Buckley, N. and Cuff, K. and Hurley, J. and Mestelman, S. and Thomas, S. and Cameron, D. 2015. Support for public provision of a private good with top-up and opt-out: A controlled laboratory experiment. Journal of Economic Behavior & Organization. 111: pp. 177-196.

1. Introduction

Mixed systems of public and private financing support the provision of many private goods such as education and health care. Unlike standard public goods, these goods are rivalrous in consumption and excludable. Systems of mixed finance of such private goods are characterized by regular (at times, seemingly endless) debate regarding the relative sizes and roles of the public and private sectors. Debate about the role of school vouchers in the education sector, public and private insurance in health systems internationally, and about public and private options for retirement savings typify policy discourse regarding mixed systems of finance. Debate often centers on the impact of alternative systems of mixed finance on choice, access, competition, quality, and, ultimately, on desired outcomes (e.g., student achievement, access to care, and income security). Formal economic analysis of mixed systems of finance for private goods emphasizes the potential impact of these systems on citizen support for public provision of the private good.

Analyses of the welfare effects of mixed systems of finance (e.g., Ireland 1990; Sonstelie, 1982; Marchand and Schroyen 2005) focus on the channels by which different configurations of public and private roles affect welfare. Central to the welfare effects is the income redistribution engendered by mixed systems of finance and its associated equity/efficiency trade-offs (e.g., Boadway et al. 1998; Besley and Coate 1991).[1] These normative analyses highlight the crucial role that distributional issues play in the analysis of mixed systems of finance. Positive, political economy models that explicitly analyze how mixed finance affects public support for public provision typically assume that the degree of public funding is determined from majority-voting and the government is restricted from using a progressive linear income tax, so uniform provision of a

[1]Currie and Gahvari (2008) provide a survey of the normative arguments for public provision of various private goods.

private good financed by a proportional tax is the only means to redistribute income in the economy. Such income redistribution receives support from a majority.[2] As Glomm et al. (2011, p.617) note in the context of education, a key question of this literature is *what is the majority preferred level of funding for tax-financed public education when private options are available?* A household's private options typically include either that of 'topping-up' tax-financed public provision with private purchases (e.g., pay for private after-school tutoring lessons), or 'opting-out' of consuming the amount of public provision (e.g, send child to a private school instead of the local public school but continued to pay taxes to support the public school system).[3] Internationally, one or both of these private options exist in many countries' mixed financing systems for education, health care, and other private goods.

A key conclusion of this theoretical literature is that the type of private option available affects the majority-preferred level of public funding for the private good. If individuals can top-up public provision, induced preferences over public provision will be single-peaked and there exists a majority-rule equilibrium implementing the preferred policy of the median voter (Epple and Romano 1996a; Gouvieau 1997; Fernandez and Rogerson 2003). If instead individuals can opt-out of public provision then induced preferences are no longer single-peaked (Stiglitz 1974). A majority-rule equilibrium can, however, still exist (Glomm and Ravikumar 1998; Myers and Lülfesmann 2011). If it does exist, then depending on the form of individual preferences the equilibrium will either be one in which the median voter is decisive or one in which there will be a coalition of high income and low income individuals against a coalition of middle-income individuals or 'ends-against-the-middle' (Epple and Romano, 1996b). A

[2]Blomquist and Christiansen (1999) show that even with an unrestricted income tax, public provision of a private good will receive majority support since such provision enhances the efficiency of the income tax system given imperfect information about individuals' earning abilities.

[3]A third option we do not consider in this paper is one in which individuals can opt-out of public provision and take their tax dollars with them. This option is explored in Buckley et al. (2014).

common feature of all these models is that the tax-financed public provision of a private good redistributes income from higher- to lower-income individuals.

Recent empirical literature has focused on two aspects of these majority-rule voting models. First, papers have attempted to determine the effect of the income distribution, in particular, income inequality, on the support for public spending on private goods. (e.g. Corcoran and Evans 2010; Boustan et al. 2013). Second, papers have empirically examined the nature of the political economy equilibrium, that is, whether the median voter is decisive or whether there is an 'ends-against-the middle' outcome, for different forms of public spending. For example, Cohen-Zada and Justman (2003) examines public education spending, Kotakorpi and Laamanen (2010) look at public health care spending, and Brunner and Ross (2010) focuses on local public spending decisions. And a recent paper by Bearse et al. (2013) calibrates a theoretical model similar to the one we adopt under the status quo (a system of opting-out) to match U.S. data and demonstrates that a uniform voucher system (similar to a system of topping-up) will never receive majority-support. But, to our knowledge, no empirical studies have directly tested the predictions of these models regarding the equilibrium level of the public provision of the private good under alternative mixed systems of finance.

In this paper, we present the results of a series of controlled laboratory experiments designed to test the theoretical prediction of a standard political economy model of systems of mixed finance for a private good. We adopt a functional form for preferences that ensures a majority-rule equilibrium exists for both the top-up and opt-out options in an environment characterized by income heterogeneity and in which the median-income individual is decisive. We consider three experimental treatments — public-finance-only, mixed financing with top-up, and mixed financing with opt-out — and examine their impact on the size of the tax-financed public system as determined by majority-rule and on individual decisions about whether to exercise the private option

and to what extent, i.e., the quantity of their private purchases. We use a combination of within-subject and between-subject designs in which all subjects experienced ten decision periods of a public only financed treatment and ten decision periods of one of the two mixed financing systems (and we randomized the order of the public-only and mixed-finance treatments across experimental sessions to control for potential order effects).

Our aggregate analysis shows that the majority-preferred tax rate matched the predicted rate under public-only finance and mixed financing with top-up, but was significantly higher than predicted under mixed financing with opt-out. Counter to theoretical predictions, higher-income individuals support the public system in both types of mixed financing systems despite not having the financial incentive to do so. Non-parametric regression analysis of individual-level decisions regarding whether to exercise the private option (top-up, opt-out) and the quantity of good to purchase privately found that under both forms of mixed financing, income level had a significant positive effect on the probability of exercising the private option, as predicted.

In the next section, we outline our political economy theoretical framework. In Section 3, we describe the laboratory implementation of the theoretical framework and present our experimental results in Section 4. We discuss our results in Section 5 and conclude in Section 6.

2. Theoretical Framework

The theoretical framework we adopt is based on standard majority-rule models of tax-financed public provision of a private good (see, e.g., Epple and Romano 1996a; Myers and Lülfesmann 2011; Bearse et al. 2013). Below, we outline the main features of these models and the specific functional form for household preferences that we use in each of the three treatments we consider (public finance only, mixed financing with

a top-up option and with an opt-out option), and state the theoretical predictions.

2.1. Benchmark Model: Public Finance Only

There are N households who differ in their fixed income (or endowment of a numeraire consumption good) denoted by y. The mean income in the population is $\bar{y}$. The median income in the population, y_m, is assumed to be less than the mean. Households have preferences over consumption of a numeraire good, given by c, and of a specific private good E which may be publicly provided or purchased privately.[4] To obtain closed-form solutions, we assume household preferences can be represented by the following utility function:

$$U(c, E) = ac^{\eta} + bE^{\eta} \tag{1}$$

where $a, b > 0$ and $\eta \in (0, 1)$. The private good E is produced using the numeraire good. Following the literature, it takes one unit of the numeraire good to produce one unit of the private good and this is independent of whether the good is publicly (i.e., tax-financed) or privately financed.[5]

Consider first a public-only system where the provision of the private good is financed solely through a proportional income tax, whose rate is denoted by t. This proportional tax rate is determined by majority-rule. The government provides a uniform amount of the private good to each household, denoted by g.[6] The government's

[4]For illustrative purposes, one could think of this private good as education, but the model can apply to any number of publicly provided private goods, such as garbage collection and health care. In the case of education, we can think about a household as comprising a parent and a child.

[5]Following Glomm et al. (2011), one could interpret E as the quality of the private good being consumed. The production function for the quality of the good is linear in expenditure on the good regardless of which sector finances the good, i.e., publicly-financed or privately-financed.

[6]For the remainder of the paper, we use the terms 'public provision of the private good' and 'publicly financed private good' interchangeably in referring to g.

budget constraint is

$$t\bar{y} = g. \tag{2}$$

Using the government's budget constraint (2), the household's budget constraint can be written as

$$c = y - (y/\bar{y})g \tag{3}$$

where $T(y) = y/\bar{y}$ is the household's *relative tax price* for the private good. Public provision of the private good effectively redistributes resources from households with incomes above the mean to households with incomes below the mean.

Substituting the household's budget constraint (3) with $E = g$ into (1), yields the household's induced utility function over the public provision of the private good

$$V(g) \equiv \max_{g \geq 0} \quad a(y - T(y)g)^{\eta} + bg^{\eta} \tag{4}$$

which is strictly concave in g. Therefore, each household has a unique preferred level of public provision of the private good, denoted by $g(y)$, and a unique preferred tax rate, denoted by $t(y)$, which are both strictly decreasing in household income. It follows directly from the median voter theorem that the equilibrium outcome under majority rule will be given by the preferred tax rate of the median income household, $t(y_m)$, where

$$t(y_m) = \frac{1}{\phi T(y_m)^{\frac{\eta}{1-\eta}} + 1} \tag{5}$$

and $\phi = (a/b)^{\frac{1}{1-\eta}}$. The amount of publicly provided private good in equilibrium will be

$$g(y_m) = \frac{y_m}{\phi T(y_m)^{\frac{1}{1-\eta}} + T(y_m)}. \tag{6}$$

Theoretical Prediction 1 *In a public-only financed system, preferred tax rates are*

strictly decreasing in income and the equilibrium outcome with majority-rule will be determined by the preferred tax rate of the median income household.

Next consider what happens to the equilibrium size of the public system when individuals can choose to supplement public provision of the private good with private purchases. We consider two cases: First, individuals can consume privately purchased amounts of the good in addition to the amount financed publicly (mixed financing with a top-up option) and second, individuals can substitute private consumption for the publicly financed private good, but must continue to pay taxes to finance public provision of the private good (mixed financing with an opt-out option).

