}^R to g_{Li}^R is given by

$$\Delta u_i^R = \left(g_{oi}^R - g_{Li}^R\right) + a\left(g_{Li}^R - g_{oi}^R\right) + a\left[\gamma g_j^R(\bar{g}_L) - g_j^R(\bar{g}_o)\right] + a\left[\delta \sum_{k=1}^{2} g_k^P(\bar{g}_L) - \sum_{l=1}^{2} g_l^R(\bar{g}_o)\right] \quad (26)$$

while the change in his payoff resulting from a no change in contribution can be written as

$$\Delta u_i^R = a\left[\gamma g_j^R(\bar{g}_o) - g_j^R(\bar{g}_o)\right] + a[\delta \sum_{k=1}^{2} g_k^P(\bar{g}_o) - \sum_{l=1}^{2} g_l^R(\bar{g}_o)]. \quad (27)$$

Given the above equation, we can follow the same thought process presented in the theoretical framework section to reach similar hypotheses regarding the behavior of high-income individuals.