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Central banks typically find it difficult to turn off the "political pressure valve". This has important consequences for the types of monetary policies they implement. This paper presents an analysis of how political factors may come into play in the equilibrium determination of inflation. We employ a standard overlapping generations model with heterogeneous young-age endowments, and a government that funds an exogenous spending via a combination of nondistortionary income taxes and the inflation tax. Agents have access to two stores of value: fiat money and an inflation-shielded, yet costly, asset. The model predicts that the relationship between elected reliance on the inflation tax (for revenue) and income inequality is non-monotonic; in particular, the reliance on seigniorage may decrease as income inequality rises above a threshold. We find robust empirical backing for this hypothesis from a cross-section of countries.

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THE NON-MONOTONIC RELATIONSHIP BETWEEN SEIGNIORAGE

AND INEQUALITY[*]

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Abstract

Central banks typically find it difficult to turn off the "political pressure valve". This has important consequences for the types of monetary policies they implement. This paper presents an analysis of how political factors may come into play in the equilibrium determination of inflation. We employ a standard overlapping generations model with heterogenous young-age endowments, and a government that funds an exogenous spending via a combination of nondistortionary income taxes and the inflation tax. Agents have access to two stores of value: fiat money and an inflation-shielded, yet costly, asset. The model predicts that the relationship between elected reliance on the inflation tax (for revenue) and income inequality is non-monotonic; in particular, the reliance on seigniorage may decrease as income inequality rises above a threshold. We find robust empirical backing for this hypothesis from a cross-section of countries.

1 Introduction

In most monetary models in the general equilibrium tradition, monetary policy (or more specifically, the money growth rate) is either exogenously given, picked by an independent central bank/ revenue-seeking government, or determined by a benevolent social planner. While such constructs have their uses, they represent clear departures from reality. After all, the inflation rate of no country is ever determined by a mythical social planner, or by the monetary authority in a vacuum. Economic agents clearly exhibit an entire spectrum of tastes for inflation and the political consensus from the different segments of society (reflecting their various likes and dislikes) most certainly weighs heavily in the decision making of the central banks.[1] In fact, the latter routinely face overt political pressure to adhere to clearly stated mandates on the inflation rate.[2] Even the most independent central banks, as US Federal Reserve Chairman Alan Greenspan has said, are not in any position to "shut down the political pressure valve".[3,4] This paper presents one possible analysis of how political factors may come into play in the equilibrium determination of inflation in a democracy.

There are three "stylized facts" that such an analysis ought to contend with. First, the fraction of household wealth held in liquid assets (checking accounts, savings accounts, money market accounts, call accounts, cds, and directly held mutual funds) decreases with income and wealth, as documented for the United States in Kennickell, Starr-McCluer, and Surette (2000). The implication is that the rich hold a large fraction of their wealth in the form of interest-bearing assets and not in the form of barren money. Second, even in the most financially developed countries, a small fraction of the

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[1] Easterly and Fischer (2001) using polling data for 31869 households in 38 countries, find evidence that suggests that the poor view inflation more as a problem than the rich.

[2] Bob Woodward, Assistant Managing Editor, *The Washington Post* in an interview, January 18, 2001 put it nicely: "Obviously the job of the Federal Reserve is to keep inflation under control: It's kind of rule one, and there's good reason. If you go back to what happened in the '70s when inflation got out of control, it really hurt the economy, drove millions of people out of work, [and] was a giant setback for everyone who lived in the country at the time when you really look at it historically, so that's his [Greenspan's] job: To fight inflation."

[3] From ABC News: [http://204.202.137.112/sections/politics/DailyNews/greenspanbush 0001217.html]: U.S Vice President on Fed Chairman Greenspan "We want to work very closely [with Greenspan]. He is the independent chairman of the Federal Reserve. They are responsible for monetary policy, but there is a degree of cooperation required between any administration in terms of monetary policy and fiscal policy ... It would be foolish not to work closely together."

[4] "What I am striving for is the concept of policy consistency over time: a countercyclical response which is consistent with, or can be reconciled with, the FOMC's long-run goal and which, furthermore, is seen as *consistent by the public.*"(emphasis ours) [Gary Stern, President Federal Reserve Bank of Minneapolis, *Formulating a Consistent Approach to Monetary Policy,* 1996]

population hold interest-bearing assets; in the US, 59% of households do not hold any interest-bearing assets [Mulligan and Sala-i-Martin (2000)].[5] They also point out that the relevant decision for the majority of US households is "not the fraction of assets to be held in interest bearing form, but whether to hold *any* amount of [such] assets at all." Moreover, this "decision to adopt the financial technology" depends largely on the opportunity cost in terms of interest-income foregone and other physical costs. This suggests that even when interest-bearing assets are available, not everyone may be able to afford them. The third and final fact is this: every country in the world relies to *some* extent on seigniorage as a source of revenue.[6]

We produce a pure-exchange overlapping-generations model with two-period lived agents that builds upon these aforementioned ideas. The model exhibits income heterogeneity among the young; the old, however, have no endowment. There are two saving instruments, fiat money (the "bad" asset) and an inflation-shielded asset (the "good" high-real-return asset). Following Bryant and Wallace (1984) and more recently, Mulligan and Sala-i-Martin (2000), we assume that the good asset can be accessed only upon payment of a fixed upfront cost. Agents choose whether to pay this cost and hold the better asset or not pay it and simply hold money.

Following Dolmas, Huffman and Wynne (2000), we introduce a democratically-elected government as the entity that must raise revenue to finance a fixed exogenous level of spending (that benefits no one). In our setup, there are two instruments for revenue generation: a lump-sum tax paid by the young, and an inflation tax.Young agents in the economy vote on the fraction of the government's spending that will be paid for by the inflation tax. As will be clear below, the aforementioned fixed cost introduces a non-convexity in their preferences over this fraction thereby destroying the single-peakedness of indirect

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[5]Keister (2000) using Surveys of Consumer Finances data, documents that after housing, "the second most popular form of saving for a vast majority of Americans was cash accounts; families in the bottom 80% of the distribution kept 11 percent of their assets in checking, and savings accounts, and other highly liquid financial instruments." Kenickell et. al (2000) report that 13.2% of US families in 1998 (down from 18.7% in 1989) did not hold even a checking account, and that 82.6% of them had annual incomes less than $25,000. Interestingly, when asked why they did not have a checking account, 12.9% of the respondents cited "not enough money" and 11% cited "service charges too high" as their "most important" reason.

