

# Equilibrium Tax Rates and Income Redistribution: A Laboratory Study<sup>1</sup>

Marina Agranov<sup>2</sup> and Thomas R. Palfrey<sup>3</sup>

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<sup>2</sup>Division of the Humanities and Social Sciences, California Institute of Technology, Mail Code 228-77, Pasadena, CA 91125. Email: magranov@hss.caltech.edu.

<sup>3</sup>Division of the Humanities and Social Sciences, California Institute of Technology, Mail Code 228-77, Pasadena, CA 91125. Email: trp@hss.caltech.edu.

## **Abstract**

This paper reports results from a laboratory experiment that investigates the Meltzer-Richard model of equilibrium tax rates, income redistribution, and the growth of government.

# 1 Introduction

In the US and other democratic countries, taxes are decided by the political process, and income tax policy especially has enormous consequences for the economy, both in terms of the distribution of income and inequality as well as economic efficiency. On one hand, income taxes are used to finance public expenditures on government services that are at least partly redistributive in nature, such as public education, public insurance and social programs. These expenditures are aimed at benefiting society as a whole, but the costs of these programs are borne in proportion to income (or, under progressive taxation, more than proportionally to income). On the other hand, taxes may negatively affect efficiency of the economy through distortions in the private sector. In fact, this fundamental tradeoff between the level of income taxes (and hence the amount of redistribution) and the functioning of the economy is the main dimension of political conflict and polarization over tax policy that has come to dominate electoral and legislative politics on economic issues.

Theoretical literature in the 1970s has proposed a rigorous, equilibrium-based political economy approach to addressing the positive question of how the level of income taxes are determined in the democratic society (see Romer (1975), Roberts (1977) and Meltzer and Richard (1981)). The efficiency-equity tradeoff in these models is captured by a distortion to labor supply created by a gap between the after-tax wage and a workers marginal productivity. The heterogeneity in the agents' productivities is the driving force behind inequality in the pre-tax incomes. While predictions of these models have enormous consequences for the economy, both in terms of inequality level and economic efficiency, implications of these theories are extremely difficult to test using macro field and historical data sets, for which there are relatively limited time series available. There are open methodological issues about the extent to which these studies enable one to draw causal conclusions, as well as the deeper problem of endogeneity of the economic and political variables using historical or contemporary data. There have been several attempts, but taken collectively, these studies have led to ambiguous (and sometimes conflicting) conclusions.<sup>1</sup>

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<sup>1</sup>Several papers attempted to test the median voter tax hypothesis, which is implied by models mentioned above and suggests that the tax rate and/or government expenditures in democracies will correspond to the ideal level of public expenditure of the median voter. Meltzer and Richard (1983) test this with data on their categorization of redistributive expenditures in the U.S. between 1936 and 1977, but exclude expenditures on public goods such as public safety, defense, and infrastructure. They don't find direct evidence for the hypothesis, but find that purely redistributive expenditures are positively correlated with the ratio of mean to median income. Milanovic (2000), in a cross-sectional study of 24 democracies, also finds that factor income redistribution to the poor

In spite of the inconclusive empirical evidence, there is a widespread consensus about interdependence between agents' behavior in economical and political domains. Indeed, labor supply crucially depends on the amount of taxation imposed by the political process and, vice-versa, indirect preferences of agents for the level of taxation and redistribution crucially depend upon agents' beliefs about labor market behavior of other agent. For instance, poor may prefer a lower tax rates if they have reason to believe that rich might withhold labor when taxes are too high. While theoretical literature has long recognized the necessity to study the interplay between market behavior of heterogeneous agents and their preferences for redistribution expressed in the political arena, existing experimental literature lags behind (see Section 1.1 for the literature review).<sup>2</sup>

Our paper aims to fill this void. In our experiment subjects operate in two environments: political environment, in which the level of taxation is determined, and the labor market (economical environment), in which given the level of redistribution and the assigned productivities citizens choose labor supply that generates pre-tax income. Because of the redistributive effect of income taxation and because individuals differ in their productivities and hence their incomes, individuals in our experiment have different indirect preferences for the level of taxation and these preferences depend upon the distribution of productivities in the economy. Political institutions are the means by which these heterogeneous preferences are aggregated into a public decision on the tax rate. However, because the tax rate in turn affects the amount of income that is generated by the private economy, agents preferences for redistribution themselves are endogenous and depend on how taxes affect individual labor supply decisions.

Our experimental design is motivated by two main goals and it integrates ideas from economic experiments on labor supply, voting experiments and experiments on candidate competition in elections. The first goal is to provides a direct test of Meltzer

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correlates with measures of income inequality, but finds little support for the median voter hypothesis. On the other hand, Perotti (1996), in his cross-sectional study of 67 countries, does not find significant evidence for a positive relationship between inequality and middle class tax rates. Thus, the overall picture is one of mixed empirical findings. While some of the findings are suggestive of a link that would be consistent with the median voter tax hypothesis, the link is tenuous and does not help identify the mechanism by which the median voters preferences are revealed in the political process.

<sup>2</sup>The noticeable exception is recent study of Grosser and Reuben (2013) which we discuss in details in Section 1.1.

and Richards (1981) model and study the political economy equilibrium that emerges under two different majoritarian political processes: *direct democracy* and *representative democracy*. In the direct democracy mechanism, the median voter's preferred policy is elicited directly, while in the representative democracy mechanism voters choose in an election between two office-motivated candidates who compete by choosing tax rates as their platforms.<sup>3</sup> The second exercise is to study the link between inequality and redistribution. To do that we fix the political environment, vary the inequality level by varying the initial productivities of the citizens and test whether higher inequality leads to higher levels of taxation for a given political institution.

We have several main results. First, higher inequality leads to more income redistribution through higher taxation in both political regimes (direct democracy and representative democracy). Second, both regimes implement on average theoretically predicted tax rates. Third, labor supply decisions of agents are very close to the optimal with the exception that high income agents undersupply their labor especially for the high tax rates. Finally, we observe a lot of heterogeneity in the implemented taxes across different groups and this variation does not appear to be connected to the variation of empirical labor supply functions across groups.

We see experiments as valuable component of the research agenda that aims at advancing our understanding of the political economy of redistribution and taxation. Indeed, these controlled laboratory experiments provide a clean test of the theoretical models in very simple environments, while preserving the main incentives and trade-offs that people face outside of the laboratory. Hence, data created from a carefully controlled setting that can be used toward the development of better models. With respect to income redistribution, perhaps the most obvious candidate to be an important behavioral factor would be other-regarding preferences (see Section XX). Further, our paper can be seen as one of the first attempts to study the interaction between labor market and political behavior, while keeping all the remaining details (political institution and distribution of productivities) constant and varying one parameter at a time. For these purposes, experiments have a significant advantage over empirical research using historical time-series or cross-sectional data.

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<sup>3</sup>One of the shortcomings of most theoretical models of the political economy of income taxation is that they are completely silent about the mechanics of the political process by which a tax rate is chosen. The models simply assume that under majority rule the tax rate preferred by the median voter would emerge, as if by magic. However recent work in political economics indicates that a institutional details of a democratic system cannot be ignored, as they may lead to a variety of different outcomes that do not correspond to the ideal point of the median voter.

The paper is structured as follows. In the remainder of this section, we discuss related literature. Section 2 presents theoretical model which would serve as the basis for our experiments. Section 3 discusses in details experimental design. Results are presented in Section 4 and Section 5 offers some conclusions. All the instructions for the experiments are presented in Appendix.

## 1.1 Related Literature

Existing experimental literature has devoted a lot of attention to measuring preferences for redistribution. Some papers concentrate entirely on examination of two motives - self-interest versus fairness - and abstract away from efficiency concern<sup>4</sup>. Others more recent studies investigate whether and how efficiency affects participants' social preferences by exogenously varying the size of the total pie to be distributed and (in)equality of the shares. Bolton and Ockenfels (2002) conduct a series of voting games, in which subjects are confronted with two distributions of incomes - one that promotes efficiency and one that promotes equity. Tyran and Sausgruber (2006) report that social preferences of the Fehr-Schmidt type may explain voting behavior on redistribution in an experiment where subjects were endowed with different income levels and vote on a fixed amount of redistribution. Hocht, Tyran and Sausgruber (2012) report a followup experiment suggesting that the ability of inequality aversion to explain voting behavior on redistribution depends heavily on the pre-tax distribution of income. In all papers described above, the amount of resources to be distributed is fixed exogenously and participants can only decide how to reallocate this surplus between themselves. In our experiments subjects' labor market decisions determine the total surplus generated. Moreover, while measuring preferences for redistribution is not the main focus of our paper, our design allows us to detect the presence of social preferences through analyzing both labor market decisions of agents as well as their voting patterns.