2.2. Mixed Financing with a Top-Up Option

Assume households can top-up public provision of the private good with individual purchases of the good. The timing of decision-making is as follows:

> **Stage 1:** Households vote on a proportional income tax that finances the uniform provision of the private good, and the outcome is determined by majority rule.
>
> **Stage 2:** Taking the amount of publicly provided private good as given, households choose how much additional amount of the good, denoted by $s \geq 0$, to purchase.

The solution is obtained by applying backward induction. At Stage 2, the household's budget constraint is

$$c = y - T(y)g - s \tag{7}$$

and total consumption of the private good is $E = g + s$. Therefore, the household solves

the following problem in Stage 2:[7]

$$\max_{s\geq 0} \quad a(y - T(y)g - s)^{\eta} + b(g + s)^{\eta}. \tag{8}$$

Demand for the private good (as a function of g) by a household with income y is given by

$$s(g) = \max\{h(y + (1 - T(y))g) - g, 0\}. \tag{9}$$

where $h(y + (1 - T(y))g)$ is the demand for the good if the household had income $y + (1 - T(y))g$.[8] It follows from (9) that there is some level of publicly provided private good $\hat{g}(y)$ above which a household with income y will not purchase the good where

$$\hat{g}(y) = \frac{y}{\phi + T(y)}. \tag{10}$$

Next, consider the household's induced preferences over the amount of publicly financed private good in Stage 1 which are given by

$$W(g) \equiv \max_{g\geq 0} \quad a(y - T(y)g - s(g))^{\eta} + b(g + s(g))^{\eta} \tag{11}$$

and are again strictly concave in g.

Recall, households with income above the mean pay a higher price for g than for s, that is, $T(y) > 1$ for $y > \bar{y}$. Therefore, these households are better off with $t = 0$ ($g = 0$) and purchasing all of the private good privately than with any positive tax rate. On the other hand, households with income below the mean pay a lower price for g than for s, so such households are better off with a tax rate that ensures they do not top-up public provision at its optimum. Consequently, these households' preferred tax

[7]The second-order condition is satisfied.

[8]The demand function $h(\cdot)$ is obtained by maximizing (1) subject to $c + s = y + (1 - T(y))g$.

rates are the same as in a public-only financed system. Given the median income is assumed to be below the mean, the equilibrium tax rate and public provision will be the same as in a public-only financed system and given by $t(y_m)$ and $g(y_m)$, respectively.

The decision to purchase the private good comes down to whether a household has some unmet demand for the good which can occur only if the household has sufficiently high (after-tax) income. A household will supplement the publicly provided private good if $\hat{g}(y) \geq g(y_m)$ or using (10) and (6) if

$$y \geq y_m T(y_m)^{\frac{1}{\eta-1}} = \left(\frac{\bar{y}}{y_m}\right)^{\frac{1}{1-\eta}} y_m. \tag{12}$$

A necessary condition for (12) to be satisfied is that the household has an income above the mean income. Further, since $\hat{g}(y)$ is increasing in income it follows that for the set of incomes such that (12) is satisfied, private purchases will be increasing in income.

Theoretical Prediction 2 *In a mixed financing system with a top-up option, households with incomes greater than the mean prefer a zero tax rate. All other households prefer the same tax rates as in a public-only financed system. The size of the public system will be the same as in a public-only financed system. Households with sufficiently high income will top-up the public provision of the private good with private purchases and the amount of private purchases will be increasing in income.*

2.3. Mixed Financing with an Opt-Out Option

Now assume that households can privately finance their consumption of the private good, but only if the household opts-out of consuming the publicly provided private good and continues to pay taxes to finance public provision of the private good. In this financing scenario, the amount of the publicly provided private good available to a given household will depend on the number of households who opt-out. Let N^* be the number of households who consume the publicly provided private good, so $N - N^*$

is the number of households who choose to opt-out. The amount of publicly provided private good per capita will be

$$g = t\frac{N}{N^*}\bar{y}. \tag{13}$$

The timing of decision-making is as follows:

> **Stage 1:** Households vote on a proportional income tax that finances the uniform provision of the private good to those households who do not opt-out of consuming the publicly financed private good and the outcome is determined by majority rule.
>
> **Stage 2:** Taking as given both the amount of public provision of the private good and the opt-out decisions of other households, each household chooses whether to consume the amount of publicly provided private good or to opt-out and purchase all of their consumption of the good privately.

Using backwards induction, consider first a household who chooses to opt-out. This household solves the following problem

$$\max_{e} \quad a(y(1-t)-e)^{\eta} + be^{\eta} \tag{14}$$

where e is private expenditure on the private good which yields the demand $h(y(1-t)) = y(1-t)/(\phi+1)$. Substituting this demand back into the household's objective yields the household's maximized level of utility if the household opts out (given t)

$$\left[\frac{y(1-t)}{\phi+1}\right]^{\eta}[a\phi^{\eta}+b] \tag{15}$$

which is increasing in income. A household who does not opt-out has utility

$$a(y(1-t))^{\eta} + b\left(t\frac{N}{N^*}\bar{y}\right)^{\eta} \tag{16}$$

which is also increasing in income, but at a slower rate than (15).[9] Therefore, a household with an income greater than $\hat{y}(t, N^*)$ will optimally choose to opt-out and households with income below $\hat{y}(t, N^*)$ will optimally consume the amount of public provision of the private good, where by equating (15) and (16),

$$\hat{y}(t, N^*) = K\left(\frac{t}{1-t}\frac{N}{N^*}\bar{y}\right) \tag{17}$$

and $K > 0$.[10] This cut-off income level is increasing in t and decreasing in N^* as one would expect.[11]

In equilibrium, the number of individuals choosing not to opt-out given the equilibrium tax rate, i.e., those with incomes less than $\hat{y}(N^*, t)$, must be exactly equal to N^*. This condition determines N^* as a function of t. Suppose income is distributed according to the cumulative distribution function $F(y)$ with a corresponding density $f(y) > 0$ for all y, then the condition implicitly determining $N^*(t)$ is $N^* = F(\hat{y}(N^*, t))$ where $N^{*\prime}(t) > 0$.

By comparing (15) and (16) given $N^*(t)$, under the opt-out option, for t close to zero households with any income prefer a private-only financed system, and for t close to 1 households with any income prefer a public-only financed system. Therefore, as shown in Myers and Lülfesmann (2011), there must exist some critical tax $\hat{t}(y)$ between (0,1) such that a household with income y is indifferent between opting-out or not (treating N^* as a function of t) in Stage 2. For tax rates higher than $\hat{t}(y)$, the household is better off not opting-out and for tax rates lower than $\hat{t}(y)$, the household is better off opting-out. This critical tax rate is increasing in income. One way to interpret this

[9] This follows from assuming that $[\phi^\eta + b/a]/[\phi + 1]^\eta > 1$.

[10] That is, $K = \frac{(b/a)^{1/\eta}}{\left[\left[\frac{1}{\phi+1}\right]^\eta [\phi^\eta + b/a] - 1\right]^{1/\eta}} > 0$.

[11] We have $\partial\hat{y}/\partial t = \hat{y}/[t(1-t)^2] > 0$ and $\partial\hat{y}/\partial N^* = -\hat{y}/N^* < 0$.

result is that higher income households are better off opting-out over a larger range of tax rates than lower income households.

Consider Stage 1. For households who opt-out in Stage 2, their preferred tax rate is zero regardless of the opt-out decisions of other households since these households continue to pay taxes to finance the public provision of the private good, but do not consume any of the publicly financed private good. A household that does not opt-out solves the following problem:

$$\max_{t\in(0,1)} \quad a(y(1-t))^{\eta} + b\left(t\frac{N}{N^*(t)}\bar{y}\right)^{\eta}$$

where the household treats N^* as a function of the tax rate. Define the solution as $t^*(y)$ where $t^*(y)$ will be decreasing in income.

Consider the median income household. Suppose $\hat{t}(y_m) < t^*(y_m)$. Then the median income household will choose to vote for $t^*(y_m)$ since they obtain higher utility by not opting-out. In this case, since $\hat{t}(y)$ is increasing in income and $t^*(y)$ is decreasing in income, higher income households will vote for a lower tax rate, possibly zero, and lower income individuals will vote for a tax rate higher than $t^*(y_m)$. Therefore, $t^*(y_m)$ will be the equilibrium tax rate. If instead $\hat{t}(y_m) > t^*(y_m)$, the median income household will vote for a zero tax rate and opt-out, and the equilibrium tax rate will be zero. In this case, all individuals will opt-out by default.

Theoretical Prediction 3 *In a mixed financing system with an opt-out option, the outcome is again determined by the median income household's preferred tax rate. If the median income household has a positive preferred tax rate, then all lower income households will not opt-out of the public system and preferred tax rates will be decreasing in income. Only households with sufficiently high income will opt-out of the public system and will have a preferred tax rate of zero.*

3. Laboratory Implementation

The purpose of the experiment is to test the above theoretical predictions of majority-rule voting over the tax-financed public provision of a private good under public-only financing, mixed financing with a top-up option and mixed financing with an opt-out option. Following standard experimental economic methodology, subjects in the experiment are incentivized with real monetary payoffs and the experiment is framed in a neutral context to minimize potential content-related framing effects (Alm and Jacobson 2007). Subject decisions are framed as choices over how much to invest in alternative investment funds, including a collective fund and an individual private fund.[12] The complete set of instructions used in the experiment can be found in Appendix B.

The experiment used a combination of within-subject and between-subject designs. All subjects experienced ten decision periods of a public only financing treatment and ten decision periods of one of the two mixed financing systems, where the order of the two treatments (public/mixed) was randomized across the different experimental sessions to control for potential order effects. Comparison of the baseline public-only financed system and the two mixed financing systems relies on within-subject variation, while the comparison of the different mixed financing systems (top-up and opt-out) relies on between-subject variation. In the public-only decision periods individuals were assigned an exogenous income of laboratory dollars and asked to choose their preferred proportional tax rate knowing that the median tax rate submitted would determine the tax rate for the period. In each mixed financing decision period individuals were assigned an exogenous income of laboratory dollars and asked to make two sequential decisions. First, individuals were asked to choose a proportional tax rate and second,

[12]Compared to framing decisions in the context of education or health care, the current neutral framing might bias findings against public provision of these private goods.

individuals were asked how much of the good to purchase privately given their income, the tax rate (as determined in the first stage) and the treatment (top-up, opt-out). Finally payoffs were realized.