[6]Click (1998) documents that between 1971-90, in a wide cross-section of countries, currency seignorage as percent of GDP ranged from 0.3% to 14% and seignorage as percent of government spending ranged from 1% to 148%. By various measures, the United States has raised about 0.3% of real GDP via seigniorage in the post-war period, although the use of inflation as a means of funding war expenditures was not uncommon in the 19th century. See also Cukierman, Edwards, and Tabellini (1992).

utilities. Suppose the precise policy-package combination (of the inflation and the lump sum tax) is chosen by the Condorcet criterion, i.e., the winner defeats all others in pairwise majority-rule elections. Restricting attention to stationary states, we ask: Would the electorate prefer that the inflation tax partly or fully pay for the spending?

We specify a lognormal distribution for young-age endowments and apply numerical methods to examine the properties of our model economy. We find a positive support for inflation. Somewhat surprisingly, the model produces a interesting and novel non-monotonic theoretical relationship between the winning policy-combination and the extent of income inequality. In other words, at sufficiently low levels of inequality, the winning policy-package combination involves high reliance on direct taxes and less on inflation. As the level of inequality increases, the reliance on inflation starts to increase. As inequality crosses a certain threshold, however, the elected reliance on inflation starts to *fall*. The intuition for this result plays off two effects, a "tax rate" and a "tax base" effect. Agents who hold only storage escape the inflation tax and therefore vote for 100% use of the inflation tax. As income inequality rises, the number of storage holders rise, and this shrinks the size of the inflation tax base. The money-holders then pit the prospect of a relatively high inflation tax (which is regressive, since it is not paid by the rich storage holders) versus the regressive lump-sum tax (which is paid by all). The non-monotonic nature of the predicted relationship is also broadly supported by cross-country evidence.

What is novel here is that the inflation rate, the real money demand, and the distribution of money and storage holders, are all jointly endogenous. In general, changes in the inflation rate, therefore, bring about changes in the size of money demand via the actual amount of money desired by each money holder and also via changes in the composition of society among storage and money holders. It is this last "composition" effect that serves to increase the regressivity of the inflation tax beyond the standard effect that works off the fact that poorer people hold a larger fraction of their wealth in liquid form than richer agents. That is, as inequality continues to climb, the fact that there are more storage holders all of whom can entirely avoid the inflation tax, makes the latter even more regressive than the lump sum tax. It is this last effect that is responsible for why the elected reliance on inflation falls beyond a certain threshold of inequality.

Our paper is part of a line of research that tries to address monetary issues in models with het-

erogenous agents using insights from political economy models.[7] To date, this literature has focussed on two issues: a) accounting for a positive relationship between income inequality and inflation, and b) identifying an inflation bias on the part of the median voter. The papers that are closest in spirit to our current endeavor are those by Dolmas, Huffman, and Wynne (2000), Bullard and Waller (2001), and Albanesi (2003). We extend Dolmas, *et al.* in two crucial ways: (i) we allow agents to avoid the inflation tax by permitting them access to a costly storage technology, and (ii) in addition to seigniorage, the government can implement an alternative regressive tax.

Albanesi (2003) offers a model that can account for both the positive correlation between income inequality and inflation and the redistributional effects of the inflation tax. In her model, infinitely lived agents are permanently differentiated by human capital endowments. Two transaction technologies are available: cash and an alternative means of payment that allows agents to avoid the inflation tax. As the inflation tax increases, highly productive agents will use the alternative payment technology to purchase a larger fraction of the consumption goods. Albanesi uses Nash bargaining to choose the division between labor taxes and inflation taxes. Like our model, her setup can account for cases in which the poor are more vulnerable to inflation than the rich. Since the poor tend to lose more if there is inflation, they are the weaker party in the political process that determines the course of fiscal and monetary policy.

Erosa and Ventura (2002) calibrate a model that is well-equipped to handle the distributional effects of inflation to US data. Like us, they allow the rich to avoid the inflation tax. A principal finding of their paper is that "the burden of inflation is substantially higher for individuals at the bottom of the income distribution than for those at the top." However, they do not study the concomitant political economy issues that naturally arise as a by-product of their finding. Bullard and Waller (2004) focus their attention on precisely the political economy issues. In particular, they consider the more general issue of "central bank design". In a model with multiple assets (including bonds and capital) but no within-generation heterogeneity, they consider the welfare (and dynamic) implications of conducting monetary

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[7]An early important work in this area is Loewy (1988). There is a broader literature that considers, among others, issues like: a) whether monetary policy is influenced indirectly by who gets appointed by the President to the Board of Governors in the United States, b) whether political parties have an incentive to initiate "monetary surprises" that increase consumption and GDP temporarily right before an election, c) whether the median voter likes inflation because inflation erodes the cost of servicing a high debt.

policy via either majority voting, or a policy board, or a constitutional rule (inspired by Azariadis and Galasso, 1996). In their setup, the real action lies in the tension between the young and the old over the desired inflation rate, and the old may veto the young. They find the presence of a inflation bias in monetary policy both in stationary and nonstationary settings under the majority-voting design.

The rest of the paper is organized as follows. Section 2 describes the model environment and Section 3 presents the voting equilibria and their properties. Section 4 describes our main empirical findings and discusses the fitted econometric relationship between reliance on seigniorage and income inequality. Section 5 concludes.

2 The model

Consider a simple pure-exchange overlapping generations model where at any discrete date $t = 1, 2, 3...$, a new generation of unit measure is born, and lives two periods. There is intragenerational income heterogeneity among young agents. Each young agent draws his first period endowment, y, of the single consumption good from a density function, $f(.)$ with support $[y_{\min}, \infty)$. Agents have no endowment of the good when old. The preferences of each young agent over consumption in the two periods of life are described by an atemporal additively-separable utility function, $U(c_1, c_2)$ where c_1 stands for consumption in the first period and c_2 stands for consumption in the second period. For analytical tractability, we will assume a specific functional form for U namely:[8]

$$U(c_1, c_2) = \ln c_1 + \ln c_2. \tag{1}$$

Because agents like old age consumption but have no old age income, they have to save. There exists two saving instruments. First, there is a sure-return linear storage technology. One unit of the consumption good invested in this technology earns a sure gross real return of $x > 1$ next period. Notice that the real return to storage is perfectly invariant to inflation, and hence, the voting outcome. Second, there is fiat money and R_m is its stationary return. Money is the "bad" asset; it is dominated in rate of return by storage, i.e., $x > R_m$. The good storage technology is accessible only upon payment of a

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[8]The additive log formulation and much of the general environment draws heavily from Dolmas, Huffman, and Wynne (2000).

fixed cost of $\delta > 0$ that is payable by young agents.[9] In an equilibrium, agents will hold either storage or money but never both. This split captures, albeit in an extreme way, the notion that the rich in the real world do not store much of their wealth in the form of money. It also generates an endogenous distribution of money and interest-bearing asset holders.