There are two recent studies that are closely related to our paper. Durante and Putterman (2009) conduct a laboratory experiment to study how preferences for redistribution vary with fairness preferences, risk aversion, self-interest and the source of pre-tax inequality. In particular, the authors investigate whether preferences for redistribution are affected by (1) the way the distribution of pre-tax endowments are determined: randomly (by luck) or based on the score obtained in the unrelated task

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<sup>4</sup>See Fehr-Schmidt (1999), Bolton and Ockenfels (2000), Rabin (1993), Andreoni and Miller (2002) and Fisman et al. (2007) for experimental work that studies dictator games

(such as SAT quiz or TETRIS game) and (2) whether the person choosing level of redistribution is affected by this redistribution process him/herself or is merely a disinterested observer. Among other things, the authors document that most subjects prefer a more equal distribution of final wealth; however, this preference for high redistribution decreases substantially when the initial distribution of endowments is determined based on the task performance rather than randomly. Similarly to the discussed above literature, the main goal of Duarnte and Putterman study is to *measure* subjects' preferences for redistribution and how they are affected by various factors. Consistent with this goal, the authors use random dictator method to elicit subjects' preferences and abstract away from the details of political process that determine taxation level as well as strategic behavior of subjects in the political sphere, which is what we do in our study. Put differently, our focus is on the equilibrium behavior of agents in both economical and political markets and how this behavior is affected by various political institutions used to determine taxes in the democratic societies.

The second closely related paper is that of Grosser and Reuben (2013), in which the authors report the results of two laboratory experiments. In the first experiment, subjects first earn their income by trading in a double auction knowing that after the trading is over their earned incomes will be subject to *exogenously* imposed redistribution (either zero or full redistribution). The goal of this experiment is to assess the effect of redistribution on trading efficiency. The second experiment investigates *endogenous redistribution* by introducing competition between two office-oriented candidates who propose the level of redistribution just like in our study. However, in Grosser and Reuben, trading occurs before sellers and buyers know what tax rate would be imposed on their earned incomes. In other words, agents operating in the market need to form beliefs regarding the tax rate that would emerge from the candidate competition and adjust their market behavior accordingly. On the contrary, in our experiments the tax rates are determined before agents choose their labor market supply, which allows us to study how taxes affect labor market decisions directly and not through the belief channel.

We are aware of only one experiment that investigates the MR model: Konrad and Morath (2010). The main difference between Konrad and Morath and our paper is that in the former the experiment looks at individual choice behavior without any strategic interaction. Each subject plays against two computers that have programmed behavior. Thus it does not test the equilibrium questions that are central to the theory we are interested in our paper. In contrast, the experiment reported here

employs a design where workers/voters with heterogeneous productivities engage in multiplayer strategic interaction in both the political and economical domains. Furthermore, Konrad and Morath (2010) focus on different questions about the relationship between social mobility and redistributive taxation, which we abstract away in the current paper.

## 2 The Model

The economy consists of  $n > 1$  agents. Agents operate in an perfectly competitive and frictionless labor market and also participate in a democratic political process that determines taxes which in turn affect labor decisions. We start by discussing the decision problem of an agent in the labor market assuming that the tax rate is fixed, and then turn our attention to how political process shapes tax rates. To simplify exposition, we describe here the setup with the utility function we implement in the experiments. We refer readers to MR for the derivation of equilibrium with general utility functions.

### The Labor Market

Agent  $i$  is endowed with productivity  $w_i$ . Individuals are identical in all other respects. The difference in choice of labor and consumption arise solely because of the differences in productivity. An agent with productivity  $w_i$  that works  $x_i$  time units earns pre-tax income  $y_i = w_i x_i$  and bears an effort cost of  $\frac{1}{2}x_i^2$  which represents the tradeoff between labor and leisure. Income and costs are measured in units of consumption and we assume no savings. In addition, an agent pays fraction  $t$  of earned income in taxes. Tax revenues are redistributed in equal shares.<sup>5</sup> So, utility  $U_i$  of agent  $i$  consists of three parts: after-tax disposable income, costs of labor and their share of redistributed taxes, where the latter depends on the entire profile of

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<sup>5</sup>Equivalently, taxes are used to finance a level of public good,

$$y = \frac{1}{n} \sum_{j=1}^n t \cdot w_j x_j$$

and all agents value the public good according to the function  $V(y) = y$ , corresponding to the last term of equation (1).

productivities,  $w = (w_1, \dots, w_n)$  and labor supply decisions  $x = (x_1, \dots, x_n)$  :

$$U_i(w_i, x_i, t) = (1 - t) \cdot w_i x_i - \frac{1}{2} x_i^2 + \frac{1}{n} \sum_{j=1}^n t \cdot w_j x_j \quad (1)$$

Given the tax rate  $t$ , agent  $i$  chooses labor supply  $x_i$  that maximizes the utility above, taking  $x_{-i}$  as given. The utility function is concave, and the unique optimal labor supply for individual  $i$  characterized by the first order condition:

$$x_i^*(w_i, t) = \left(1 - \frac{n-1}{n}t\right) w_i \quad (2)$$

Thus, all productive agents (i.e.,  $w_i > 0$ ) have positive labor supply for all tax rates,  $t \in [0, 1]$ . Labor supply is declining in the tax rate and is proportional to a worker's productivity. Hence, pre-tax income is proportional to the square of productivity. Note that because of the additively separable specification of utilities, optimal labor supply in our model does not depend on the labor supply decisions of other agents in the economy.

### The Political Process

Tax rates are determined by a political process. There are many possible voting rules ranging from dictatorship to unanimous consent, and each may produce a different outcome. In this paper, we focus on the majority voting rule, which is common in many political situations. We start by describing the preferences of agents over tax rates and then derive the tax rate that emerges from the majority voting rule. The utility of agent  $i$  when the tax rate  $t$  is implemented and all other agents follow the behavior prescribed by the equilibrium in the labor market is:

$$U_i^*(w_i, t) = \frac{1}{2} \left( (1-t)^2 - \frac{t^2}{n^2} \right) w_i^2 + \frac{t}{n} \left( 1 - \frac{n-1}{n}t \right) Z \quad (3)$$

where  $Z = \sum_j w_j^2$  denotes the aggregate income of the economy if the tax rate is  $t = 0$ .

### PROPOSITION 1:

Agents' preferences over tax rates satisfy three following properties:

1. Single-peakedness: for any  $w_i$ , there exists  $t_i^* \in [0, 1]$  such that

$$U_i^*(w_i, t) < U_i^*(w_i, t') \text{ for all } t < t' \leq t_i^*$$

$$U_i^*(w_i, t) < U_i^*(w_i, t') \text{ for all } t_i^* \geq t' > t$$

2. Ideal points are ordered by productivity:

$$t_i^* \leq t_j^* \Leftrightarrow w_i > w_j$$

3. The median ideal tax rate,  $t_m^*$ , is given by:

$$t_m^* = \begin{cases} \frac{n^2}{n^2-1} \cdot \frac{\frac{1}{n}Z - w_m^2}{\frac{2}{n+1}Z - w_m^2} & \text{if } w_m^2 \leq \frac{1}{n}Z \\ 0 & \text{if } w_m^2 > \frac{1}{n}Z \end{cases} \quad (4)$$

**Proof:** Single-peakedness is established in two steps. Clearly, if  $\frac{d^2U_i^*(w_i, t)}{dt^2} < 0$  in the region  $t \in [0, 1]$ , then single peakedness in the policy space follows immediately. From 3, we get:

$$\frac{dU_i^*(w_i, t)}{dt} = -w_i^2 \left(1 - t + \frac{t}{n^2}\right) + \frac{1}{n}Z \left(1 - 2\frac{n-1}{n}t\right) \quad (5)$$

$$\frac{d^2U_i^*(w_i, t)}{dt^2} = \frac{n-1}{n^2} ((n+1)w_i^2 - 2Z) \quad (6)$$

Thus, single-peakedness is guaranteed by concavity of  $U_i^*$  for all individuals whose productivity is sufficiently low, specifically if  $w_i^2 < \frac{2}{n+1}Z$ , i.e., as long as  $i$ 's zero-tax income is less than the average zero-tax income in the society. For relatively high productivity workers, who do not satisfy this inequality,  $U_i^*$  is convex, rather than concave. However, by solving for the tax rate,  $t_i^*$  that satisfies  $i$ 's first order condition, (5), we get:

$$t_i^* = \frac{n^2}{n^2-1} \cdot \frac{\frac{1}{n}Z - w_i^2}{\frac{2}{n+1}Z - w_i^2} \quad (7)$$

When  $0 \leq w_i^2 < \frac{1}{n}Z$ , then concavity holds and the expression above characterizes  $i$ 's ideal tax rate. When  $i$ 's productivity is in a slightly higher range,  $w_i^2 \in [\frac{1}{n}Z, \frac{2}{n+1}Z]$ , then concavity continues to hold, and  $i$ 's ideal tax rate equals 0, since the value of  $t_i^*$  given by (7) is negative, which is infeasible. Finally, for even higher productivity individuals, such that  $w_i^2 > \frac{2}{n+1}Z$ , it is easy to show that  $\frac{dU_i^*(w_i, t)}{dt} < 0$  for all values of  $t \in [0, 1]$ :

$$-w_i^2 \left(1 - t + \frac{t}{n^2}\right) + \frac{1}{n}Z \left(1 - 2\frac{n-1}{n}t\right) < 0 \Leftrightarrow w_i^2 > Z \cdot \frac{n(1-2t) + 2t}{n^2(1-t) + t}$$