Each session ran with ten subjects each of whom was told that they would be randomly assigned to be a member of a group of five people, but were not told who else was in their group. Each group remained together through the session (following Kroll et al., 2007 and Margrieter et al., 2005) so that the two groups in each session represented independent observations. Subjects were told that, at the beginning of each decision round, each member of their group would be assigned an income, expressed in laboratory dollars (L$), from the following set of five income levels (125, 275, 640, 700, 1500), and that each individual would be assigned each of the income levels twice over the course of the session in a random fashion. The income distribution was chosen to ensure that the median income was below the mean (consistent with the theoretical assumption). To keep subjects actively thinking about their decisions, incomes were assigned in a pre-determined pseudo-random order such that subjects experienced each of the five income levels in the first five periods of each treatment and then again in the last five periods of each treatment, but in a different order.

Twenty groups of five subjects were recruited using an online recruitment system for controlled laboratory experiments (ORSEE, Greiner 2003) and the experiment was administered in the McMaster Experimental Economics Laboratory. Five groups each experienced the following ordering of treatments: public-only followed by top-up; top-up followed by public-only; public-only followed by opt-out; and opt-out followed by public-only. Each experimental session had twenty decision periods (ten decision periods for each treatment) and lasted approximately 70 minutes. The average subject payoff was $23 including a $5 show-up fee. Subjects were individually paid their cash earnings in private. The experiment was conducted using z-Tree software (Fischbacher 2007)

and the laboratory protocol was approved by the McMaster University Research Ethics Board. Observations from the 100 subjects are included in the results below.

3.1. Publicly Financed Provision of the Private Good

At the beginning of each decision period of the public-only finance treatment, subjects were told that their income must be divided between two Investment Funds: a Group Investment Fund (GIF) and a Private Investment Fund (PIF). Subjects were told that everyone in their group must contribute the same fixed percentage of their income to the GIF and that this percentage would be determined by the group. The total amount contributed to the GIF would be divided into five equal shares. Each share would be invested in Market A and the subject would earn a return from this investment. The subject's remaining income after contributing to the GIF would go into the subject's PIF and invested in Market B where it would earn a return for the subject.

The returns earned on the investments were calculated using the payoff function given by (1), where the GIF investment in Market A is for the private good E and the PIF investment in Market B is for the numeraire good c with the following parameter values: $a = 20$, $b = 22$ and $\eta = 0.6$. This parameter set was chosen to ensure salience in the payoffs and to obtain theoretical predictions of some topping-up and opting-out in equilibrium.

In each of the decision periods of the public-only treatment, subjects were asked to submit their preferred mandatory GIF contribution rate. To replicate the outcome of majority-rule in a laboratory environment, subjects were told that submitted GIF contribution rates would be ranked from highest to lowest and that the median contribution rate would be implemented.[13] It was explained to them why there was no

[13]Differing voting processes have been implemented experimentally. The seminal work by Fiorino

incentive to submit a contribution rate other than their preferred rate.

Subjects were provided with a table to illustrate how their returns worked in the markets. Subjects were also given a tutorial with examples to ensure their comprehension about how payoffs are determined in the treatment. The tutorial explained to subjects how they could use the onscreen calculator to determine both their returns in each market and their total payoff for different GIF contribution rates. The calculator removed the complexity of the payoff function and explicitly allowed subjects to calculate the payoffs earned by themselves and others in their group with different incomes. Subjects were able to access the calculator throughout the session.

3.2. Publicly Financed Provision of the Private Good with a Top-up Option

In the top-up treatment, subjects were provided the same information as in the public-only treatment (described above), but were also told that they could choose to invest some of their PIF contribution in Market A rather than having it all automatically invested in Market B (Market A represented the private good that was being publicly funded). This additional investment decision could only be made, however, after the mandatory GIF contribution rate had been determined. Subjects were therefore first asked to submit their preferred GIF contribution rate, told the resulting GIF contribution rate that was to be implemented, and then asked how much of their PIF they would like to invest in Market A to supplement their GIF contribution. Any income remaining was automatically invested in Market B. Before submitting their preferred GIF contribution rate and before deciding how much to invest in Market A, individuals were again provided with an online calculator that allowed them to calculate their total re-

and Plott (1978) uses a sequential amendment driven voting protocol while more recent papers use either simultaneous voting protocols (e.g., Margreiter et al. 2005; Kroll et al. 2007) or a binary yes/no vote on a given tax proposal (e.g. Sutter and Weck-Hannemann 2003.) Another approach is to allow each individual to propose a tax rate and to implement the median tax rate (e.g. Norton and Isaac 2013.) We adopt the latter voting process since it most closely resembles the theoretical environments that were being implemented in the lab.

turn for different income levels, GIF contribution rates and individual PIF investments in Market A.

3.3. Publicly Financed Provision of the Private Good with an Opt-out Option

In the opt-out treatment, subjects were also provided with the same information as in the public-only treatment, but were also told that they could choose to invest any amount of their PIF in a third market, Market C. Investments in Market C would earn the same returns as in Market A. This private investment decision could only be made after the mandatory GIF contribution rate had been determined but, unlike the top-up treatment, if the subject chose to make a private investment in Market C then they would no longer receive a share of the GIF. The total GIF was divided equally only among those members of the group who did not invest in Market C. These subjects would, however, still have to make the mandatory contribution to the GIF. As in the other two treatments, before deciding on what GIF contribution rate to submit and how much to invest in market C, subjects were provided with an online calculator that allowed them to calculate their total return for different income levels, GIF contribution rates, number of others investing in Market C, and individual PIF investments in Market C.[14]

Table 1 shows the theoretically predicted tax rates (i.e., mandatory GIF contribution rates) for the three treatments and Table 2 shows the theoretical predictions for the preferred tax rates by income for the three treatments.[15]

[14]For all three treatments, at the end of each decision period individuals were provided with summary information on the implemented GIF rate and the subjects' investment decisions, including the returns to the different investment decisions and the subject's final payoff.

[15]Numerical predictions for the three treatments were obtained by applying the theoretical results to the discrete income distribution used in the experiment.

4. Experimental Results

Tests confirm an absence of order effects with respect to the variables of interest—the mean implemented GIF rate (hereafter referred to as the "the tax rate")[16], the mean top-up/opt-out frequencies, and the mean top-up and opt-out private purchases—so the analysis pools data across the two treatment orderings (public-only treatment followed by a mixed financing treatment and a mixed financing treatment followed by the public-only treatment).[17] Our tests also confirm an absence of learning effects for these variables *except* for the mean frequency of opting-out and the corresponding mean private purchases conditional on opting-out.[18] Given this evidence of some learning effects, for all treatments we use data only from the last five decision periods in our analysis.

Each treatment includes ten independent observations for between-group comparisons. For tests of differences between public-only and each of top-up and opt-out (which used within-group comparisons) the unit of observation is the mean observed values of the difference between focus variables over the last 5 decision periods for each 5-person group in each treatment. There are ten independent observations for each difference between treatments for within-group comparisons. The descriptive analysis uses both nonparametric Mann-Whitney or Wilcoxon signed-rank tests and parametric unpaired or paired t-tests, as appropriate to test for treatment effects. The ten inde-

[16]Implemented GIF or tax rate refers to the median submitted contribution rate and is used to calculate subject payoffs at the end of a given decision period.

[17]Because the ordering of treatments was varied across subjects, the mean observations are independent; we therefore test for order effects using both Mann-Whitney and Fisher-Pitman Randomization nonparametric tests (Moir, 1998). The p-values are all above 0.10 and we cannot reject the null hypotheses of no differences in these mean outcomes across the three treatments. These results are also supported by parametric t-tests.

[18]We test for learning effects using a nonparametric Wilcoxon signed-rank test to obtain five independent observations (data from the first five periods matched to that from the last five periods) for each treatment since the same subjects make decisions in the first-half and the second-half of each treatment. Parametric paired t-tests produced identical results.

pendent observations from each treatment are also used to test for differences between mean observed values and their predicted values using one-sample parametric t-tests. Due to the small sample sizes, tests of statistical significant use a 10% critical value.

We begin by examining the observed tax rates. First, we examine the aggregate data on the implemented tax rates (i.e., the median of the submitted tax rates in a given decision period) by treatment and compare these values to their theoretical predictions. We then examine submitted tax rates by income level and compare them to the theoretical predictions. We also test for any treatment effects in the mean observed implemented tax rates and the mean submitted tax rates by income. Next, for each of the two mixed financing treatments (top-up and opt-out) we examine the amount of private purchases by income level and conduct non-parametric analysis on the subject-level data to determine whether income and the actual implemented tax rate affected subjects' private purchase decisions as would be predicted by the theory.

4.1. Observed Tax Rates

4.1.1. Mean Observed Implemented Tax Rates

The observed mean implemented tax rate for each of the public-finance-only and top-up treatments did not differ from the theoretically predicted rate of 56.39 (Table 1).[19] Only in the opt-out treatment is the mean observed implemented rate (54.58) statistically different from its predicted rate (26.51).[20] Further, there is no evidence of any treatment effects at the aggregate level. The observed mean implemented tax rates

[19]Tables 1 and 2 present observed mean implemented tax rates separately for public-finance-only treatments matched with top-up treatments and for public-finance-only treatments matched with opt-out treatments because each comparison is based on the within-subject experimental design. The observed mean implemented tax rates for the two public-finance-only treatments are not significantly different from each other.

[20]The intuition for the lower tax rate in opt-out compared to top-up (26.51 vs. 56.39) is that, under opt-out, if the median voter raised her preferred tax rate then the highest income individual would no longer choose to opt-out and the median voter would be worse off than with a higher tax rate since the total amount of public provision would now be shared among a greater number of people.

did not differ between each of top-up and opt-out, top-up and public-only, and opt-out and public-only treatments.