When young, agents pay a lump-sum tax, T, to the government.[10] Consider the problem of an individual with income y who wishes to access the storage technology by paying the fixed cost. Then, her budget constraints are given by

$$c_1^s = y - S - T - \delta \qquad c_2^s = xS \tag{2}$$

where S is her saving in the form of storage, and the superscript s indicates storage. Notice that since money is dominated in rate of return by storage, individuals have no incentive to hold both money and storage. Agents maximize (1) subject to (2) to get at their optimal investment in the storage technology: $S(y) = \frac{y-\delta-T}{2}$. This implies that an agent contemplating investing in storage would enjoy first and second period consumption given by

$$c_1^s = \frac{y - \delta - T}{2}, \quad c_2^s = x\left(\frac{y - \delta - T}{2}\right) \tag{3}$$

Her indirect utility would be

$$U^s(y) = \ln\left[\frac{y - \delta - T}{2}\right] + \ln\left[x\left(\frac{y - \delta - T}{2}\right)\right]. \tag{4}$$

Now, consider a person who wishes to hold only money. Such an agent's budget constraints are given by:

$$c_1^m = y - T - m \qquad c_2^m = R_m \cdot m \tag{5}$$

where m is the amount of real money balances held between periods, and the superscript m stands for money. Such an agent maximizes (1) subject to (5) to get at her optimal money holdings: $m(y) = \frac{y-T}{2}$. This implies that her consumption in the first and second periods will be

$$c_1^m = \frac{1}{2}\left[y - T\right], \qquad c_2^m = \frac{1}{2}\left[R_m(y - T)\right].$$

and her indirect utility will be

$$U^m\left(y\right) = \ln\left[\frac{y-T}{2}\right] + \ln\left[R_m\left(\frac{y-T}{2}\right)\right]. \tag{6}$$

Obviously, agents with income y for whom $U^s\left(y\right) \geq U^m\left(y\right)$ will not hold any money. This condition reduces to

$$\ln\left[x\left(\frac{y-\delta-T}{2}\right)^2\right] \geq \ln\left[R_m\left(\frac{y-T}{2}\right)^2\right] \Leftrightarrow (x - R_m)\left(y - T\right)^2 - 2\delta x\left(y - T\right) + x\delta^2 \geq 0$$

It is easy to check that this inequality is satisfied for incomes that satisfy

$$y - T \leq \delta\left[\frac{x + \sqrt{xR_m}}{(x - R_m)}\right] \tag{7}$$

We define

$$y^\dagger \equiv \delta\left[\frac{x + \sqrt{xR_m}}{(x - R_m)}\right]. \tag{8}$$

Only agents with incomes $y > y^\dagger + T$ will access the storage technology. All others will hold only money. We now turn to the determination of R_m.

2.1   Return on money

The only purpose of the government is to raise enough revenue from lump-sum taxes and from the inflation tax (seigniorage) to finance its exogenously-specified spending of g per young person. We assume that this spending is entirely "purposeless" in that government purchases do not affect agents' utility or their budget sets.[11] Young agents vote on the fraction of this spending that should be financed using lump-sum taxes (which we denote by ϕ). Whatever amount is not to be raised by lump-sum taxes

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[11]The assumption of "purposeless" spending allows us to abstract away from considering the distributional effects of government spending.

must be raised via seigniorage. The central bank controls the nominal money stock changing it to raise the requisite revenue.[12]

At each date $t \geq 1$, the government has a balanced budget. The government budget constraint is represented as: $T + SN = g$, where SN stands for seigniorage. Formally, the government's reliance on tax revenues, denoted $\phi \in [0, 1]$, is captured by the following expression:

$$T = \phi g, \quad SN \equiv M(1 - R_m) = (1 - \phi)g \tag{9}$$

where M stands for the aggregate demand for real money balances. Higher values of ϕ represent the will of the electorate to raise more of the revenue from taxes and less from seigniorage. So as to not bankrupt anyone, we will assume that $y_{\min} > g$. This assumption implies that $\phi = 1$ is feasible.

Aggregate money demand is computed from

$$M = \int_{y_{\min}}^{y^\dagger} m(y) f(y) dy.$$

Then, it follows that

$$(1 - R_m) \int_{y_{\min}}^{y^\dagger} m(y) f(y) dy = (1 - \phi)g \Leftrightarrow \left[\int_{y_{\min}}^{y^\dagger} y f(y) dy - T \int_{y_{\min}}^{y^\dagger} f(y) dy \right] = \frac{2(1 - \phi)g}{(1 - R_m)}.$$

Noting that $T = \phi g$, we can calculate the return to money as:

$$R_m = 1 - \frac{2(1 - \phi)g}{\int_{y_{\min}}^{y^\dagger} y f(y) dy - \phi g \int_{y_{\min}}^{y^\dagger} f(y) dy} = 1 - \frac{2(1 - \phi)g}{\int_{y_{\min}}^{y^\dagger} y f(y) dy - \phi g F(y^\dagger)} \tag{10}$$

where F is the cumulative distribution. The determinants of R_m are government purchases, the to-be elected reliance on seigniorage, and the size of the inflation tax base. Note that the holders of the inflation tax base are young agents whose incomes lie in the interval $[y_{\min}, y^\dagger]$. Since $y^\dagger$ is a function of ϕ, it follows that both the measure of agents holding money *and* the amount of money being held by that measure are both endogenous variables. Furthermore, equations (10) and (8) jointly determine $y^\dagger$ and R_m which are both functions of ϕ. That is, given a ϕ, any agent can immediately use (10) and (8) to jointly compute $y^\dagger$ and R_m which in turn tells her if for that value of ϕ, she would be happier holding storage or holding money.

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[12]The central bank is not independent. It receives a mandate from the electorate on how much seigniorage revenue it must raise. It prints new money to generate the mandated revenue.

Equations (10) and (8) embody a direct connection between the elected value of ϕ and the real return on money in the economy. Agents understand this connection and use it when ranking different values of ϕ. It is easily seen that the outcome of the election on ϕ indirectly determines a money growth rate that is to be passively implemented by the central bank.[13] It is in this precise sense that the central bank is not independent.[14] Higher values of ϕ represent greater reliance on taxes and less on seigniorage.

The environment described above is fairly rich in the sense that the return to money *as well as* the distribution of storage and money holders are jointly endogenous. With logarithmic utility, changes in the aggregate demand for money comes from agents switching from holding only money to holding only storage and vice versa.