The last inequality holds true for  $w_i^2 > \frac{2}{n+1}Z$  since  $\frac{2}{n+1} > \frac{n(1-2t)+2t}{n^2(1-t)+t}$ . The second and third properties follow immediately. **QED**

The intuition for this characterization is straightforward. Agents with lower productivity prefer higher taxes, because they enjoy substantial redistributive benefits which for the most part come from the tax payments of the higher productivity, and hence higher income, agents. In contrast, agents with higher productivity prefer lower taxes (or no taxes at all), because they end up subsidizing the large portion of the tax revenues from which they receive back only a small part in benefits.<sup>6</sup>

Single-peakedness and monotonicity of optimal tax with respect to productivities combined with the majority rule guarantee that the agent with the median productivity (median voter) is decisive. Put differently, the tax rate, which is the most preferred by the median voter, is the only tax rate which beats any other tax rate in a pairwise competition, and is therefore a Condorcet winner. This result echoes the median voter theorem from the spatial models of electoral competition.

Thus, the tax rate that emerges in a society that uses majority voting rule is  $t_m^*$ :

$$t_m^* = \begin{cases} \frac{n^2}{n^2-1} \cdot \frac{\frac{1}{n}Z - w_m^2}{\frac{2}{n+1}Z - w_m^2} & \text{if } w_m^2 \leq \frac{1}{n}Z \\ 0 & \text{if } w_m^2 > \frac{1}{n}Z \end{cases}$$

Total income in equilibrium is:<sup>7</sup>

$$\sum_{i=1}^n U_i^*(w_i, t) = \frac{1}{2} \left( 1 - \frac{(n-1)^2}{n^2} t^2 \right) \sum_{i=1}^n w_i^2$$

One natural question that arises in this setup is how do tax rates compare across economies that differ in the distribution of productivity levels of its agents. The following corollary to Proposition 1 provides an answer to this question.

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<sup>6</sup>These two properties are central in the theoretical literature that studies the political economy of redistributive taxation. Romer (1977) assumes that agents have Cobb-Douglas preferences over consumption and leisure and derives conditions under which the preferences of agents are single-peaked in the tax rate. Roberts (1977) derives a more general condition that guarantees that ideal points are inversely ordered by income. Meltzer and Richard (1981) assume the regularity condition of Roberts (1977).

<sup>7</sup>The tax rate that maximizes total income is  $t = 0$ .

**Corollary.** Consider two economies with  $n$  individuals, which differ only in the profile of productivities:  $w^A$  in economy A and  $w^B$  in economy B, and suppose that  $w_m^A = w_m^B$ . Then,

$$\begin{aligned} t^{*A} = t^{*B} = 0 & \text{ if and only if } w_m^2 > \frac{1}{n}Z^A > \frac{1}{n}Z^B \\ t^{*A} > t^{*B} = 0 & \text{ if and only if } \frac{1}{n}Z^A > w_m^2 > \frac{1}{n}Z^B \\ t^{*A} > t^{*B} > 0 & \text{ if and only if } \frac{1}{n}Z^A > \frac{1}{n}Z^B > w_m^2 \end{aligned}$$

The corollary can be interpreted in terms of inequality in productivities as measured approximately by the variance of worker productivities. To see this, notice that in the special case where the median productivity equals the *mean* productivity, then  $\frac{1}{n}Z$  is approximately equal to the variance of  $w_i$ , with the approximation being arbitrarily close for large  $n$ . In this case, an increase in the variance that leaves the mean unchanged will lead to a higher equilibrium tax rate. The tax rate chosen by the median voter will be higher in the economy in which the productivity levels are more unequal as captured by this variance-related measure,  $\frac{1}{n}Z$ .

Also, if the distribution of productivities in economy A is more right skewed than the one in economy B then  $\frac{1}{n}Z^A > \frac{1}{n}Z^B$  and we would expect (weakly) higher taxes in economy A than in economy B. The intuition for this result comes from the fact that tax revenues are rebated back to all agents in equal shares. When higher productivity agents become more productive, they work more and, thus, contribute more to the total tax revenues. Therefore, the median voter would prefer higher taxes and more redistribution since an increase in the tax rebate associated with an increase in tax rates outweighs the decrease in after-tax disposable income.

### 3 Experimental Design

The experiment is designed to examine the comparative statics implied by the equilibrium tax rates and labor supply in the theoretical model described in Section 2, and to examine the robustness of these outcomes to the political institution. Before we launch into the details of the experimental design, recall that theory is silent about the mechanics of the political process by which a tax rate is chosen. Indeed, the model simply assumes that under majority rule the tax rate preferred by the median voter would somehow emerge, as if by an invisible (political) hand. However, empirical work suggests that institutional details of a democratic system may lead to outcomes that do not correspond exactly to the ideal point of the median voter. In fact, there is also considerable theoretical work demonstrating the plausibility of

non-median outcomes even with highly competitive democratic process. For example, competition between two purely office-motivated candidates on one dimension, and Euclidean preferences of voters, imply equilibrium policies at the *mean* voter ideal point if voting is probabilistic. (Hinich 1977, Ledyard 1984, Coughlin 1992). Potential entry of third parties, proportional representation with multiple parties, and many other variations in the democratic institutions could, in principle, also lead to non-median outcomes. Considerations like this lead us to design our experiment in a way that may allow us to reach some initial conclusions about the robustness of the MR theory of median voter tax rates to variations the democratic institutions.

With this in mind, our design considers two very different competitive democratic institutions for determining the tax rate. In a world with perfect information and perfect optimization by all agents, both regimes theoretically will produce the same tax rate outcome, which will correspond to the median voter ideal point. The two institutions we consider are *direct democracy* and *representative democracy*.

Direct democracy (DD) is implemented by simply allowing every individual voter an equal say in the outcome, without introducing candidates or representatives. Under the direct democracy mechanism, each voter proposes a tax rate, and the median proposal is directly implemented. It is well known (Moulin 1985) that under this mechanism every voter has a *dominant strategy* to propose his or her ideal tax rate. Because it is a dominant strategy, as long as voters have rational expectations about how the tax rate affects the labor supply decisions of the other voters, then this should lead unambiguously to tax rate outcomes corresponding to equation 4, without any additional assumptions about information or beliefs held by the players in the game.

Representative democracy (RD) is implemented as Downsian candidate competition, by introducing two additional players into the game, both of whom are purely office motivated candidates, with no private preferences over tax rates. This leads to a three stage game. In the first stage, the two candidates simultaneously propose (binding) tax rates, which they will impose if they are elected to represent the voters. In the second stage, voters simultaneously vote for one of the two candidates for representative, with no abstention. In the third stage, after the representative is elected, the voters make their labor supply decisions, taking as given the tax rate of the winning candidate. In this regime, if candidates have rational expectations about how each voter will vote between every pair of proposed tax rates, *and in addition*

voters have rational expectations about how tax rates affect labor supply decisions, then the unique subgame perfect Nash equilibrium is for both candidates to propose the ideal tax rate of the median voter.

According to theory, the median voter's ideal tax rate is the equilibrium in both regimes. However, the informational requirements for the equilibrium are more difficult to achieve in the RD regime. Not only must voters have rational expectations about labor supply distortions, but in addition the candidates must also have rational expectations about how voters choose between tax rates. In contrast, in the first stage of the DD regime, each voter has a dominant strategy to propose his or her ideal tax rate, regardless of their beliefs about the proposal strategies of the other voters. Thus, a priori, the RD regime, which more closely resembles a democratic process we observe, provides a tougher test for the theory.

In addition to questions about the effect of institutions on the tax rate, we also wanted our design to address the basic question that originally motivated the theoretical papers on equilibrium tax rates. Will a more unequal distribution of income lead to greater income redistribution, via higher equilibrium tax rates? Thus, in addition to having two regime treatments (DD and RD) we have two distributional treatments, which we call Low inequality and High inequality. The productivity of the median voter is the same in both treatments ( $w_m^{\text{Low}} = w_m^{\text{High}}$ ), but the relevant inequality measure is higher in High than Low ( $Z^{\text{Low}} < Z^{\text{High}}$ ). Both have interior equilibrium tax rates, so that  $0 < t^{*\text{Low}} < t^{*\text{High}} < 1$ .

Table 1 specifies the values used in each treatment and lists the ideal tax rates for all agents. Notice that the only difference between parameters in the High and Low inequality treatments is the productivity of the most productive agent. We now describe in greater detail the exact procedures used in each experiment.