Examination of the full distribution of implemented tax rates, however, reveals some important differences masked by a comparison of only the means. Figure 1 shows the density estimates of the implemented tax rates observed in each of the last five decision periods across all sessions for each treatment.[21] Although there are no statistically significant differences across the observed mean implemented tax rates by treatment, one can see by visually inspecting these density curves that the variance of the distribution of observed implemented tax rates is greater in the mixed financing treatments (top-up/opt-out) relative to their paired public-only treatment. To test for differences in these observed distributions, we compare the standard deviations (std) of the four observed distributions: public-only paired with top-up (6.39), top-up (9.28), public-only paired with opt-out (2.45), and opt-out (14.20). The standard deviation of the implemented tax rate distribution for the opt-out treatment is significantly different from the standard deviation of its paired public-only treatment (p-value of 0.0039). The pair-wise testing of the standard deviation of implemented tax rates between the other treatments does not find any other significant findings at a 10% critical level.[22] This suggests that while the mean implemented tax rate of the opt-out treatment was not significantly different from the public-only treatment (but was significantly different from the opt-out theoretical prediction), the empirical distribution underlying the mean observed implemented tax rate differs relative to that in the public-only treatment. Further, the higher frequency of observed implemented tax rates in the left tail of the opt-out tax rate distribution compared to the other three distributions is consistent with the predicted lower tax rates in opt-out compared to the public-only and top-up

[21]The density estimates in Figure 1 and Figure 2 (discussed further below) were generated using R's stats package default Gaussian kernel for smoothed density estimates.

[22]These non-parametric tests are also confirmed using parametric t-tests.

treatments.

4.1.2. Mean Submitted Tax Rates by Income

Table 2 presents the observed mean submitted tax rates and the theoretically predicted values by income. For both public-only treatments, the mean submitted tax rates largely conform to predictions: the expected income gradient in rates is present and, although the mean submitted rates are slightly less than predicted for some income levels (e.g., income = 125), the median rates match the predicted values. Overall, the submitted rates confirm the theoretical predictions. For the top-up treatment, although we do observe an income gradient in rates as expected, the mean submitted tax rates differ importantly from the predicted values: the mean submitted rate are less than predicted for the two lowest income levels, and notably higher than the predicted rate of zero for the two highest income levels. Only for the median income level does the mean submitted tax rate not differ from its predicted level. Further, with the exception of that for income level L$700, the mean submitted tax rates under top-up do not differ significantly from those under public-finance-only.

Similarly, for the opt-out treatment, the mean submitted tax rates are less than the predicted levels for the two lowest income levels and higher than predicted for the two highest income levels. For opt-out, however, the mean submitted tax rate of the median income level (54.94) is also significantly higher than the predicted rate of 26.5. Hence, for all income levels the submitted rates differ from predictions. For the two lowest income levels the mean submitted rates are significantly less than those observed in the public-only treatments. Finally, there are no statistical differences between the income-specific mean submitted tax rates across the two mixed financing treatments. For both mixed financing treatments, the median submitted tax rates for high-income levels deviate substantially from the predicted values, indicating that the underlying subject behaviour was not as predicted for these two income levels in these environments.

Figure 2 shows the density curves of the observed submitted tax rates by income for the last five decision periods across all sessions for each treatment. These densities reveal that submitted tax rates differed greatly by income level and that, for a given income level, they were similar across the two mixed financing treatments, but differed notably between each of the mixed financing treatments and the public-only financing treatment for the three highest incomes. We now discuss an implication of this observed heterogeneity in subject behavior across the different treatments.

4.1.3. Who submitted the tax rate that was subsequently implemented?

For all treatments, the submitted tax rate of the median income subject should be the implemented tax rate. Table 3 shows the number of times subjects of a given income level submitted the median tax rate that was subsequently implemented. Across all treatments, the median income subject submitted the implemented tax rate fewer times than predicted and subjects with other income levels submitted the implemented tax rates more times than predicted (except the lowest income level in the public-only treatments). These counts differ across the treatments. In the public-only treatment subjects with either L$640 or L$700 submit the implemented tax rate 94% of the time while the corresponding figures for top-up and opt-out were 72% and 64%. Focusing on the median income subject, in the public only treatment 56% of the time this subject submitted the implemented tax rate, which statistically does not differ from the top-up treatment but is significantly higher than in the opt-out treatment (19% of the time). These data reinforce the conclusion that subjects behaved differently in the opt-out treatment relative to the public-only treatment.

Result 1: Observed Tax Rates

(i) *Public-Only Finance: The implemented and submitted tax rates match the theoretical predictions.*

(ii) *Mixed-Systems of Finance: The mean implemented tax rate for top-up matches the prediction while for opt-out the mean implemented tax rate is significantly above what theory predicts. In both mixed financing treatments, the submitted tax rate of the two highest income subjects were significantly higher than predicted.*

(iii) *The mean implemented tax rates do not differ across treatments, but the distributions of implemented tax rates do differ across the opt-out and public-only treatment.*

4.2. Top-Up Behavior

With our assumed payoff function and parameter values, only subjects with the two highest income levels, L$700 and L$1500, are predicted to have positive private expenditure of the amounts L$9.71 and L$204.84 at the predicted equilibrium tax rate which is 56.4 (column 2 of Table 4). Given that the mean observed implemented tax rate in the top-up treatment did not differ statistically from the predicted rate, one might expect the average top-up behavior of subjects to match the predictions. However, the observed mean private expenditure was significantly higher than predicted for all income levels except the highest income level (column 3 of Table 4). While subjects with the three lowest income levels are predicted to choose zero expenditure, on average, these subjects on average chose to spend between 5-7% of their income on the publicly-provided private good. This was also true of the individuals with income L$700 who, at the predicted equilibrium tax rate, were predicted to spend just over 1% of their income. These deviations from the predictions are relatively small in magnitude and so overall, the aggregate data support the predicted top-up behaviour.

To better understand these numbers, we can examine the number of subjects who choose to top-up and the amount purchased conditional on topping-up (columns 4 and 5 of Table 4). Highest income subjects did not always choose to top-up (as predicted) but, when they did, they topped-up more than predicted so that the average top-up

amount of the highest income subjects was as predicted. Among the two lowest income subjects, 22-24% chose to top-up and those who did spent on average between 27-34% of income on the publicly-provided private good. Both the median income and the second highest income subjects, topped-up just over half of the time and spent between 10-11% of total income. Whether these top-up decisions were in fact optimal depends on the actual implemented tax rate the subjects faced.

4.2.1. Nonparametric Analysis of Top-Up Behaviour

Individual's decisions about how much to purchase of the publicly-provided private good is predicted to be increasing in income and decreasing in the implemented tax rate as shown in section 2.2. Given our parameter assumptions, we can determine, by income level, the tax rate above which an individual should not top-up. For the five income levels, these cut-offs are 19.7, 35.1, 55.7, 57.9, and 74.7, respectively. Therefore, if the actual implemented tax was, for example, 30%, we would expect to see all but the lowest income subject top-up; at the predicted rate of 56.4% we would expect only the two highest income subjects to be top-up; and at any tax rate above 60% only the highest income subjects would top-up. We are interested in determining whether subjects did in fact choose to top-up below these critical rates (as predicted) and whether the amount they choose to top-up was affected by either income or the implemented tax rate.

To uncover these relationships, we use nonparametric local linear regression.[23] Although this technique does not explicitly model correlations in subject decisions across

[23]This approach does not have any prior hypotheses about their specific functional forms and relies only on the assumptions that the joint distribution exists, is differentiable and its second moment is finite. This approach avoids imposing a mis-specified parametric model while nesting all parametric models we might choose. See Li and Racine (2004) for further details. The nonparametric estimator uses a product kernel consisting of an Epanechnikov kernel for the continuous implemented tax rate and a Wang and Van Ryzin kernel for the ordered income levels. Bandwidths were chosen using the data-driven improved Akaike Information criterion (Hurvich, Simonoff and Tsai 1998.) Error bounds were calculated by bootstrapping the entire fitted object (with 399 replications.) Nonparametric significance testing was undertaken following Hayfield and Racine's (2008) np package which is analogous to the parametric t-test and employs bootstrapping.

periods that could potentially reduce the significance of the implemented tax rate and of the income level in predicting individual decisions, our experimental design mitigates the possibility of such correlation for two reasons. First, the experimental design re-assigns income to subjects after each decision period and so subjects do not benefit from submitting the same tax rate each decision period. Second, because the median submitted tax rate becomes the implemented tax rate in each decision period, subjects have an incentive to reveal their true preferred tax rate, which is related to their period-specific assigned income.

Using R's (R Core Team, 2012) np package from Hayfield and Racine (2008) for nonparametric local-linear regression, we obtain a 3-dimensional object defined on the following three axes: 1) the predicted probability of purchasing a positive amount of publicly-provided private good or 'topping-up', 2) the implemented tax rates resulting from the experiment and 3) the five income levels. Interactions are automatically incorporated since all dimensions are estimated simultaneously.[24] Viewing one plane of the object with the implemented tax rates as the x axis and predicted probabilities of topping up as the y axis yields Figure 3. Figure 4 illustrates similar results for the predicted amounts of private expenditure.

The non-parametric analysis reveals in Figure 3 that the probability of topping-up is affected by both the implemented tax rate and income level ($p = 0.00$ and $p = 0.00$ respectively). Figure 3 also shows a significant non-linear relationship between the probability of topping-up and income.[25] Between tax rates of 20% and 55% the

[24]Experimental session group is not included in the following analysis. Including it as a factor variable in the local linear regression was found to be insignificant except for the probability of positive private expenditure. In this case, the effect was not attributable to differences in behavior across groups within income classes and implemented tax rate, but across these income classes (the marginal effects surface for group was virtually flat). In no case was the significance of either implemented tax rate or income affected by the inclusion of this variable.

[25]The nonparametric approach provides the needed flexibility to identify these highly non-linear relationships. The coefficient of determination for the nonparametric model is 0.41, versus 0.29 for a parametric probit model.

probability of topping-up is significantly less for those with incomes of 125 and 275 than for those with incomes of 640, 700 and 1500. For tax rates between 55% and 75% the probability of topping up is higher for those with an income of 1500 than it is for the four other incomes. The probabilities of those with the middle incomes of 640 and 700 switches at tax rates between 50% and 60%: at rates less than 50%, they have high probabilities of topping-up and their behavior tracks that of subjects with incomes of 1500; but just as the tax rate reaches 50%, their probability of topping-up falls precipitously, and above rates of 60%, they have relatively low probabilities of topping up and their behavior follows that of subjects with incomes of 125 and 275. As there was no implemented tax rate below 19.7, the lowest income subjects would never be predicted to top-up. In similar fashion, subjects with income of 275 decided to top up more frequently than our theory predicted, with a fair amount of topping up at the high tax rates. Despite some non-optimal behaviour in the tails of the distribution of implemented tax rates (see Figure 1), there is still an observable drop in the probability of topping up right around where we predict it to occur at the tax rate of 35.1.