2.2   Voting

The timeline (see Figure 1) is as follows. Each young agent (indexed by a unique income y) takes part in the voting process.[15] We think of agents as voting on ϕ before making their consumption-saving decisions. As Dolmas, Huffman, and Wynne (2000) note, this is the most interesting case to look at. It is important to note here that indirect utilities induced by the policy choice ϕ may not be single-peaked. This happens because agents may be induced, for higher ϕ, to switch to the storage technology. In what follows, we focus only on the Condorcet majority winner. Once the winning ϕ becomes known, the central bank picks the money growth rate that implements that ϕ. This determines the return on money that the current young will enjoy when they are old. In other words, the current old have no reason to care about the election of ϕ going on during the period.[16] This in turn implies that the

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[13]Dolmas, Huffman, and Wynne (2000) allow agents to vote directly on R_m. Our formulation is isomorphic to theirs.

[14]Alesina and Summers (1993) define the notion of "economic independence" as follows: "Economic independence is defined as the ability [of the central bank] to use instruments of monetary policy without restrictions. The most common constraint imposed upon the conduct of monetary policy is the extent to which the central bank is required to finance government deficits." In other words, the central bank in our model is not economically independent.

[15]Azariadis and Galasso (1996) provide some evidence to suggest that the age of the median voter in *many* elections in the United States has been below 45. In other words, they lend credence to the usual assumption that is made (just as we indirectly do) that the median voter is young.

[16]Recall that elections are held before young agents make their consumption-saving decisions. We assume that the price level for the period (p_t) is known at the start of the period. After the election is declared, the ϕ becomes known, and so does R_m $(= p_t/p_{t+1})$. Following the election, the current old and the young (who now know how much money they want in equilibrium) trade goods for money at the known price level (p_t). In effect then, when the young elect a ϕ at date t, they are picking the price level for the *next* period (p_{t+1}). Since the current old will not be around next period, the "choice" of

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standard commitment problem of getting the future young to implement the election outcomes reached by the current young does not arise here.[17]

Formally, a voting equilibrium is defined as stationary allocations $\{c_1^s, c_2^s, c_1^m, c_2^m\}$ that maximize (1) taking prices and the distribution of endowments as given, equations (8) and (10) that completely characterize money market clearing and price determination, the government budget constraint is satisfied, and the fraction of government reliance on lump-sum taxes (ϕ) is the Condorcet majority winner.

3   Computational Experiments

Since single-peakedness is absent, the median voter theorem may not be available to pick the Condorcet winner. Following standard practice, we resort to numerical computations. We start by choosing a functional form for the density function, $f(y)$. We assume a lognormal distribution [$\ln y$ distributed as $N(\mu, \sigma^2)$] with mean $\mu = 3.606$ and standard deviation $\sigma = 0.615$. Bearse, Glomm, and Janeba (2000) argue that such a choice does a good job of capturing the actual US household income distribution in 1992 if income is measured in thousands of dollars. In our experiments, we will change σ, and this in turn will change the Gini coefficient, leaving the median unchanged.[18]Draws of 50,001 incomes are taken from this distribution. The unit interval for ϕ is converted into a grid of 301 points. We set $x = 4.5$,

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p_{t+1} does not affect them; hence, they do not care about the current election.

It is interesting to consider what would happen if the timing assumptions were altered (say p_t, and hence, the return on money, p_{t-1}/p_t between $t-1$ and t was determined *after* the election at t) to make the current old care about and vote in the current election. First, there would be two types of current old to contend with, those who held only storage when young, and those who held only money when young (recall, this composition is endogenous in our model). The storage holders would not care about the current election since the return on storage is unaffected by the election; also, under our current assumptions, the old do not pay the lump sum tax. As a modeling issue, we would be forced to take a stand on how these old storage holders would vote (i.e., would they choose high or low inflation). Were we to leave them out of the electoral process, matters would get even more complicated because we would then have a situation where *even* the size of the electorate was endogenous (and depended on the election itself!).

[17]Bullard and Waller (2001) produce a model similar in some respects to ours where the real action lies in the tension between the young and the old over the desired inflation rate in the economy. In their model (theirs is a model with capital and no intragenerational heterogeneity), elections to determine the value of the money growth rate takes place near the *end* of a period. At that time, the soon-to-be old want low inflation (high real interest rates) so as to maximize the return on their past predetermined saving, while the soon-to-be born young want high inflation (which via a Tobin-type effect, produces higher capital and hence, higher wages for them).

[18]The lognormal density [$\ln y$ distributed as $N(\mu, \sigma^2)$] is given by $\dfrac{e^{\left\{-(\ln y - \mu)^2/2\sigma^2\right\}}}{y\sigma\sqrt{2\pi}}$, its mean by $e^{\mu + 0.5\sigma^2}$, its median by e^μ, skewness by $e^{\sigma^2} + 2\left(\sqrt{e^{\sigma^2}} + 1\right)$, and the Gini by $2\Phi(\sigma/\sqrt{2}) - 1$, where Φ is the Cdf for the standard normal distribution.

$\delta = 55$, and $g = 8$. The corresponding Gini is 0.336.

For this baseline set of parameters, the unique voting equilibrium has the following features.[19] In this equilibrium, only 4.85% of the electorate ends up accessing the storage technology.[20] The winning policy-combination is given by $\phi = 0.687$ which implies that the electorate votes for 30.13% of the government's revenue to be raised via seigniorage. The implied elected inflation rate is 18.1%. The equilibrium also has the feature that the seigniorage to real GDP (GDP in the example is measured by adding up the real endowments y of all the young) ratio is about 5.63%, and the government expenditures to GDP ratio is 18.0%. Ours is not an attempt at a full-blown calibration exercise; our goal is simply to present a "plausible" numerical example to illustrate certain novel features of the theoretical relationship between monetary policy and income inequality.

We are particularly interested in the relationship between the winning policy-combination and the extent of income inequality. Figure 2 plots the elected ϕ against the Gini coefficient. The figure is striking in one particular aspect: the relationship is nonmonotonic; indeed, the plot is U-shaped. When evaluated at low levels of inequality, an increase in income inequality is associated with an increase in the reliance on inflation. There exists, however, a threshold value such that for values of the Gini coefficient above it, the elected reliance on inflation *falls* in response to any further increases in income equality.

The intuition behind Figure 2 is as follows. Consider a starting point where σ is low (low inequality) implying that a large mass of people are centered around the median. For expositional convenience, assume also that at this point, no one can afford storage and so everyone holds money. Voters tradeoff the regressivity of the lump sum tax against the distortionary effects of the inflation tax. Figure 3 graphs the indirect utility for individuals at each decile of the endowment distribution.[21]The poorest among these voters hold little money and therefore like inflation while the richer ones prefer the lump-sum tax.