**Table 1:** Parameters and Equilibrium Tax Rates

High Inequality Treatment		
Agent	Productivity	Ideal Tax Rate
1	2	0.62
2	6	0.59
3	10	<b>0.53</b>
4	14	0.37
5	35	0.00
Low Inequality Treatment		
Agent	Productivity	Ideal Tax Rate
1	2	0.62
2	6	0.54
3	10	<b>0.28</b>
4	14	0.0
5	18	0.0

### 3.1 Experimental Procedures

All the experiments were conducted at the CASSEL (California Social Science Experimental Laboratory) using students from the University of California, Los Angeles. Subjects were recruited from a database of volunteer subjects.<sup>8</sup> Eleven sessions were run, using a total of 228 subjects. No subject participated in more than one session. We used a between subjects design, so each subject participated in only one treatment. Table 2 summarizes the sessions.

The experimental currency was called tokens. Each token a subject earned was converted to dollars at an exchange rate of  $\$1 = 200$  tokens.<sup>9</sup> Total earnings for a subject was the sum of earnings across all periods in the session, plus a \$10 show up fee. Average earnings were \$22 with a standard deviation of \$7.8. Each session lasted approximately 2 hours.

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<sup>8</sup>The software for the experiment was developed from the open source Multistage package, available for download at <http://software.ssel.caltech.edu/>.

<sup>9</sup>The exchange rate was higher ( $\$1 = 100$  tokens) for the low inequality treatment because the potential theoretical earnings were lower.

**Table 2:** Experimental Design

Regime	High Inequality	Low Inequality
DD	2 sessions (60 subjects; 12 groups)	3 sessions (70 subjects; 14 groups)
RD	2 sessions (49 subjects; 7 groups)	2 sessions (49 subjects; 7 groups)

### 3.1.1 Regime 1: Direct Democracy

In this regime all participants perform the role of agents. At the beginning of the each DD session, all participants are divided into groups of five agents, each with one of five different productivity/wage levels. The profile of the five wage levels is public information. Each agent in a group is assigned one of the five productivities (see Table 2). Productivities and the group assignments are fixed for the whole duration of the session, which lasts for 20 periods. There are two parts in each DD session. Subjects first go through 10 periods of a training part to give them some experience in the labor market, which corresponds to the second stage of the DD game. The last 10 periods involve both stages of the DD game. In the first stage they simultaneously propose tax rates, in the second stage they choose their labor supply, given the median proposed tax rate is implemented. Instructions for the second part of the session are given only after they finish the first part.<sup>10</sup>

In the first (training) part of the session, at the beginning of each period agents observe a tax rate. Then they choose how much labor to supply without knowing what other subjects in their group chose.<sup>11</sup> Labor supply decisions are allowed to be any number between 0 and 25 with up to two decimal places.<sup>12</sup> After everybody made their choice, subjects received feedback information which specifies the labor supplies of all the agents in their group and displays an agent's payoff broken down into three

<sup>10</sup>See Appendix A for a copy of the instructions that were read aloud.

<sup>11</sup>The terminology in the experiment avoided reference to work, effort, productivity or other terms associated with labor markets. The individual labor supply decision was called the "investment level" and productivities/wages were called "values". Pre-tax labor income was called "investment earnings".

<sup>12</sup>Recall, that the optimal choice of labor given the tax rate is  $x_i(w_i, t) = (1 - \frac{k-1}{k}t) \cdot w_i = (1 - 0.8t) \cdot w_i$ . Thus, for all agents and for all tax rates, the theoretically optimal choice of labor is away from the boundaries (strictly below 25 and strictly above 0), except for the agent with highest productivity in High inequality treatment ( $w_i = 35$ ). Agent with  $w_i = 35$  should choose  $x_i(35, t) = 25$  for any tax rate below 0.36. In equilibrium, the upper bound of 25 is not binding for either parameter set.

parts: after-tax income, cost of labor and the tax rebate (equal share of collected taxes. After the period is over, the group moves on to the next period which is identical to the previous one except for the tax rate imposed at the beginning of the period. In this training part of the session, subjects went through different possible tax rates, in the following order: 0.50, 0.15, 0.70, 0.62, 0.35, 0.05, 0.27, 0.75, 0.90, 0.20.

To help subjects calculate hypothetical earnings from different labor supply choices, they were provided with a built-in calculator that appeared on their monitors. To use the calculator, subjects enter two numbers: a labor supply decision and a guess for the total taxes collected from the other members in their group. Then, the calculator computes the payoff of the subject in this hypothetical scenario taking into account the current tax rate in this training period and the wage assigned to the subject.

In the second part of the session (the DD game), at the beginning of each period each agent is asked to submit a proposal for the tax rate. The median proposal (third lowest tax rate) is announced to all subjects and is implemented in that period. After the tax rate is determined, subjects choose their labor decision exactly as in the first training part. Again, after the tax rate is determined, subjects could use the on-screen calculator to evaluate different hypothetical scenarios before they submit their labor decision. This two-stage process is repeated 10 times (10 periods).

### **3.1.2 Regime 2 - Representative Democracy**

At the beginning of an RD session, participants are divided into groups of seven: two subjects are randomly chosen to perform the role of candidates and the remaining five subjects perform the role of agents (voters). Each agent is assigned one of the productivity levels corresponding to the values specified in Table 2, as in the DD sessions. Roles, productivities and the group assignments are fixed for the whole duration of the session, which lasts for 20 periods.. As before, the profile of productivities/wages was common knowledge to all seven subjects in the group, including the two candidates.

In the first 10 periods of the game the five voters engaged in the same training as they did in the Experiment 1. In each period, they went through different possible tax rates in the same order as they did in the first 10 periods of the DD sessions. After the tax rate for a period was announced, each agent chose their labor supply

(with the aid of the earnings calculator) and then observed the choices made by all other agents in their group. In order to focus the candidates' attention during these periods, in each period each candidate was randomly assigned one of the agents, was told the agent's productivity and the tax rate for that period, and then was asked to guess the labor supply of that agent. In each of the first ten periods, a candidate earned 100 tokens for guessing correctly and 0 tokens for guessing incorrectly, where the correct guess was defined as the one within 2 points of the actual labor choice of that agent in that period. At the end of each period, the candidates and agents observed all the labor choices of all five agents in their group.

Each of the last 10 periods had three stages. In the first stage, the two candidates simultaneously submitted tax rate proposals. In the second stage, all agents in a group observe the two candidates' tax rate proposals and vote for one of the candidates, with no abstention. The tax rate proposal submitted by the candidate who receives the majority of votes (three or more votes) is implemented for that period. In the third stage, the process is the same as in the DD sessions: agents observe the tax rate, choose how much to work and then get feedback for that period. The only source of earnings for the candidates is winning elections: in each period, the winning candidate earns 200 tokens and the loser earns 0 tokens. This payoff structure aims to incentivize candidates to propose the ideal tax rate of the median voter, since, in theory, it defeats any other proposed tax rate if all agents are choosing their labor supply decisions optimally. As in the DD regime, once the tax rate for the period is determined, agents could use the built-in calculator to evaluate hypothetical scenarios before submitting the final labor decision. A sample copy of the RD instructions is in Appendix B.<sup>13</sup>

## 4 Results

We organize the results of the experiment in the following manner. We start by analyzing the political outcomes in each regime and compare implemented taxes across the different experimental treatments, including studying the voting behavior

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<sup>13</sup>Additional RD sessions were also conducted with an alternative protocol that was problematic because it eliminated the learning phase and limited comparability with the DD sessions. In the alternative protocol, there was no 10 period training session; instead, the RD game was repeated for 20 periods. Unfortunately, without the first 10 rounds of labor supply observations across a wide range of tax rates, we are unable to get good estimates of the empirical labor supply functions. Similar comparative static effects are observed, although tax rates are lower on average, and there is more variance across groups. That data (RD20) is summarized in Appendix D.

of the subjects in the RD regime and the proposal behavior of the agents in the DD regime. We then look into the economic outcomes and analyze the labor market behavior of agents given the implemented taxes. The next two subsections look at the interaction between labor market behavior and political behavior. The first of these two subsections explores the efficiency-equity tradeoff by defining an *efficiency-equity frontier* and investigating how the outcomes compare to this frontier. In the last subsection we consider an "empirical political equilibrium" by measuring the extent to which implemented tax rates in each group are optimal given the labor market behavior of agents. In the empirical equilibrium analysis we compute, for each group, an "adjusted" equilibrium tax rate and "adjusted" voting behavior, which would be optimal given the actual (suboptimal) labor supply decisions of the agents in a group. We then ask whether the observed tax rates are closer to the ones predicted by the empirical equilibrium than to the ones predicted by the theory derived earlier.

## 4.1 Political Behavior

### 4.1.1 Implemented Taxes

Theoretical framework described in Section 2 suggests that economies with higher inequality levels would end up with higher taxes compared to economies with lower inequality levels (see Corollary). In other words, we expect higher tax rates to emerge in High than in Low inequality treatment irrespectively of the political regime used to select this tax.