The nonparametric analysis of the amount of private purchases finds that the amount topped-up is also affected by both the implemented tax rate and by income ($p = 0.00$ and $p = 0.00$ respectively). The significant effect of income is reflected in Figure 4 by the gap between the confidence bands for the subjects with incomes of 1500 and the confidence bands for subjects with incomes less than 1500 over a wide range of the implemented tax rates. There is also a gap between the confidence bands for subjects with incomes 640 and 700 and subjects with incomes of 125 and 275 although over a smaller range of implemented tax rates. The significantly negative effect of the implemented tax rate is reflected by the absence of overlap of the confidence bands at low tax rates when compared with the confidence bands at high tax rates for the income level 1500. The amount of private purchases by subjects choosing to top-up at low tax

rates is significantly higher than the amount of private purchases by subjects choosing to top-up at high tax rates. This finding is intuitive and supports the theoretical prediction that higher income individuals should top-up by more for a given tax rate and for a given income private purchases should be decreasing in the implemented tax rate.

Result 2: Top-Up Behavior

(i) *Top-up behaviour of subjects, on average, is as predicted.*

(ii) *Income positively and significantly affects the top-up decision, but some lower income subjects choose to top-up when they were not predicted to do so.*

(iii) *Implemented tax rates negatively affect the top-up decision.*

4.3. Opt-Out Behavior

At the predicted equilibrium tax rate (26.5), only the highest income individual is predicted to opt-out and to spend L$616.53 on the private good or 41% of their income (Table 5). Conditional on opting out, the highest income individuals had an observed average private purchase that was not significantly different from the predicted amount. However, as discussed in section 4.1, the mean observed implemented tax rates were significantly higher than the predicted tax rate and so only 20% of the highest income individuals chose to opt-out. For the 125, 640 and 700 income levels, observed frequencies of opt-outs are significantly higher than the prediction of zero (although deviations are small, 6%, 6% and 10%, respectively) and the average amounts of private purchases per person when opting out are not significantly different from the predicted amount of zero, except for the subjects with income of 700, who purchased L$187 on average, significantly more than predicted.

But, as mentioned the observed mean implemented tax rate differed significantly from the predicted rate and therefore, to better understand the relationship between the actual implemented tax rate and both the likelihood of opting out and the amount

an individual privately purchases conditional on opting-out, we use a nonparametric local linear regression.

4.3.1. Nonparametric Analysis: Opt-Out Behaviour

Nonparametric local linear regression indicates that the probability of opting out of the publicly provided private good is significantly affected by both the actual implemented tax rate and income (Figure 5; p = 0.00 and p = 0.02 respectively). The negative relationship between the probability of opting out and the implemented tax rate is clearly shown in Figure 5 by income level. The significant relationship between the probability of opting out and income level is difficult to see from Figure 5. But, for more than 60% of the observations (between implemented tax rates of about 30% and about 70%, see Figure 1) the 90% confidence bands do not overlap between the subjects with income 1500, and those with the lower incomes of 125 and 275. There is substantial overlap of the confidence bands around the top three income levels (1500, 700 and 640) over most tax rates and around the bottom four income levels (125, 275, 640 and 700).

The amount of private purchases conditional on choosing to out-out is not significantly affected by the actual implemented tax rate, but is significantly affected by the income level (p = 0.11 and p = 0.00 respectively). The insignificant effect of the tax rate is reflected by the overlap of the confidence bands throughout the range of tax rates for each income level. The significant effect of income is reflected in Figure 6 by the gap between the confidence bands for the individuals with incomes of 1500 and the confidence bands of the individuals with income between 700 and 125.

Result 3: Opt-Out Behavior

(i) *Income positively affects the opt-out decision although some lower income subjects opted-out when not predicted to do so.*

(ii) *Implemented tax rates negatively affect the probability of opting-out, but not the amount purchased if opting-out.*

5. Discussion

5.1. Possible Explanations for Observed Behavior

While the behaviour of subjects in the experiment supported the theoretical predictions in a number of key respects, there are some discrepancies for which it is important to consider possible explanations. The behaviour of individuals with respect to private expenditure decisions in the mixed financing treatment, for example, generally supports the theoretical predictions with the exception of decisions by low-income individuals to make private purchases when they were not predicted to do so. The proportion of low-income individuals who made (non-predicted) private purchases was notably higher in the top-up treatment (22-24%) than in the opt-out treatment (0-6%). This difference across treatments may be explained in part by the lower relative cost of topping-up compared to the cost of opting-out. The cost is lower when topping-up because, unlike opt-out, topping-up does not require individuals to forfeit their consumption of the publicly-financed provision of the private good. This relatively lower cost of topping-up may also explain why those with an income of 640, who were not predicted to top-up at all, topped-up at levels similar to those with incomes of 700.

While the top-up and opt-out behaviour of higher-income subjects was as predicted under the mixed financing treatments, their average submitted tax rates differed from predictions. Specifically, the mean submitted tax rates by high-income individuals were similar across the public-only and mixed financing treatments, suggesting that they failed to recognize that under mixed financing it would be in their interest to have a zero tax rate. But subject-level data (as shown in Figure 2) reveal substantial heterogeneity, and that the two highest-income individuals more frequently submitted a

zero preferred tax rate under mixed financing than under public-only financing—11 out of 100 possible times in the public-only treatment, 12 out of the 50 possible times in the top-up treatment, and 11 out of 50 possible times in the opt-out treatment (p-values of 0.023 and 0.043 respectively for tests of each mixed treatment against public-only). This suggests that a significant number of high-income subjects recognized the benefit of lower tax rates and acted optimally under the mixed financing schemes.

More difficult to explain is the behaviour of the median income subjects in the opt-out treatment. We find no support for the prediction that the median income subject would submit a lower tax rate in the opt-out treatment than in both the top-up and public-only treatments. A number of factors, singly or in combination, may have contributed to this unexpected result. One possibility is risk aversion. The median income subject's motivation for submitting a lower tax rate under opt-out is that the lower rate will induce the highest-income subject to opt-out. Consequently, although the lower tax rate reduces total public revenue, if the highest-income subject opts-out this revenue is shared among a smaller number of individuals, raising the public provision for the median voter. This prediction, however, assumes that all subjects act rationally and self-interestedly. If the highest-income subject fails to recognize their self-interest and does not opt-out at the lower-tax rate, the median-income subject is worse off than if they had submitted a higher rate. In the context of the experiment, the behaviour of the highest-income subject is uncertain. In such a context, a risk-averse median-income subject may hedge their bets and submit a tax rate higher than would be the case were they certain the highest-income subject would opt-out at the lower rate.

Another possibility is that subjects found the opt-out scenario too cognitively challenging, a factor that may have been exacerbated by varying individuals' incomes across decision periods (a design intended to give subjects incentive to keep actively thinking

about their decisions, but which may have increased cognitive burden). Data from subjects use of the on-screen calculator (which enabled them to test the effects of decisions) provides evidence that subjects understood the opt-out environment. Specifically, the hypothetical decisions they entered into the calculators indicate that many high-income subjects planned to opt-out early in the decision period, but when the implemented tax rate turned out to be high they rightfully chose not to do so.

A final possibility is that the subjects have other-regarding preferences and wanted to support public provision of the private good (which recall in this case is simply the returns to some group investment in the market). In a similarly framed experiment that explored another mixed financing system in which subjects could choose to completely exit the public system by withdrawing their contributions as well as forfeiting the public provision, we found that subjects exited the public system at rates less than predicted (Buckley et al. 2014). This behaviour did not completely go away even if subjects experienced the same income every decision period (and so had a better chance of learning the benefits of exiting); nor was the less-than-expected exit behaviour related to the cooperativeness or altruism of subjects as measured by a social-value-orientation ring-game.

5.2. Equity and Policy Implications of Observed Behaviour

The public provision of a private good such as education is often motivated by an equity concern, a desire to reduce inequality in consumption of the good. Pure public provision ensures that an equal amount of a good is provided to everyone. An important question that our results can shed some light on is to what extent does allowing private purchases under mixed financing affect inequality in subjects' consumption of the publicly provided private good. Using the coefficient of variation (CoV) as a convenient measure of inequality, in our environment a public-only system of financing is predicted to have perfect equality in consumption (CoV = 0), mixed financing with

top-up is predicted to result in a CoV of 0.22 for consumption, and mixed financing with opt-out is predicted to result in a CoV of 0.61 for consumption.[26] Allowing private purchases through top-up, therefore, is predicted to still redistribute income and achieve equity improvements on par with those under public-only finance. Opt-out is predicted to have notably greater inequality in consumption of the private good.

By design, the mean observed CoV for consumption in the public-only treatment is, as predicted, equal to 0. Under top-up, the mean observed CoV of 0.24 is not significantly different from the predicted value of 0.22. Despite some low-income individuals topping-up the overall effect on consumption inequality was negligible. The results under opt-out, however deviate from predictions: the distribution of consumption is significantly more equal than predicted (CoV of 0.15 versus the prediction of 0.61) and the distribution of consumption is significantly more equal than under top-up. Consumption under opt-out is distributed more equally than predicted because the implemented tax rate was significantly higher than predicted and therefore, low-income individuals consumed more of the good (though public provision) than predicted and high-income individuals consumed less (because given the higher tax rates they chose not to opt-out and make private purchases). The higher relative cost of opting-out compared to topping-up at high tax rates resulted in a significantly more equal distribution of consumption of the private good under opt-out than under top-up.