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[19]As is well known, absent regularity conditions on the indirect utilities, Condorcet cycles may emerge [ϕ_a wins against ϕ_b and ϕ_b wins against ϕ_c but ϕ_c wins against ϕ_a]. Following standard practice, we ignore these cycles in our numerical analysis.

[20]It is easy to generate examples where a much higher percentage of the electorate uses the storage technology. In fact, ceteris paribus, using a utility function $U(c_1, c_2) = \ln c_1 + \beta \ln c_2$ where $\beta < 1$, we have been able to generate examples where the percent of people holding only storage is as high as 20%.

[21]Figure 3 uses $g = 5$, $\delta = 30$, $x = 4.5$, and $\sigma = 0.615$ (corresponding to a Gini of 33.6). A electorate of a 1001 voters is used.

The elected ϕ is high because a large mass of voters centered around the median who hold relatively large amounts of money dislike seigniorage. As σ increases (causing the Gini to rise), the mass of people at the tails increase, but the median is unchanged. In popular language, the middle class gets "hollowed out"; some get poorer and some get richer. The mass at the low tails increases and these voters start to like inflation more. The mass at the upper tails also increases: the mass of storage holders increase and they all prefer 100% reliance on inflation. The only mass of voters that likes inflation less is the group who were near the center and got richer, but are not rich enough to afford storage. Overall, because the income distribution got more skewed, this last group has smaller mass than the combined mass of voters who like inflation more than before. The winning ϕ is therefore lower. The elected ϕ continues to fall as σ rises until a crucial threshold is reached; now the mass of storage holders is quite high and the inflation tax base is small. To satisfy the government budget constraint (recall g is fixed), money-holding voters would have to either further increase inflation or they start imposing a lump-sum tax so as to be able to get the storage holders to pay some of the expenses. In other words, after a certain threshold level of inequality is reached, because of the shrinking inflation tax base, voters start to find the inflation tax even more regressive than the lump sum tax. ¿From then on, the winning ϕ starts to rise.

We now turn to some welfare comparisons. In this analysis, our welfare comparisons are made against a zero-inflation (constant money stock) benchmark. We construct a measure of aggregate welfare which is a weighted sum of the steady-state lifetime utilities of all the electorate computed at the winning policy-package combination. We then compare this number to the weighted sum of the utilities of all the electorate computed at $\phi = 1$ (the zero inflation rate). The "welfare cost of inflation" ratio is the ratio of aggregate welfare under the winning ϕ to welfare under $\phi = 1$. Figure 4 plots this "welfare cost of inflation" ratio (as a percent) against levels of income inequality. The ratio is 100% when the elected ϕ is 1 (when all the revenue is raised through direct taxes). Whenever this ratio exceeds 100%, it implies that aggregate welfare is higher with some positive inflation when compared to zero inflation. As is clear from the figure, there is a range of Ginis (36-54) in which society, as a whole, is "better off" with some positive inflation rather than with zero inflation. [22] Finally, Figure 5 illustrates the difference

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[22]Just to clarify further, we are *not* comparing the average steady state utility under the voting equilibrium with inflation *with* the average steady state utility under the first best (no inflation and person-specific lump sum income tax). We are,

between the ϕ which the median income voter would have preferred, and the Condorcet winning ϕ. Note that when there is little income inequality, the median voter's preferred ϕ and the Condorcet winner are essentially identical.

4 Empirics

The model has produced a causal relationship between income inequality and an electorate's preference for inflationary finance. In particular, the relationship is predicted to be non-monotonic. Below, we test this powerful implication using time-averaged cross-country data from the 56 countries listed in Table 2.[23] To that end, we regress a measure of a country's reliance on seigniorage on inequality and some controls.

We allow the model to guide us in the creation of a measure of a country's reliance on seigniorage. This approach is different from the literature (discussed in the introduction) that focuses on income inequality and its connection with inflation. In the model, an electorate's preference for inflationary finance is $1 - \phi$ which we compute as follows: from the government budget constraint, total seigniorage revenue collected must satisfy $SN = (1 - \phi)g$, and so,

$$\frac{\frac{\text{seigniorage}}{\text{GDP}}}{\frac{G}{\text{GDP}}} = (1 - \phi).$$

Cross country data on seigniorage to GDP and government spending to GDP is easy to find. Seigniorage to GDP ratio is measured as the average ratio of the change in the monetary base to GDP. The government spending to GDP ratio is the average ratio of government to GDP for the sample period. The data are taken from Click (1998), using the sample means computed using data for the period 1971-90.

The Gini data are time-averages (for the period 1950 to 1990 whenever available) computed from Deininger and Squire's (1996) high-quality inequality data set. The pre-tax income distribution was used to construct these Ginis. As a control, we include a measure of financial development, PRIVO

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however, comparing utility in an equilibrium with inflation with another with no inflation.

[23]Our exercise is in line with Cukierman, Edwards, and Tabellini (1992) who find cross-country empirical backing for their central hypothesis: countries with more polarized systems rely more heavily on seigniorage as a source of revenue than do more homogeneous societies.

(credit extended to the private sector by commercial banks), taken from Beck, Demirguc-Kunt, and Levine (2001). Our purpose was to capture any cross country differences in development of financial markets.[24] Other important control variables are the level of real GDP in 1960 (RGDP60) and level of literacy in 1960 (LIT60) to capture differences in "initial" human and physical capital stocks. The literacy variable was also inspired by Easterly and Fischer (2000) who found evidence in polling data that the likelihood of citing inflation as a concern is inversely related to the educational attainment of the respondents. In addition, we include political economy measures, such as a measure of mixed government (MIX), a dummy variable for a socialist government (SOC), an index of political freedom, and an index of civil liberties (CIVIL) (to measure the importance and overall power of democratic institutions). We also included the time-averaged fraction of people at or above the age of 65 before 1970 (OLD65) to capture the differences in initial demographics and the resultant bias toward redistribution. These control or conditioning variables serve to capture inherent differences between the countries that are not included in our model.[25]

Across the countries in the data set, seigniorage accounts for an average of 10% of government expenditures. Note that since seigniorage-reliance is defined as $1 - \phi$, the relationship between the tax-reliance variable and the Gini coefficient will be opposite in sign to the relationship between seigniorage-reliance and the Gini. The simple correlation coefficient between ϕ and the Gini coefficient is -0.27. In other words, there is a positive, albeit small, correlation between the level of income inequality and the reliance on seigniorage revenue across countries. This correlation coefficient is quantitatively in line with what others have reported in the inflation-inequality literature (see, for example, Dolmas, Huffman, and Wynne, 2000, and Albanesi, 2000).