Our data suggests that these expectations are born out. Table 3 presents summary statistics regarding implemented taxes in each political regime and each inequality treatment focusing on the last 10 periods of the experiment (Part II). Figure 1 shows the evolution of average implemented tax for the same part of the game.

**Result 1: Tax rates are significantly higher when inequality is high.**

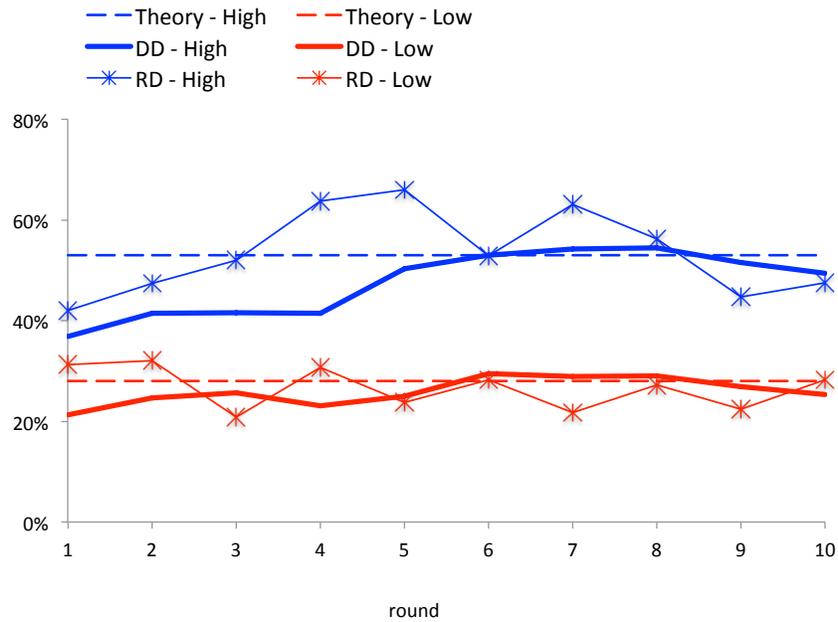
As Table 3 shows, in both regimes, taxes are higher in the High Inequality treatment than in the Low Inequality treatment. This result is confirmed statistically by the regression analysis. For each political regime, we regress the tax rates implemented in the last 10 periods on the dummy variable for the High inequality treatment clustering observations by groups of subjects that were matched together for the whole duration of the experiment (each of these groups represents one economy). For both regimes the estimated coefficient is positive and statistically significant at 1% level:

**Table 3:** Implemented Taxes in Part II in each Regime - Summary Statistics

	High Inequality $t^* = 0.53$		Low Inequality $t^* = 0.28$	
	mean (st err)	median	mean (st err)	median
DD	0.47 (0.04)	0.50	0.26 (0.03)	0.25
RD	0.54 (0.03)	0.56	0.27 (0.07)	0.22

Robust standard errors for means are reported in the parenthesis.  
The clustering is done by unique group identifier.

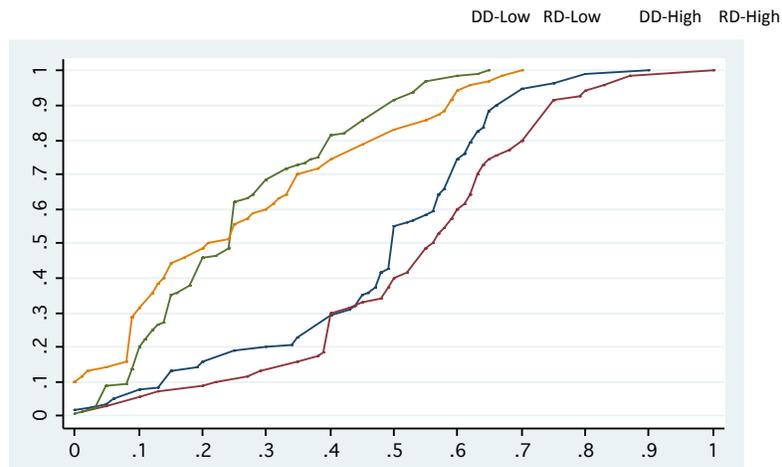
**Figure 1:** Implemented Taxes in Part II in each Regime - Dynamics



$\beta = 0.21$  for DD regime and  $\beta = 0.27$  for RD regime. <sup>14</sup>

Figure 2 presents the CDF of the implemented tax rates in each regime and each inequality treatment. For each political regime, Kolmogorov-Smirnov test rejects the null hypothesis that taxes implemented in the High inequality treatment come from the same distribution as the ones implemented in the Low inequality treatment at 1% level.

**Figure 2:** CDF of the Implemented Tax Rates in Part II in each Regime



**Result 2: Both political regimes implement ideal tax rate of the median agent in both inequality treatments.**

On average, in both regimes taxes converge to the ones predicted by the theory almost exactly. In the last 5 periods of the DD game, in the High Inequality treatment the mean implemented tax is 0.53 (median=0.53 also) and in the Low Inequality treatment the mean tax is 0.28 (median=0.25), exactly as the theory predicts. The picture is similar for the RD regime. In the last 5 periods, the mean implemented tax is 0.53 (median=0.55) in the High Inequality treatment and 0.26 (median=0.25)

<sup>14</sup>In fact, as Figure 1 suggests, in all periods the tax rates that emerge in the High inequality treatment are higher than those in the Low Inequality treatment irrespectively of the political regime. According to Wilcoxon RankSum test performed period-by-period, in the DD regime the taxes in the High Inequality treatment are significantly higher (at 5% level) than those in the Low Inequality treatment in 8 out of 10 periods, while it is the case in 6 out of 10 last periods in the RD regime.

in the Low Inequality treatment. A Wilcoxon sign test of matched pairs using one observation per group (average tax in the last 5 periods) cannot reject the hypothesis that observed tax rate is statistically different from equilibrium in each political regime and in each inequality treatment ( $p > 0.10$ ).

#### 4.1.2 Variation across groups

Figures 1 and 2 in Appendix E present the evolution of tax rates in DD and in RD regimes. For the DD groups, the circles indicate the median proposed tax rate in each of the last 10 periods for every group. In the RD groups, the winning platform is marked with a circle and the losing platform is marked with an X. The two candidates' platforms are identified by color (dark blue vs. light green). There are several striking features of the group-level data. First, there is a lot of heterogeneity across the groups. We organize this heterogeneity in two ways: convergence over time and proximity to equilibrium.

For each group, we say that the group has "converged" if the last implemented tax rates in the last three rounds are within a range of 0.10. We say the group is "approximately in equilibrium" if the average of the last three tax rates are within 0.10 of the equilibrium. Table 4 gives the percent of groups that converged and the percent of groups that are approximately in equilibrium for each of the four treatments.

	DD-High	DD-Low	RD-High	RD-Low
% Converged	75%	72%	56%	86%
% Equilibrium	67%	50%	56%	42%

**Table 4:** Convergence to the Equilibrium Tax, group-level data

In all four treatments, convergence is (weakly) more common than reaching approximate equilibrium, which reflect a feature of the data that is readily apparent. Many groups converge to tax rates that are different from the theoretical equilibrium tax rate. While this phenomenon almost never happens in the high inequality treatments (never in DD-high and only one group in RD-high), it happens quite often in the low inequality treatments (5 out of 14 groups in DD-low and 4 out of 7 groups in RD-low). In the RD regime it was also generally the case that when the implemented

tax rates converged the candidate platforms also converged, although Group 2 in RD-low is an exception.

### 4.1.3 Voter Behavior

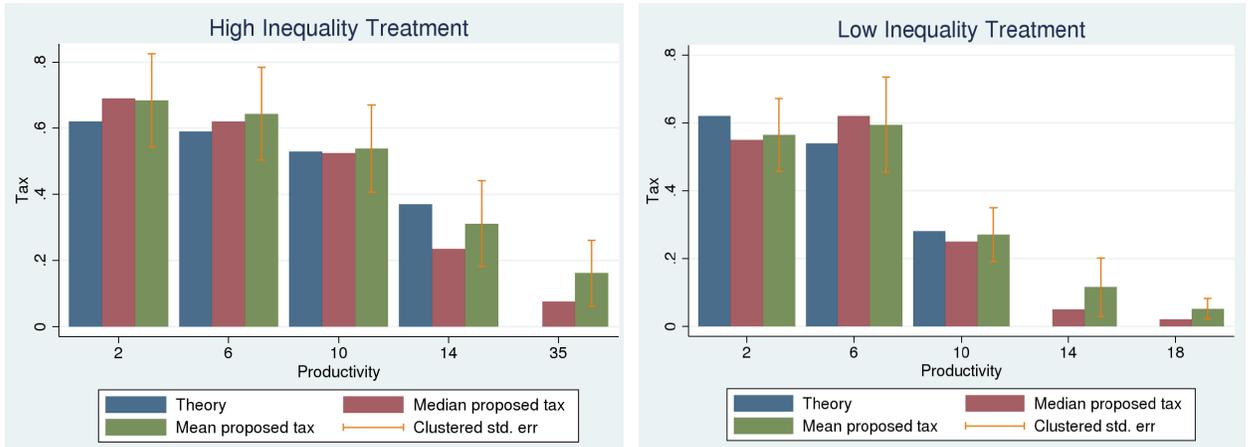
Besides making predictions about the equilibrium tax rate as a function of the distribution of productivities, the model also makes more specific predictions about voter behavior in the two institutional regimes. Specifically, in DD, all voters, regardless of productivity, have a dominant strategy to propose their most preferred tax rate, assuming all voters supply labor optimally conditional on any tax rate. Similarly, in RD, voters have a dominant strategy to vote for the candidate who proposed the more preferred of the two candidates' tax rates, once again under the assumption that all voters supply labor optimally. In this section, we investigate voter behavior relative to these two benchmarks. In a later section, we compare it to an alternative benchmark, where induced preferences over tax rates are inferred from the *empirical* labor supply curves rather than the theoretically optimal labor supply curves.