We can also examine the distribution of payoffs across the two mixed financing treatments which could inform which system of financing might be socially preferred. If society had no aversion to payoff inequality, then total payoffs could be used as a measure of social welfare. Based on observed behaviour, the mean total (per period) payoffs is higher under the public-only finance than either of the mixed financing treat-

[26]Predicted and observed CoVs for consumption and payoffs (described below) are provided in Table A.1 of Appendix A.

ment and therefore, a public-only system of finance would maximize social welfare.[27] If instead society wanted to equalize payoffs, then based on observed behaviour any of the three financing systems would result in the same degree of payoff equality as the CoVs of payoffs do not differ meaningfully between the three systems of finance. Finally, we could consider what system would be preferred by the majority. Theoretically, the mixed-systems of financing would receive majority support relative to the public-only system of finance. In our experiment, on average the median income and second-highest individual topped-up more than predicted and consequently received lower payoffs than expected. Likewise, the potential gains from being able to opt-out were not realized in the opt-out treatment given the higher than predicted tax rate. Empirically, the majority of subjects were better off, on average, in the public-only system of finance relative to the two mixed-systems of finance and therefore public-only financing would receive majority-support.

6. Conclusion

This laboratory experiment represents the first empirical test of theoretical predictions regarding support for the public provision of a private good, such as education or health care, under alternative mixed financing systems. We found that subject behavior was generally consistent with the theoretical predictions of a mixed system of finance with top-up and of a pure publicly financed system, but we identified an important treatment effect of a mixed system of finance with opt-out. Under mixed financing with opt-out, subject behavior leads to an outcome with significantly higher public provision of the private good than was predicted by theory and consequently less opting-out. On the whole, subjects exhibited the expected income-gradient with

[27]See Table A.2 of Appendix A for payoffs. Total payoffs are predicted to be 35 higher in top-up and 55 lower in opt-out compared to public-only finance.

respect to preferred tax rates — high-income subjects preferred lower tax rates than did low-income subjects. Further, the individual-level analysis revealed that, under both mixed financing systems, when choosing whether and by how much to exercise the private-purchase option subjects generally responded as predicted to variation in their income and in the tax rate they faced. One interesting finding is a seeming classification of subjects by income groups. We observe that 125 and 275 income subjects have very similar behaviours, as do 640 and 700 income level subjects, even when the incentives posed in the experiment would predict the 700 level income to behave more closely to the 1500 level subjects. Whether this is evidence of strong group identity by income level is a point which may be of interest to further research since it appears to have a strong influence on individual behaviour.

One question is whether we would observe the same behaviour in the field. The opt-out treatment implemented in the experiment could be viewed as a conservative test of the field implementation since the experiment was framed in terms of group investments rather than education or health care. At the same time, our results are based on tests of theoretical models with no quality or cost differences between the publicly and privately financed private good and no spillovers in the consumption of the private good. These assumptions are unlikely to hold in the field when considering education or health care. To evaluate behaviour under these more realistic features of the private good would involve the development of a different theoretical model which is an important step for future research.

There are many other directions for future research. Several experimental papers have investigated majority-voting over redistribution and focus on the role of inequality aversion or fairness considerations (Clark 1998; Höchtl et al. 2012; Ackert et al 2007), social identity (Klor and Shayo 2010), and source of income, i.e., endowed or task-based (Balafoutas et al. 2013), in explaining preferences for redistribution as expressed

through the voting mechanism. Testing for preferences over redistribution will require modifying the underlying behavioral model to obtain predictions consistent with various characterizations of people who have other-regarding preferences.[28] Only recently has other-regarding preferences been integrated into theoretical political economy models (e.g., Dhami and Al-Nowaihi 2010).

Second, in the field people generally express preferences regarding the provision of services rather than tax rates. For instance, a more "realistic" approach to collective decision-making through majority-rule voting might be to have participants vote on levels of spending rather than taxes. Alternatively, actual tax rates typically result from a process that is not a direct part of the public referendum process. For example, Fréchette et al. (2012) and Battaglini et al. (2012) present laboratory environments in which public good provision is presented within the context of legislative bargaining. Subjects might find this quite different frame a more natural way to think about the problem. While the theoretical predictions of a simple majority-rule models of tax-financed public provision of a private good are not captured fully by our laboratory data, the experiments reported here provide a baseline set of controlled laboratory results and leave for future work the testing of more complicated models that consider differences in quality or cost between public and privately financed private goods, spillovers in the consumption of the private good, alternative behavioral hypotheses, and different political mechanisms.

[28]Work by Clark (1998), Tyran and Sausgruber (2006), Ackert et al. (2007), Klor and Shayo (2010), Messer et al. (2010) and Höchtl et al. (2012) indicate that other-regarding preferences can be important in laboratory contexts.

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Table 1: Predicted and Implemented Tax Rates by Treatment, Last 5 Periods

	Top-Up Sessions		Opt-Out Sessions	
	Public-Only	Top-Up	Public-Only	Opt-Out
Predicted Tax Rate	56.39	56.39	56.39	26.51
Observed Mean Implemented Tax Rate	58.38	54.24	55.24	54.58*
Standard Deviations)	(4.68)	(11.61)	(3.53)	(11.13)
Observations	10	10	10	10

Notes: Statistically significant differences between an observed value and those from other treatments or between an observed value and its predicted value are indicated with superscripts. All statistical tests are conducted using a 10% significance level. * indicates that the observed value is significantly different from its predicted value.

Table 2: Predicted and Mean [Median] Observed Submitted Tax Rates by Income and Treatment, Last 5 Periods

	Predicted Rate			Top-Up Sessions Observed Rate		Opt-Out Sessions Observed Rate	
Income	Public-Only	Top-Up	Opt-Out	Public-Only	Top-Up	Public-Only	Opt-Out
125	93.7	93.7	93.7	86.36*	83.60*	86.10^{O}*	75.94^{P}*
				[94]	[90]	[94]	[90]
275	82.1	82.1	82.1	79.86	73.98*	78.34^{O}	68.22^{P}*
				[82]	[80]	[82]	[80]
640	56.4	56.4	26.5	56.56	52.36	51.94*	54.94*
				[56]	[55]	[55]	[55]
700	53.1	0	0	53.30^{T}	42.22^{P}*	49.62*	50.22*
				[53]	[50]	[53]	[50]
1500	26.5	0	0	25.72	29.10*	25.84	29.16*
				[26]	[25.5]	[26]	[27]

Notes: All statistical tests are conducted using a 10% significance level. * indicates that the observed value is significantly different from its predicted value. ^{P} indicates that the observed value to which the superscript is attached is significantly different from the corresponding value in the public-only treatment. ^{T} indicates that the observed value to which the superscript is attached is significantly different from the corresponding value in the top-up treatment. ^{O} indicates that the observed value to which the superscript is attached is significantly different from the corresponding value in the opt-out treatment.

Table 3: Observed Count of Subjects Whose Submitted Tax Rate was the Median-Ranked Submitted Tax Rate by Income and Treatment, Last 5 Periods

Income	Public-Only Sessions	Top-Up Sessions	Opt-Out Sessions
125	0^{to}	$3^{\star p}$	$5^{\star p}$
275	$4^{\star to}$	$6^{\star p}$	$10^{\star p}$
640	$56^{\star o}$	$24^{\star}$	$19^{\star p}$
700	$38^{\star to}$	$12^{\star p}$	$13^{\star p}$
1500	$2^{\star to}$	$5^{\star p}$	$3^{\star p}$
Total Count	100	50	50

Notes: For all three treatments, the subject with the median income (640) is predicted to submit the median-ranked tax rate. Therefore, the predicted count for public-only by income is (0,0,100,0,0) and for both top-up and opt-out is (0,0,50,0,0). All proportions tests are conducted using a 10% significance level. A * indicates that the observed count statistically differs from the predicted count. A ^{p} indicates that there is a statistically significant difference between the observed top-up or opt-out count and the observed public count. A ^{o} indicates that there is a statistically significant difference between the observed public or top-up count and the observed opt-out count. A ^{t} indicates that there is a statistically significant difference between the observed public or opt-out count and the observed top-up count. For instances in which two subjects submitted the same tax rate which was the median tax rate of all submitted tax rates, the subject with the income closest to the median income was determined to be the subject submitting the median tax rate. This occurred eleven times (out of a possible 200 cases) and in only two of these instances was the median income subject not involved in the tie.

Table 4: Predicted and Observed Private Expenditure Top-Up Sessions, Last 5 Periods

Income	Predicted Private Expenditure	Observed Mean Private Expenditure	Observed % with Positive Private Expenditure	Observed Mean Private Expenditure Conditional on Positive Expenditure
125	0	8.41*	24%*	39.43*
275	0	14.32*	22%*	75.85*
640	0	40.24*	56%*	72.60*
700	9.71	46.40*	60%*	71.28*
1500	204.84	210.14	78%*	267.91*

Notes: Private expenditures are in L$ per subject. A predicted private expenditure of zero implies that the individual is not predicted to top-up. All statistical tests are conducted using a 10% significance level. * indicates that the observed value is significantly different from its predicted value.

Table 5: Predicted and Observed Private Expenditure Opt-Out Sessions, Last 5 Periods

Income	Predicted Private Expenditure	Observed % who Opt-Out	Observed Mean Private Expenditure for those who Opted-Out
125	0	6%*	22.33
275	0	0%	0
640	0	6%*	140.67
700	0	10%*	186.80*
1500	616.53	20%*	622.62

Notes: Private expenditures are in L$ per subject. A predicted private expenditure of zero implies that the individual is not predicted to top-up. All statistical tests are conducted using a 10% significance level. * indicates that the observed value is significantly different from its predicted value.