Table 1 presents OLS estimates of the relationship between ϕ and income inequality along with the control variables mentioned above. The usual standard errors are reported in parenthesis.[26] In an attempt to capture any non-linearity in the relationship as suggested by our results in Section 3, we included both the Gini, and the square of the Gini. Thus, we are approximating the functional form by

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[24]We thank an anonymous referee for this suggestion.

[25]The data are from readily available World Bank sources. See http://www.worldbank.org/research/growth/paauthor.htm

[26]We also calculated White's heteroscedasticity-consistent standard errors. These are similar in magnitude to the OLS standard errors; therefore, they are not reported here.

a second degree polynomial, an acceptable procedure if the functional form is reasonably smooth. We also considered adding in the cube of Gini, but it did not add any explanatory power to the regression.[27]

Table 1 reports a negative coefficient on the Gini and a positive coefficient on the square of the Gini. These coefficients are always significant at the 5% level; moreover, the magnitudes of the coefficients are the same across all sets of control variables that we have employed. The only control variable which is ever significant is PRIVO. Adjusted R^2 varies between 0.19 and 0.23 in the regressions, which is substantially higher than the values typically reported in the inflation-inequality literature. The non-linearity in Gini accounts for about 30% of the explanatory ability of the model, yet another indication that the non-linear component of the econometric model is essential.[28]

As additional, unreported, robustness checks, we carried out weighted least squares. We weigh each observation with 1/CBI, where CBI is a measure of central bank independence taken from Cukierman, Webb, and Neyapti (1992). The idea behind the weighting is that countries with very independent central banks would likely behave very differently from the model's predictions, as these central banks would be subject to little political pressure. This procedure did not change the results. We also checked for high leverage and influential observations by calculating the leverage and the influence of the individual countries.[29] Countries with high leverage were Zimbabwe, Switzerland and South Africa, while influential observations were Argentina, Switzerland and Japan. Re-estimating the model without these countries did not in any way affect the results, and we therefore continue to include them in our dataset.[30]

The fitted econometric model implies that the relationship between ϕ and the Gini index of income inequality is given by

$$\phi = 1.48 - 0.028 \cdot \text{Gini} + 0.0003 \cdot \text{Gini}^2 + 0.001 \cdot \text{PRIVO} + \text{error}. \tag{11}$$

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[27]In fact, in a regression of Gini^3 on a constant, Gini and Gini^2, the R^2 turns out to be 0.99. This implies that the data on Gini^3 does not contain any information that is not already included in the second degree polynomial. Adding Gini^3 would therefore cause severe multicollinearity.

[28]For example, if regression I in Table 1 is carried out without Gini^2, adjusted R^2 drops to around 0.15. It is interesting to note that Dolmas, Huffman, and Wynne (2000) and Albanesi (2000) do not include a squared-gini term in their inflation vs. inequality regressions.

[29]For a formal description of such tests, see Davidson and MacKinnon (1993) pg. 32-39.

[30]Albanesi (2000) eliminates Morocco, Tunisia, Malaysia and Honduras for "being low inflation but very high inequality" countries. Our outlier and "influential observations" tests did not pick these countries.

The relationship is illustrated in Figure 6.[31] To get a rough sense of the magnitudes implied by (11), consider the fact that the US Gini increased from 34.4 in 1975 to 37.26 in 1985. A change in income inequality of this magnitude alone would have been associated with an additional 1.9% of government spending (roughly 0.4% of US GDP) being financed via seigniorage.

¿From (11), it follows that:

$$\frac{\partial \phi}{\partial \text{Gini}} = -0.028 + 0.0006 \cdot \text{Gini}$$

This implies that when the Gini is less than 46.7 (the post-war average Gini for the US is around 36), the derivative is negative, but for higher values of Gini it becomes positive. In other words, the data suggests that the relationship between ϕ and the Gini index of income inequality is non-monotone. In particular, beyond a Gini of 46.7, the reliance on seigniorage falls with further increases in income inequality. In the data, there are 9 countries with Gini higher than this threshold who also rely relatively little on seigniorage.[32] This evidence is consistent with the findings reported in Section 3, especially Figure 2.

It is important to note that the predicted positive relationship between ϕ and Gini for Gini greater than 46.7 is not necessarily at odds with the standard results in the literature on inflation-inequality. While there is a theoretical one-to-one correspondence between ϕ and seigniorage in this specific model, and there is a generally accepted link between seigniorage and inflation, the correlation in our data between $(1 - \phi)$ and inflation is 0.6, and the correlation in the data between inflation and our measure of seigniorage [see Click, 1998] is only 0.4. As such, our results do not contradict those of the inflation-inequality literature.

5   Concluding remarks

This paper attempts to answer the question: if central banks face stiff political pressure from the electorate, what kind of monetary policies are they likely to implement? We employ a standard overlapping generations model with heterogenous young-age endowments, and a government that funds an exoge-

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[31]The results from Regression I are used. The coefficient on PRIVO was multiplied by the mean of PRIVO.

[32]These countries are Trinidad and Tobago, Barbados, Jamaica, Malaysia, Honduras, Phillipines, Kenya, South Africa, and Zimbabwe.

nous spending via a combination of lump-sum income taxes and the inflation tax. Agents can hold money or a costly fixed real return asset. Numerical experiments reveal that the relationship between the long-run elected reliance on the inflation tax and income inequality is non-monotonic; in particular, the reliance on seigniorage may actually decrease as income inequality rises beyond a threshold. This is a powerful new result derived from a barebones model. We demonstrate robust empirical backing for this hypothesis from a cross-section of countries. Extending our analysis to incorporate, more general preferences (thereby allowing for two-sided seigniorage Laffer curves and interest-sensitive money demand), richer assets like capital, a non-trivial labor-leisure choice, progressive taxation, and even intergenerational conflict, etc., would constitute fruitful directions for future research.
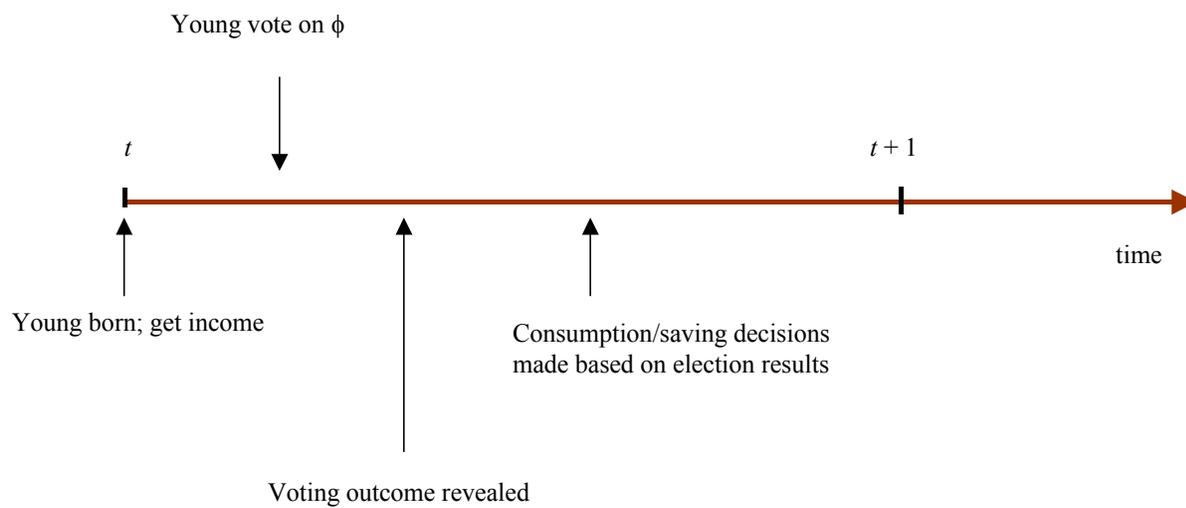
Young vote on ϕ