### Tax Proposals in DD

Figure 3 displays the mean and median tax proposal, by productivity, in the DD-High and DD-Low treatments, pooling across all groups for the last 10 periods, and compares it with the theoretical peak of the induced voter preferences. In all cases the observed mean or median proposals match up closely with the theory. In particular, the average proposals by the median voter, with a productivity of 10 is almost exactly equal to the predicted proposal (0.54 vs. 0.53 in DD-low and 0.27 vs. 0.28 in DD-high). There are a few small discrepancies that are worth noting. First, for high productivity voters who are predicted to propose zero tax, on average the proposal is for a tax rate of about 0.10. Second, in DD-high, the mean proposals are not perfectly ordered by productivity. The second lowest productivity worker have a higher mean proposed tax rate than the lowest productivity voters (0.59 vs. 0.56), but this difference is not statistically significant. We also note that while the *average* observed tax proposals match theoretically predicted ideal ones, there is a lot of variance in the proposals (as is evident from the relatively large standard errors).

Because of the within productivity variation in tax proposals, the observed median proposal in a DD election will often come from a voter other than the voter with median productivity (10). Furthermore, the distribution of proposals across productivities will induce a distribution of winning (i.e., median) proposals, with positive

**Figure 3:** Proposed Tax Rates, by productivity.



variance. Using the actual distributions used to construct Figure 3, one can simulate many groups under the assumption that proposals are generated iid according to these empirical distributions, effectively bootstrapping our data to get tight estimates of the distribution of implemented tax rates.

### Voting Behavior in RD

Table 5 summarizes voting behavior in each inequality treatment in the RD regime broken down by productivity level, pooling across all groups for the last 10 periods. The first column lists the fraction of correct votes: a vote is labeled correct if the candidate the voter voted for offered a proposed tax rate that theoretically would yield at least as high a payoff as the proposed tax rate offered by the other candidate (provided that labor market behavior exhibit no deviations from the predicted one by the theory). The second column indicates the number of the correct votes including the number of cases in which both candidates proposed the same tax rate in the parenthesis. The third and the fourth columns list the number of mistakes separated into two categories: the mistakes in which participants voted for a higher of the two proposed taxes is in column three, and the mistakes in which the vote was cast for the lowest of the two proposed taxes is in column four. Table 5 suggests that the majority of votes casted in the RD treatment were "correct" independent of the productivity level of the participants, with more accurate voting behavior observed in the Low than in the High inequality treatment. Moreover, the distribution of

mistakes of the pivotal agent is quiet balanced. Put differently, agents with productivity of 10 in both inequality treatment tend to make mistakes in both directions: sometimes vote for the higher tax rate when the lower one theoretically would benefit him and other times vote for the lower tax rate when the opposite is true.

High Inequality				
Productivity	% correct	# correct (indiff)	# voted higher	# voted lower
2	0.71	50 (6)	15	5
6	0.61	43 (6)	20	7
10	0.71	50 (6)	13	7
14	0.73	51 (6)	14	5
35	0.89	62 (6)	8	0
Low Inequality				
Productivity	% correct	# correct (indiff)	# voted higher	# voted lower
2	0.80	56 (13)	7	7
6	0.69	48 (13)	9	13
10	0.67	47 (13)	11	12
14	0.91	64 (13)	6	0
18	0.91	64 (13)	6	0

**Table 5:** Voting Behavior in RD regime

Figure 4 provides a more complete description of voting behavior in the RD sessions, again broken down by productivity level and High vs. Low inequality. Each panel in the figure displays simultaneously the two proposals that are offered in each election and the proposal the voter of that productivity voted for. The horizontal axis represents the tax rate proposed by the candidate the voter voted for, and the vertical axis corresponds to the tax rate proposed by the other candidate. Each panel also has two crossing line segments. Those line segments represent pairs of tax proposals that the voter is theoretically indifferent between. One of the segments, the upward sloping one, obviously is the diagonal. The other, downward sloping line represent pairs that are equidistant from the voter's ideal tax rate. The two lines intersect at the ideal tax rate of the voter. Therefore, correct votes are votes that are in the two quadrants that are north and south of the ideal point. Incorrect votes are in the east and west quadrants.<sup>15</sup> An interesting observation from these graphs is that incorrect

<sup>15</sup>For high productivity voters whose ideal point is zero tax, the west and south quadrants do not

votes in the Low inequality treatment tend to be votes for the higher tax rate when it is inferior (west quadrant), but incorrect votes in the High inequality treatment tend to be votes for the lower tax rate when it is inferior (east quadrant). Note also that most of the incorrect votes lie fairly close to one of the two indifference-pair line segments.

## 4.2 Economy: Labor Market Behavior

Table 7 reports the mean difference between actual labor choices of agents and the predicted one, broken down by the productivity levels and treatments. Our data shows that overall aggregate behavior of agents in the labor market is close to the one predicted by theory. However, in general agents with low productivity somewhat oversupply labor, while agents with high productivity somewhat undersupply it. This undersupply of labor is especially pronounced for agents with the highest productivity of 35 in the High Inequality treatments in both regimes: these agents on average choose labor about 3 units away from the theoretically predicted one. This is an interesting behavioral finding, as both the undersupply by high wage workers and the oversupply by low wage workers contradict some currently popular models of inequality aversion (see Appendix C for the characterization of optimal labor supply of agents that have altruistic or Fehr-Schmidt preferences). We will investigate later the group-level data to see whether this result is driven by some specific individuals or it is a general trend.

A more rigorous statistical analysis of the labor supply behavior leads to a similar conclusion. Rewriting equation (2), we define the *normalized* labor supply function,  $L(t)$ , as:

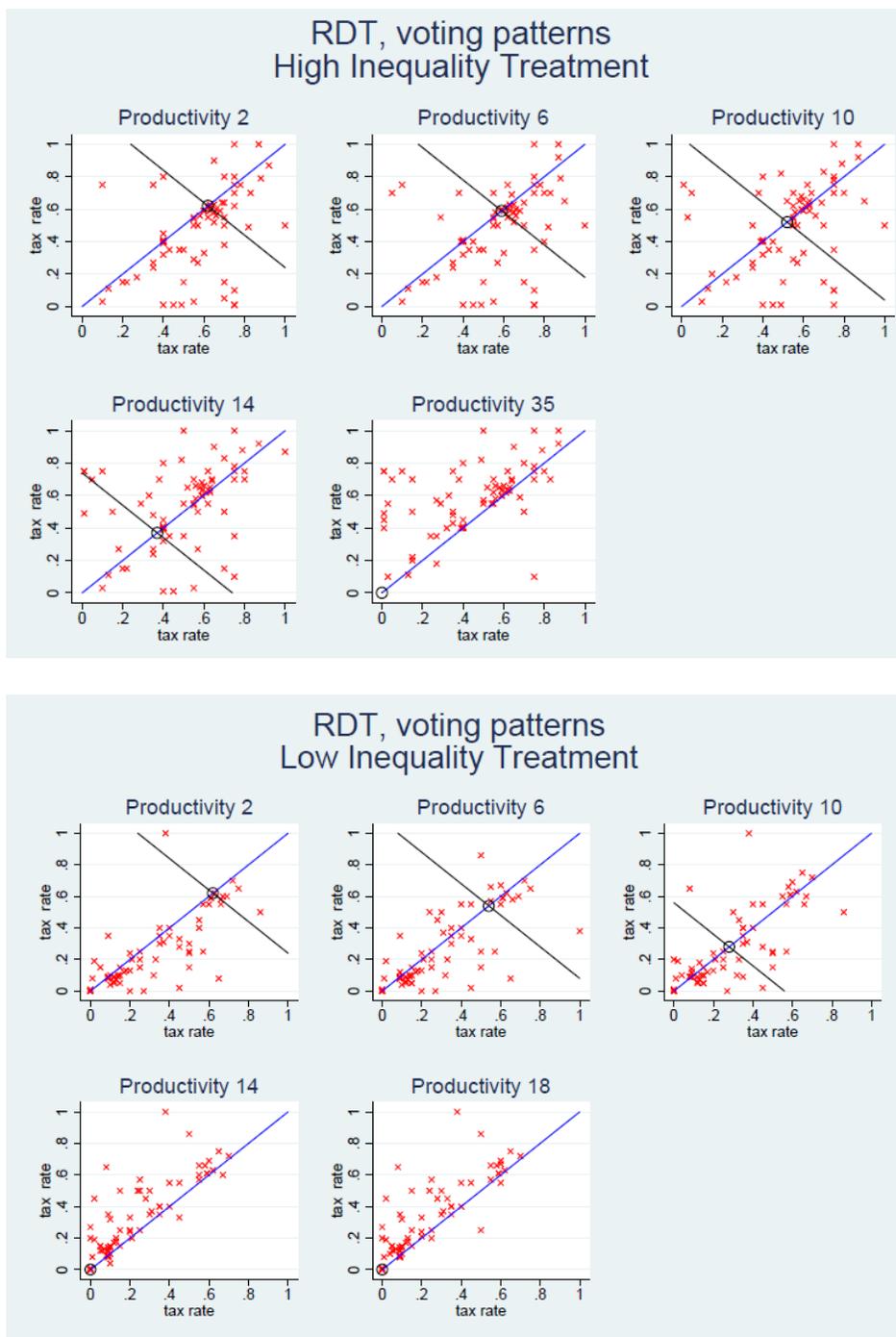
$$L(t) \equiv \frac{x_i^*(w_i, t)}{w_i} = 1 - \frac{n-1}{n}t$$