Figure 1: Observed Implemented Tax Rates in each of the Last 5 Decision Periods across all Sessions by Treatment

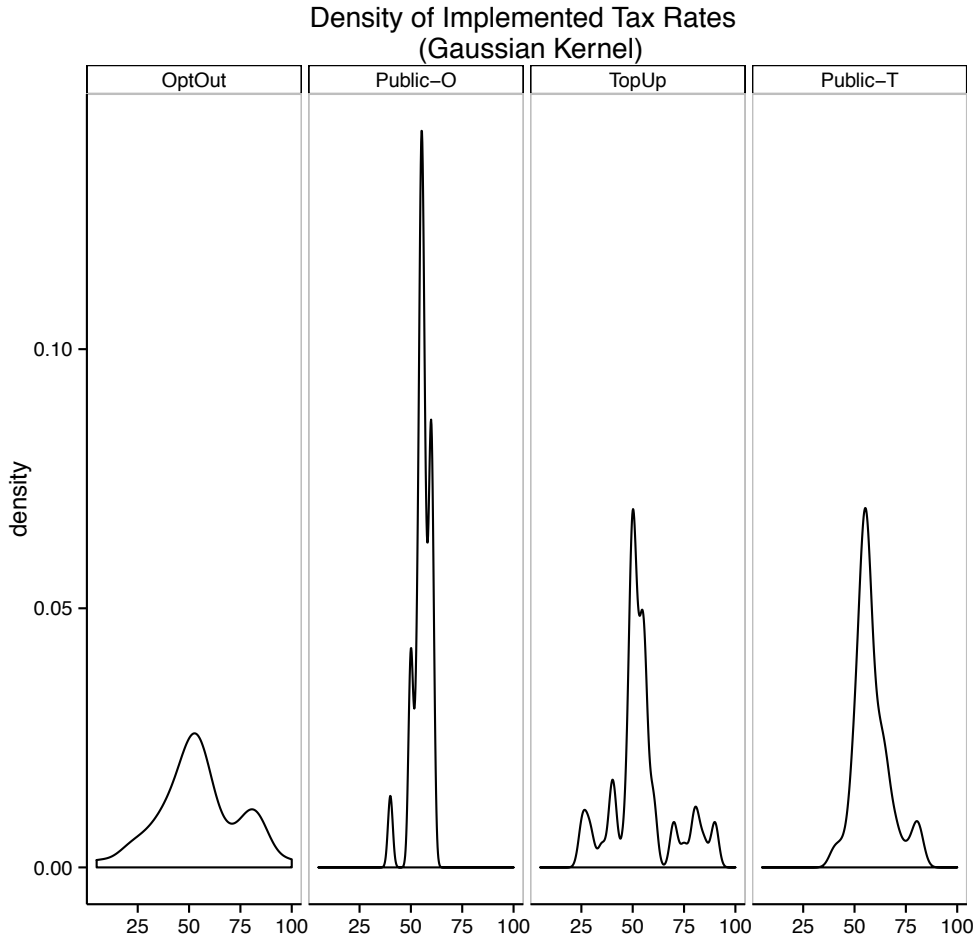


Figure 2: Observed Submitted Tax Rates in each of the Last 5 Decision Periods across all Sessions by Income and by Treatment