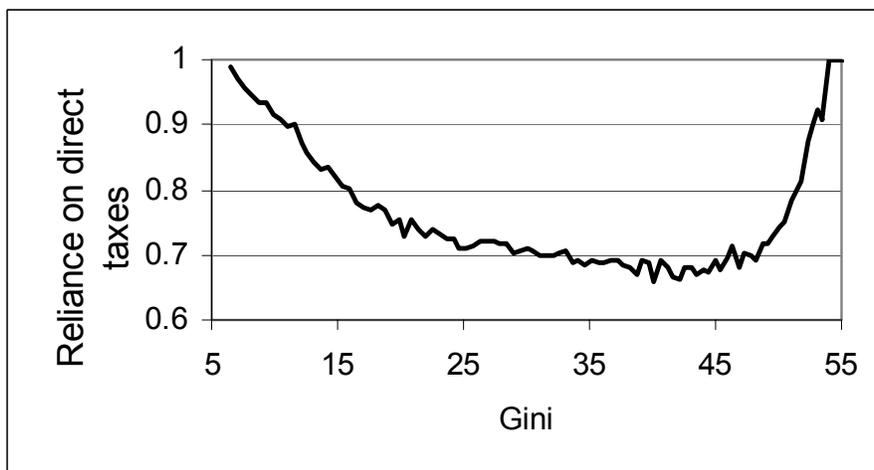t $t+1$

time

Young born; get income

Consumption/saving decisions
made based on election results

Voting outcome revealed

Figure 1: Timeline

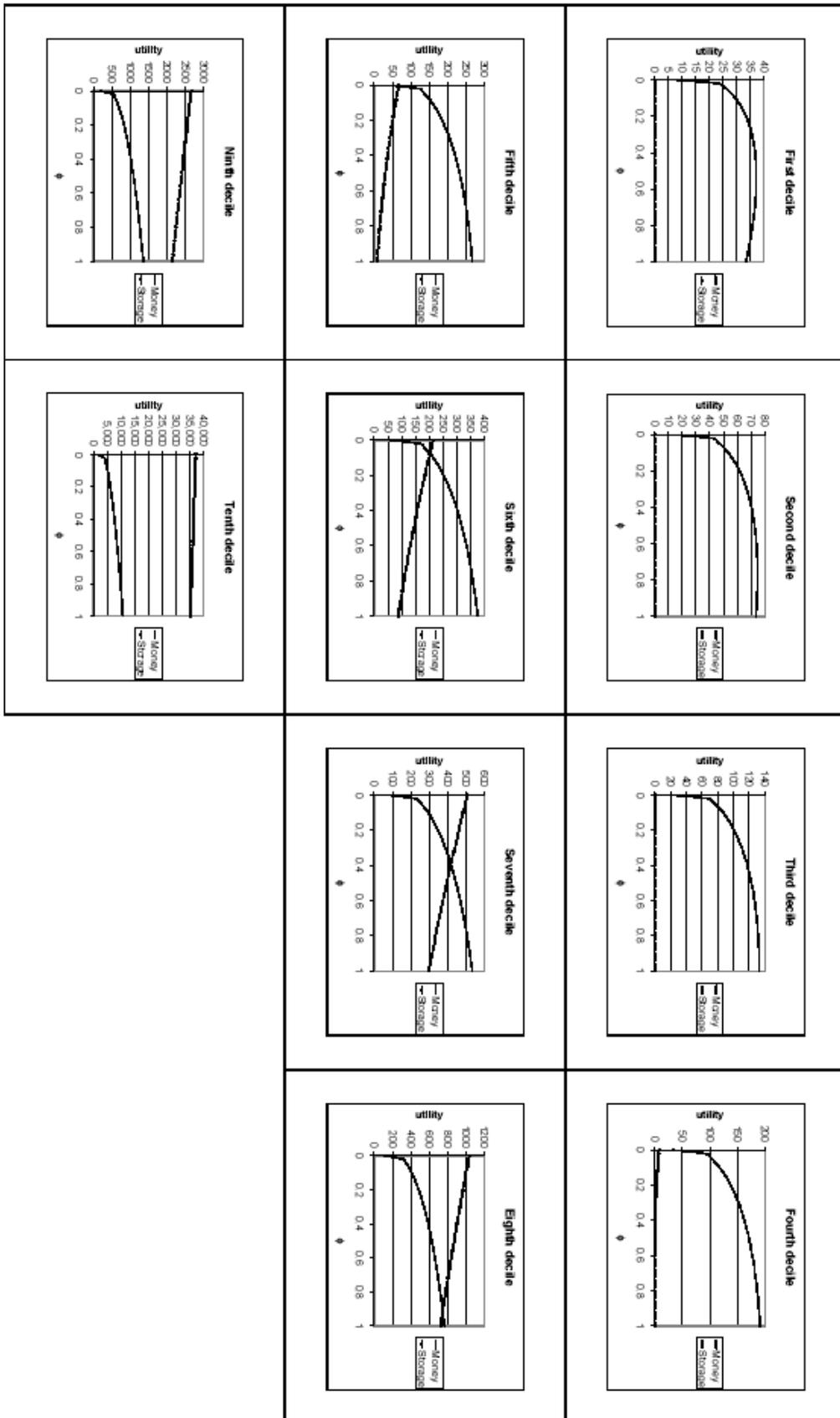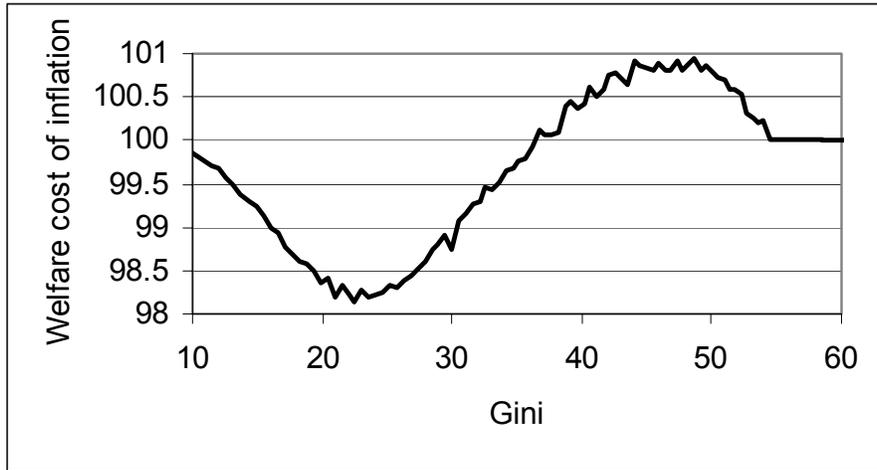Figure 2: Elected ϕ as a function of Gini