Table 8 reports the estimates obtained by regressing observed normalized labor supply ( $\frac{x_i}{w_i}$ ) on a constant and the tax rate. We do this separately for each productivity level. Because we have a total of 40 groups in all and 20 observations per group, this gives us 800 observations for each of the four lower productivity levels (which are the same in both the high and low treatments), and 400 observations for the high productivity voters (which are different in the high and low treatments). For the highest productivity worker in the High inequality treatment ( $w_i = 35$ ), the constraint  $x_o \leq 25$  is binding if the tax rate is sufficiently low ( $t \leq 0.375$ ). So we run

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exist, reflecting the fact that it is always optimal for these voters to vote for the lower tax rate.

Figure 4: Voting Behavior in RD regime.



	High Inequality treatment			
	DD regime		RD regime	
	first 10	last 10	first 10	last 10
Productivity 2	0.86	0.41	0.41	0.003
Productivity 6	0.97	0.12	1.17	-0.29
Productivity 10	0.69	0.30	-0.67	-0.56
Productivity 14	0.82	0.25	-0.12	-0.20
Productivity 35	-2.40	-3.20	-2.60	-2.86
	Low Inequality treatment			
	DD regime		RD regime	
	first 10	last 10	first 10	last 10
Productivity 2	0.87	0.45	0.76	0.17
Productivity 6	0.69	0.11	0.41	-0.24
Productivity 10	0.20	0.38	0.20	0.13
Productivity 14	-0.06	-0.01	-0.82	-0.21
Productivity 18	-0.46	-0.46	0.003	0.05

**Table 6:** Mean Difference Between Actual Labor Choice and Predicted One

separate regressions for  $t \leq 0.375$  and  $t > 0.375$  for this one class of worker-voters. Thus, the table reports the estimates of the constant term  $\alpha$  and the coefficient on the tax rate,  $\beta$  for a total of seven different regressions.<sup>16</sup> According to the theoretical normalized labor supply equation, the estimates for the first six (unconstrained) regressions are predicted to be  $\alpha = 1.0$  and  $\beta = -\frac{n-1}{n} = -0.8$ . For the constrained Tobit regression, the predicted estimates are  $\alpha = 0.71$  and  $\beta = 0.0$ .

The results reported in Table 8 are largely consistent with the theory, the two exceptions being the slope of the response to the tax rate for the very lowest productivity worker and the very highest productivity worker when the constraint  $x_o \leq 25$  is binding (last row). In the former case, labor supply is under-responsive to the tax rate, and in the latter case it is over-responsive. Despite the closeness of the estimated parameters to the theoretical prediction, there is still a considerable amount of residual variance. The average adjusted  $R^2$  across the regression was XX.

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<sup>16</sup>In all regressions, we report the statistics from a Tobit regression where labor choice is constrained to be between 0 and 25.

Productivity	$\alpha$	p-value	$\beta$	p-value
2	1.17(0.15)	0.26	-0.46(0.19)	0.07
6	1.04(0.05)	0.38	-0.74(0.08)	0.43
10	1.01(0.02)	0.46	-0.74(0.05)	0.21
14	1.02(0.02)	0.47	-0.79(0.03)	0.88
18	0.97(0.03)	0.30	-0.76(0.05)	0.46
35 ( $t > 0.36$ )	0.98(0.08)	0.77	-0.84(0.10)	0.72
35 ( $t < 0.36$ )	0.65(0.04)	0.11	-0.73(0.09)	0.02

**Table 7:** Estimates of the Regression Analysis of the Labor Supply Functions of Agents.

Our preliminary analysis of the labor supply functions of subjects participated in the experiment show no significant deviations from the ones predicted by the standard utility function specified in equation (1). In particular, this means that we do not observe behavior consistent with either Fehr-Schmidt or altruistic preferences. Put differently, our experimental data reveal that in the redistributive environment, in which subjects' actions affect not only their own payoffs but directly affect payoffs of other subjects through the taxation scheme, we do not detect preferences for redistribution beyond what the standard utility maximization yields.

### 4.3 Welfare

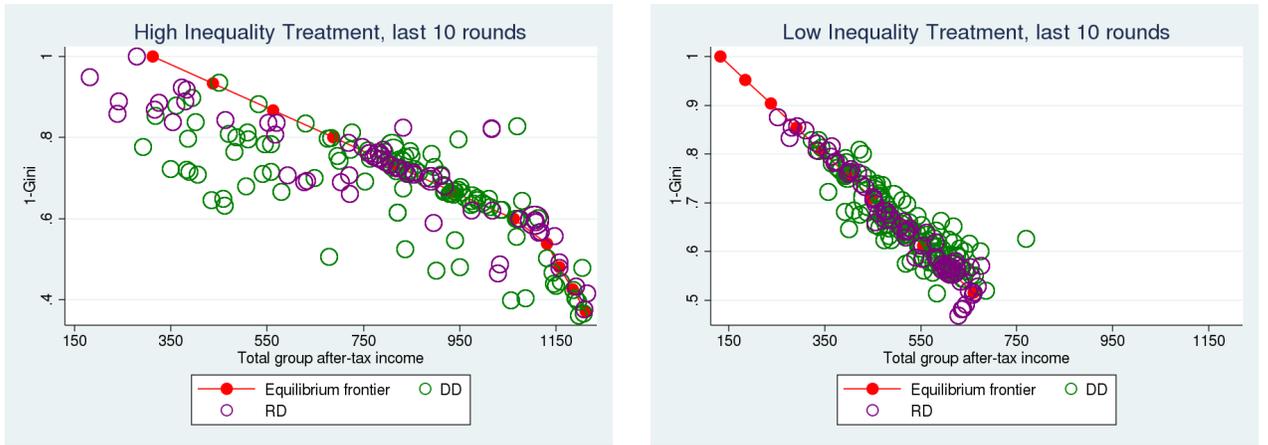
There are two dimensions to consider in the welfare analysis of redistributive taxation: equity (or related notions of redistributive justice) and efficiency.<sup>17</sup> There is a tradeoff between these two dimensions, and both are jointly determined by the tax rate determined in the political sector and the labor supply decisions made in the economic sector. Thus, the welfare analysis must consider the combined political economy effects in the two sectors. The tradeoff is explicitly modeled in the theoretical framework we use: the more pre-tax income is going to be redistributed, the less labor will be supplied. Assuming that each worker chooses his labor supply optimally given the tax rate (i.e., according to equation xxx), we can construct an equity-efficiency frontier, for any particular measure of equity and efficiency. Here we simply use the post-tax gini coefficient as our measure of inequality, and total income as the measure of efficiency.<sup>18</sup> Using these measures, we define the equity-efficiency

<sup>17</sup>cites to welfare economics literature or social choice literature

<sup>18</sup>There are alternative measures as well, such as the variance of the income distribution to measure inequality or netting out the effort costs of labor in the measure of efficiency.

frontier as the locus of points in this two dimensional space corresponding to after tax equity-efficiency pairs that would arise from optimal labor supply behavior as we vary tax rates from 0 to 1. We use this as a benchmark with which to come the actual equity-efficiency tradeoff that is observed in the experiment. Figure 7 displays all the equity efficiency pairs for all group outcomes in the low inequality and high inequality treatments, respectively. The solid line in the figures marks the frontier, with the upper left of the frontier lines corresponding to  $t = 1$  and the lower right of these lines corresponding to  $t = 0$ .<sup>19</sup>

**Figure 5:** Efficiency-Equity Tradeoff.



One way to interpret the data in these figures is to think of points below the frontier as corresponding to groups where aggregate labor is undersupplied at the given tax rate, and points above the curve correspond to oversupply of labor. The predicted outcome in equilibrium are  $(x)$  in the low inequality treatment and  $(y)$  in the high inequality treatment, corresponding to the equilibrium tax rates of  $t_x$  and  $t_y$ , respectively. For the low inequality groups, deviations from the frontier are minimal and the direction of those deviations are balanced between points above and below the frontier, and is not correlated with the tax rate.<sup>20</sup> For the high inequality groups,

<sup>19</sup>The frontier as we have defined it does not represent the boundary of *feasible* equity-efficiency pairs. In principle, workers are free to supply 25 units of labor for any tax rate, but doing so is not consistent with equilibrium in our labor market.