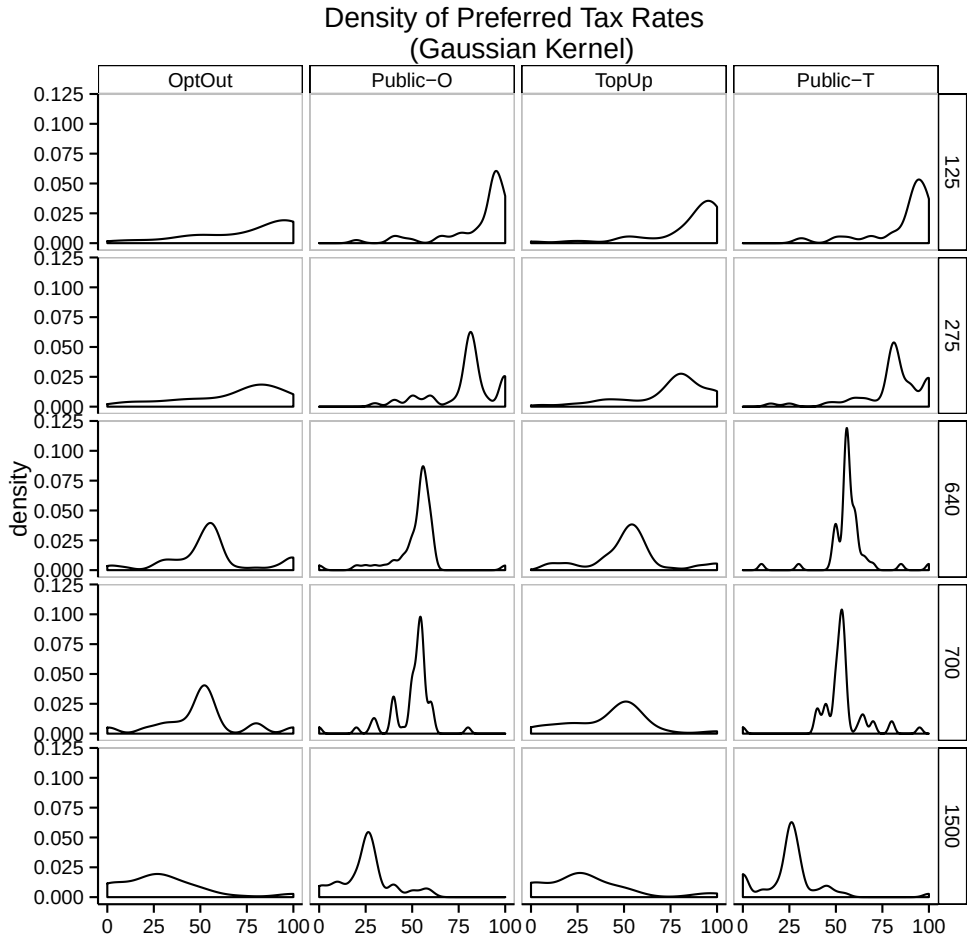


Figure 3: Probability of Topping Up by Income and Implemented Tax Rate

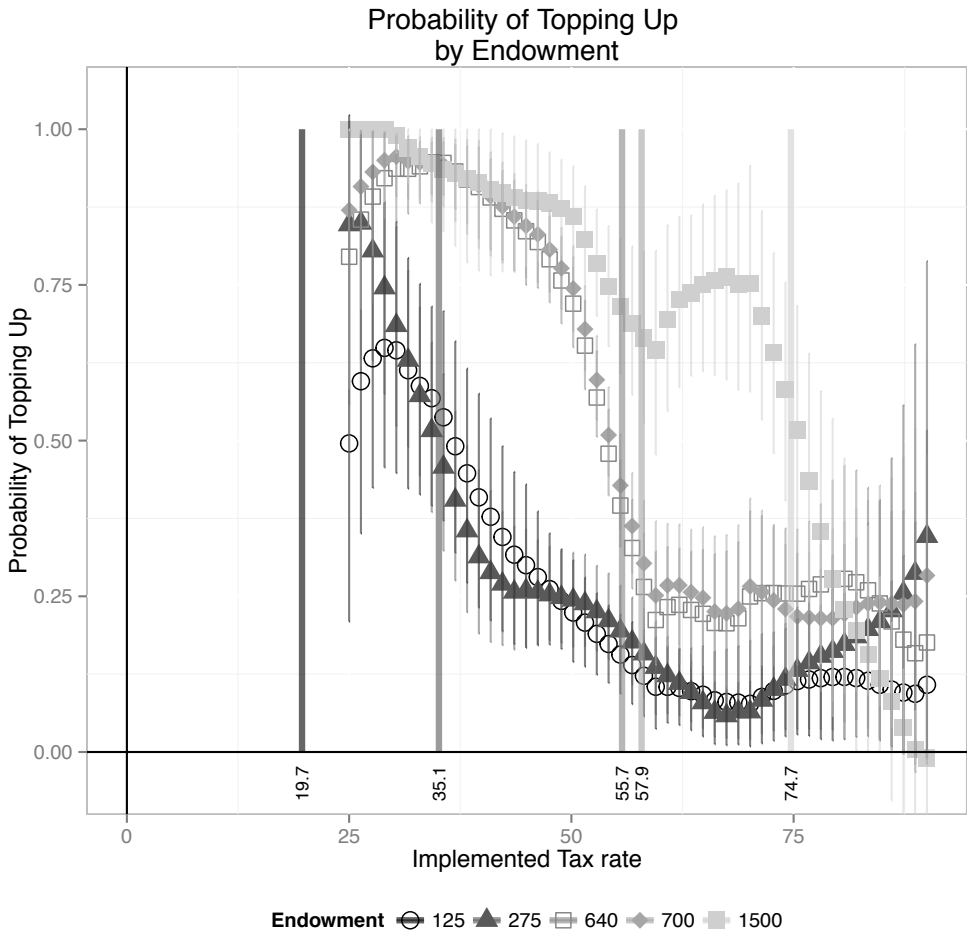


Figure 4: Amount Topped Up by Income and Implemented Tax Rate

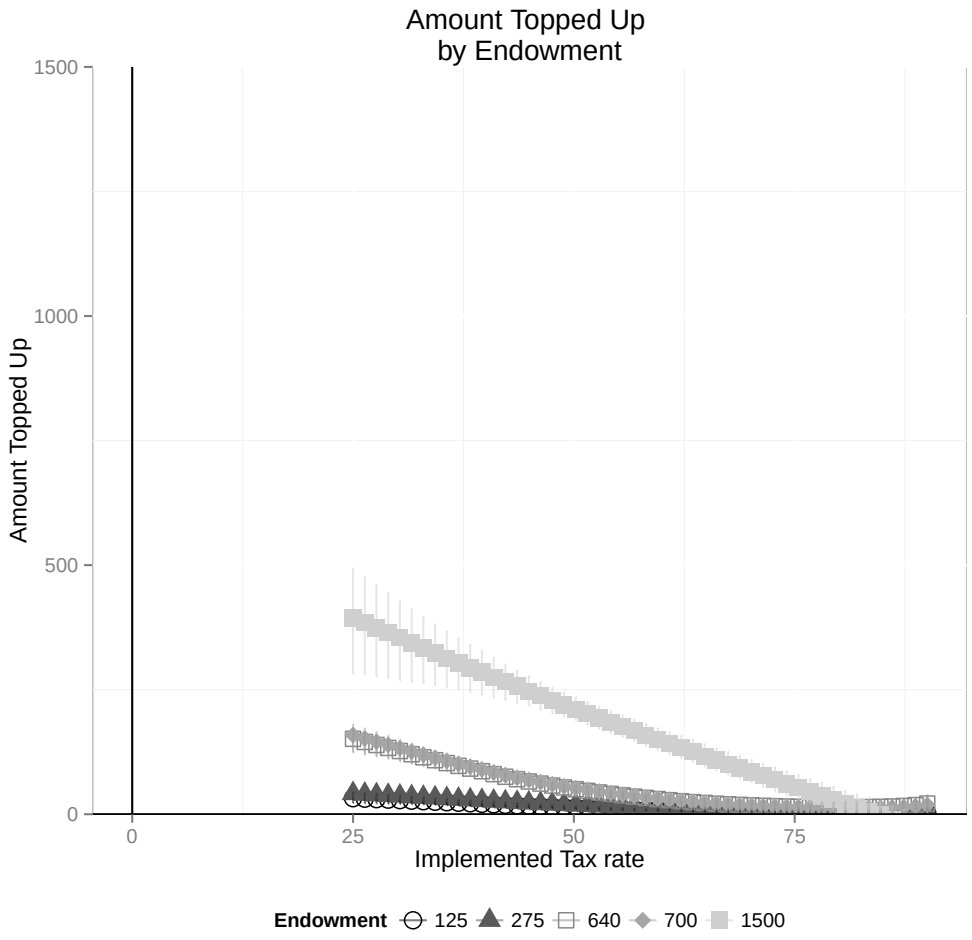


Figure 5: Probability of Opting Out by Income and Implemented Tax Rate

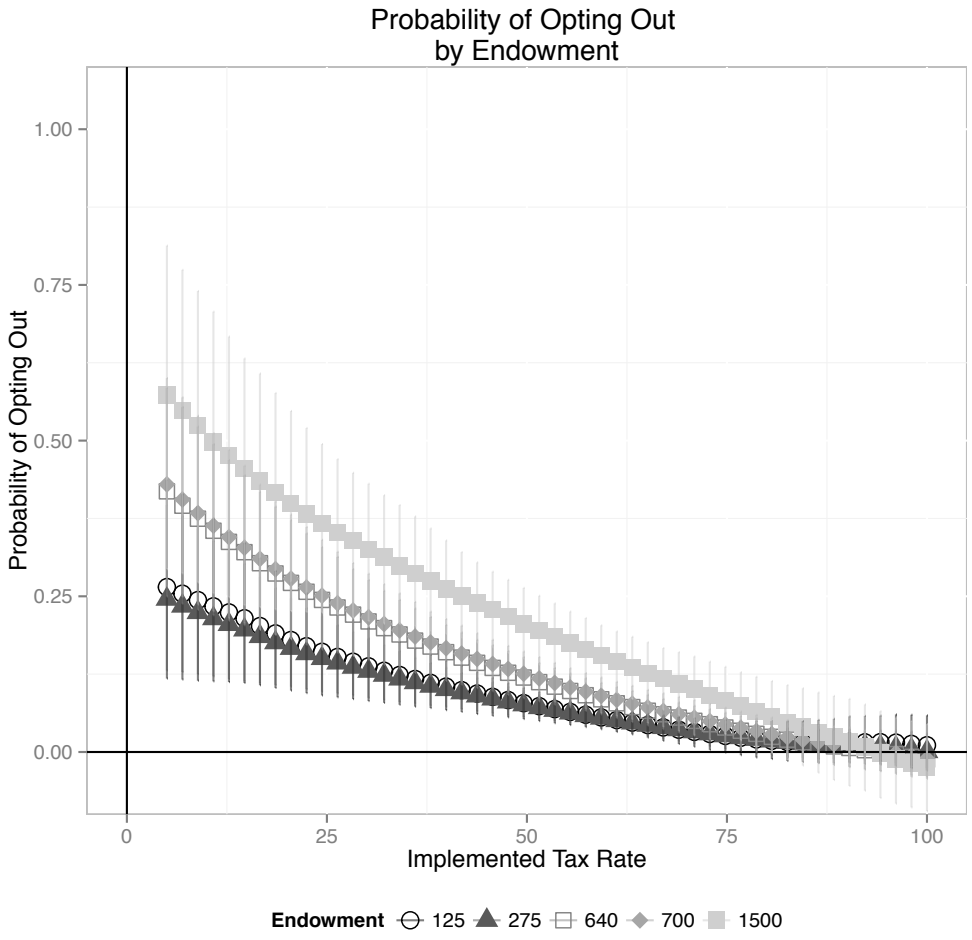
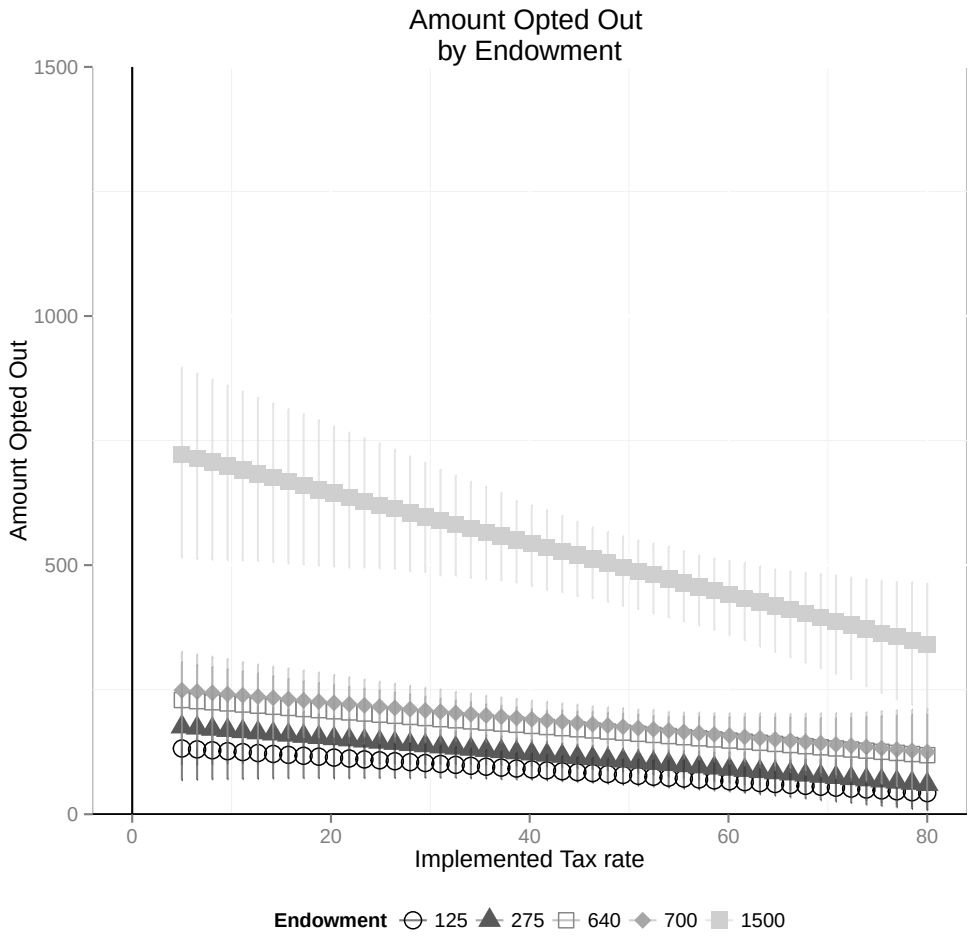


Figure 6: Amount Opted Out by Income and Implemented Tax Rate



Appendix A. Additional Tables

Table A.1: Mean Coefficient of Variation (CoV) for Consumption of Private Good and Payoffs by Income, Last 5 Periods

				Sessions with Top-Up		Sessions with Opt-Out	
	Public-only Finance Predicted	Top-Up Predicted	Opt-Out Predicted	Public-only Finance Observed	Top-Up Observed	Public only Finance Observed	Opt-Out Observed
Consumption	0	0.222	0.609	0^{T}	$0.240^{O,P}$	0^{O}	$0.149^{T,P,*}$
(Standard Deviation)	(n/a)	(n/a)	(n/a)	(0)	(0.088)	(0)	(0.107)
Payoffs	0.221	0.230	0.296	0.215^{T}	0.244^{P}	0.225	0.238*
(Standard Deviation)	(n/a)	(n/a)	(n/a)	(0.015)	(0.048)	(0.021)	(0.042)

Notes: All statistical tests are conducted using a 10% significance level. * indicates that the observed value is significantly different from its predicted value. ^{P}indicates that there is a statistically significant difference between the top-up or opt-out value and associated public value. $^{O(T)}$ indicates that there is a statistically significant difference between the observed opt-out (top-up) value for the treatment to which the superscript is attached. The observed CoV value of 0.244 for payoffs in the top-up session in the above table is only significantly different from the observed public CoV value of 0.210 using a paired t-test and is not significant using a Wilcoxon Sign-Rank test.

Table A.2: Per Period Payoffs by Treatment and Income, Last 5 Periods

				Sessions with Top-Up		Sessions with Opt-Out	
Income	Public-only Provision Predicted	Top-Up Predicted	Opt-Out Predicted	Public-only Provision Observed	Top-Up Observed	Public only Provision Observed	Opt-Out Observed
125	979	979	853	986^{T}	943^{P}	972	944*
275	1112	1112	1035	1115^{T}	$1077^{O,P,*}$	1107	1121^{T}
640	1346	1346	1354	1340*	1328*	1344*	1332*
700	1377	1378	1398	1371*	1364^{O}	1377^{O}	$1328^{P,T,*}$
1500	1737	1772	1857	1718*	1759^{O}	1741^{O}	$1668^{P,T,*}$
Payoff Per Person	1310	1317	1299	$1306^{T,*}$	$1294^{O,P,*}$	1308^{O}	$1279^{P,T,*}$
Total Payoffs	6550	6585	6495	$6522^{T,*}$	$6480^{O,P,*}$	6541^{O}	$6395^{P,T,*}$

Notes: All statistical tests are conducted using a 10% significance level. * indicates that the observed value is significantly different from its predicted value. ^{P}indicates that there is a statistically significant difference between the top-up or opt-out value and associated public value. $^{O(T)}$ indicates that there is a statistically significant difference between the observed opt-out (top-up) value for the treatment to which the superscript is attached. All of the entries are rounded to the unit. The observed top-up mean value of 1364 in the table above is only significantly different from the observed opt-out mean value of 1328 using a Mann-Whitney test and is not significant using a t-test. The observed top-up mean value of 1294 in the table above is only significantly different from the observed public mean value of 1306 using a Mann-Whitney test and is not significant using a t-test. The observed top-up mean value of 1294 in the table above is only significantly different from the observed opt-out mean value of 1279 using a Mann-Whitney test and is not significant using a t-test.