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Figure 3: Indirect utility

Figure 4: Equilibrium welfare cost of inflation as a function of Gini.
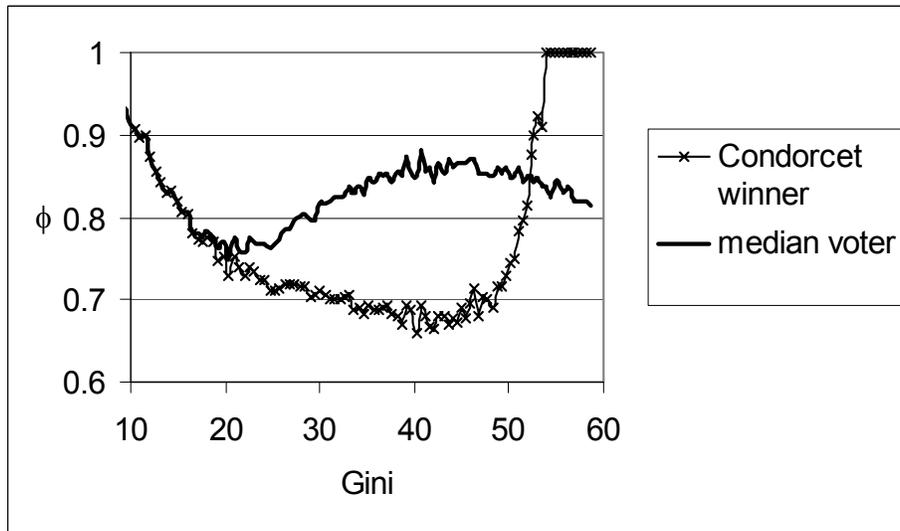

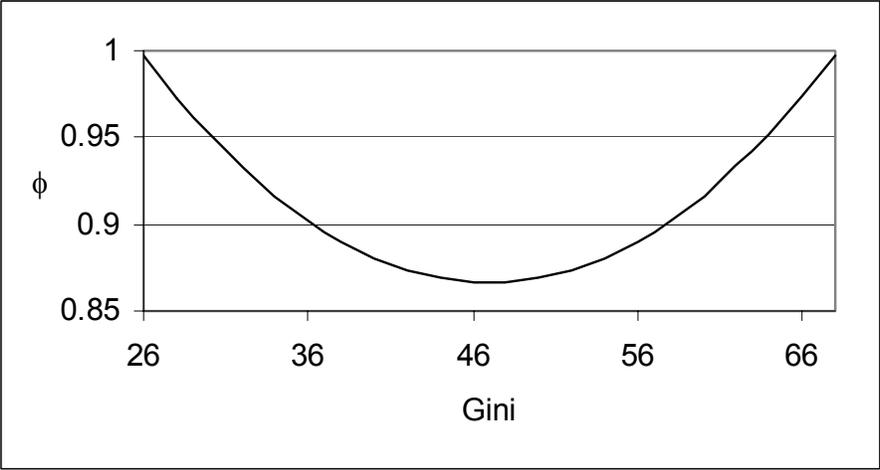Figure 5: The Condorcet winner vs. the median income voter's choice of ϕ.

Figure 6: Estimated relationship between the elected ϕ and Gini.

Table 1
(standard errors in parentheses)

Variable	I	II	III	IV	V	VI
Adjusted R^2	0.22	0.19	0.23	0.20	0.20	0.20
constant	1.48***	1.49***	1.52***	1.47***	1.50***	1.51***
	(0.254)	(0.267)	(0.254)	(0.261)	(0.260)	(0.287)
Gini	-0.028**	-0.028**	-0.028**	-0.028**	-0.028**	-0.029**
	(0.011)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)
Gini^2	0.0003**	0.0003**	0.0003**	0.0003**	0.0003**	0.0003**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
PRIVO	0.001**	0.001**	0.0007	0.001**	0.001**	0.001**
	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
RGDP60	-	0.0002	-	-	-	-
	-	(0.011)	-	-	-	-
LIT60	-	-0.037	-	-	-	-
	-	(0.068)	-	-	-	-
CIVIL	-	-	-0.013	-	-	-
	-	-	(0.010)	-	-	-
Political Freedom	-	-	-	0.002	-	-
	-	-	-	(0.011)	-	-
MIX	-	-	-	-	-0.022	-
	-	-	-	-	(0.025)	-
SOC	-	-	-	-	0.009	-
	-	-	-	-	(0.097)	-
OLD65	-	-	-	-	-	-0.103
	-	-	-	-	-	(0.530)

[33]Legend: *** indicates significant at the 1% level, ** indicates significant at the 5% level, * indicates significant at the 10% level.

Table 2 (List of Countries Used)

Argentina	El Salvador	Korea, Republic of	Sierra Leone
Australia	Finland	Malaysia	South Africa
Austria	France	Mauritius	Spain
Barbados	Germany	Mexico	Sri Lanka
Belgium	Ghana	Nepal	Sweden
Bolivia	Greece	Netherlands	Switzerland
Brazil	Honduras	New Zealand	Thailand
Canada	India	Niger	Togo
Chile	Ireland	Norway	Trinidad and Tobago
Colombia	Israel	Pakistan	United Kingdom
Costa Rica	Italy	Paraguay	United States
Denmark	Jamaica	Peru	Uruguay
Dominican Republic	Japan	Philippines	Venezuela
Ecuador	Kenya	Portugal	Zimbabwe

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