<sup>20</sup>The deviations are slightly higher in the DD treatment than the RD treatment, but are still small in magnitude.

	High Inequality treatment				
	$t = 0$	$t^* = 0.53$	$t = 1$	mean DD	mean RD
Gini coefficient	0.628	0.313	0.000	0.326	0.296
Total group GNP	1211	899.14	312.20	822.47	811.22
	Low Inequality treatment				
	$t = 0$	$t^* = 0.28$	$t = 1$	mean DD	mean RD
Gini coefficient	0.485	0.349	0.000	0.380	0.354
Total group GNP	660	512.16	132	543.45	517.17

**Table 8:** Equity-Efficiency Tradeoff.

the picture that emerges is much different. There is much greater deviation from the frontier, and it is both unbalanced and correlated with the tax rate. There are much greater deviations below the frontier than above it, and these deviations are greatest when the tax rate is relatively high. The main source of these large deviations is due to the undersupply of labor by the highest productivity types ( $w = 35$ ), which is consistent with the labor supply decisions summarized in Table 8. Table 9 below gives the averages across all the equity-efficiency pairs for the two treatments, with standard errors in parentheses (clustered by group).<sup>21</sup>

#### 4.4 Empirical Equilibrium

The results so far paint a picture of the data as being close to the theory if one focuses on the qualitative comparative statics and quantitatively at the *average* labor market behavior and tax rates. However there is considerable variance in the data, as illustrated in the group-by-group tax rates series in figures xx and yy, and the distribution of DD tax proposals in figure zz. In this section, we look Equilibrium tax rates crucially depend on expectations about the labor supply responses to taxes. We explore this variation across groups more carefully in this section.

Theoretically, deviations from equilibrium labor supply decisions in the economic sector could lead to distortions in the political equilibrium tax rates. That is, the equilibrium tax rates in High and Low Inequality treatments derived in Section 2 only constitute an equilibrium if all agents make optimal labor decisions at all tax

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<sup>21</sup>test for significant difference from equilibrium prediction

rates. However, to the extent that we find actual labor supply functions to be different from the theoretical ones, and these deviations are different across groups, then one should expect rational candidates to propose different tax rates in the RD regime and agent to offer different tax proposals in the DD regime. Therefore, in this section we will connect the analysis of the labor and political markets and ask whether the distortions in the labor supply in different groups is linked in this way to the variation in tax rates that we observed.

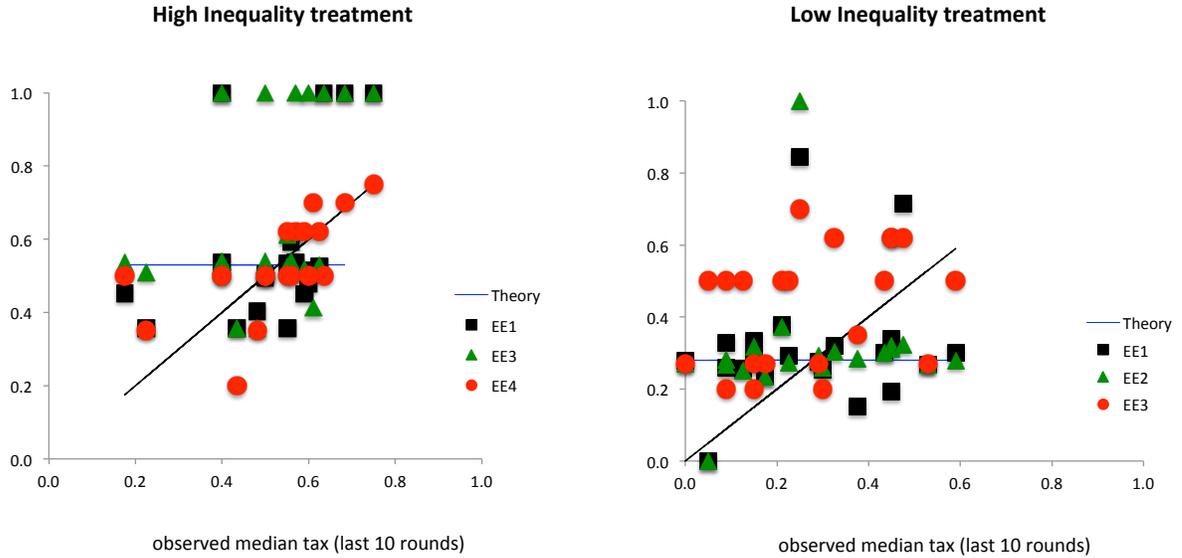
To do this, we construct several models of "empirical equilibrium" (EE) tax rates. That is, we estimate individual empirical labor supply functions of each agent in each group, and then compute the equilibrium tax in each group for the estimated labor supply functions of the five worker-voters in the group. The challenging part is obtaining good estimates of the labor supply functions. We propose three different EE models. The first, EE1, uses only the data from the first 10 periods to estimate the labor supply functions of each group member, and uses this to compute the median voter's ideal tax rate as the basis for the empirical equilibrium tax rate. The second, EE2, is similar, but uses the labor supply data from all 20 periods. The third model, EE3, is a bit different. For each group EE3 is based on the *earnings* of the median productivity worker across the ten trial tax rates in the first 10 periods; the EE3 tax rate is the one of these for which that agent had the highest earnings.

Figure 8 displays a scatter graph of the three EE model tax rates on the vertical axis against the observed tax rates on the horizontal axis, for each group.<sup>22</sup> The left panel in each figure is for the High inequality treatment and the right panel is for the Low inequality treatment, aggregating across both political institutions. The theoretical equilibrium assuming optimal labor supply is also shown on the graph, which is just a horizontal line at 0.53 for the High treatment and 0.28 for the Low treatment). Table 10 shows the results of regressing predicted against observed tax rates, using all 400 observations from the 40 groups in the experiment.

The theoretical model nails the coefficients almost exactly. A perfect theory would have an intercept equal to 0 and a slope equal to 1. The theoretical equilibrium model has an intercept equal to 0.00 and a slope equal to 0.94, and we cannot reject the hypothesis that they equal 0 and 1, respectively. All three EE models reject that hypothesis. In fact, for EE1 and EE2, one cannot even reject the hypothesis that the

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<sup>22</sup>The "observed" tax rate in each group equals the median of that group's ten implemented taxes in periods 11-20.



**Figure 6:** Empirical Equilibrium Models

	constant	slope	R <sup>2</sup>
Theory	-0.00 (0.07)	0.94 (0.17)	0.28
EE1	0.23* (0.06)	0.12** (0.13)	0.31
EE2	0.23* (0.07)	0.11** (0.13)	0.31
EE3	0.12* (0.06)	0.32** (0.14)	0.35

**Table 9:** Regressions of predicted against observed tax rates.

\* = significantly different from 0

\*\* = significantly different from 1

slope equals 0. On the other hand, the  $R^2$  is slightly higher for the three EE models than the theoretical equilibrium model, but this does not take into account that we are implicitly burning some degrees of freedom by estimating the labor supply curves for each group and then feeding those estimates into each of these models.

## 5 Conclusion

The main conclusions are as follows: (1) There is a significant and large comparative static effect: higher inequality leads to more income redistribution (higher taxes) whether taxes are determined by direct democracy or representative democracy; (2) Both regimes implement the ideal tax rates of the median productivity agents. That is, for both regimes and both the High and Low treatments, average tax rates were not significantly different from the theoretical tax rate. (3) Labor supply decisions by agents are approximately optimal, with the exception that it is systematically undersupplied by high income agents. (4) There was considerable variation in implemented tax rates across groups, and in a number of cases variation over the 10 periods within a group. (5) The variation of tax rates across groups does not appear to be linked with the variation of empirical labor supply functions across groups.

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