

Inflationary Finance in a Simple Voting Model*

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Abstract

This paper is an attempt at answering the somewhat counterfactual question: if monetary policy was to be decided in the arena of public voting (that is not by independent central banks), then what kind of monetary policies (specifically, inflation rates) would get elected? Alternatively, if central banks cannot turn off the “political pressure valve”, what kind of monetary policies are they likely to implement? We employ a standard overlapping generations model with heterogeneous young-age endowments, and a government that funds an exogenous spending via a combination of lump-sum income taxes and the inflation tax. In the baseline model with money as the sole asset, we find that elected reliance on seigniorage increases (at a decreasing rate) as the extent of income inequality increases. When the baseline model is augmented to allow for costly access to a fixed real return asset, we find that the relationship between elected reliance on the inflation tax and income inequality becomes non-monotonic; in particular, the reliance on seigniorage may actually decrease as income inequality rises. We find strong empirical backing for this hypothesis from a cross-section of countries. We also find that the likelihood of non-existence of majority voting equilibria is high in economies with a sufficiently high degree of income inequality. These economies would presumably benefit the most from a truly independent central bank.

Inflation is the senility of democracies.

— Sylvia Townsend Warner

1 Introduction

Inflation is sometimes labeled as the “cruellest tax of them all”. The underlying premise for such a statement is that inflation hurts the poor much more than it hurts the rich.¹ This could be because the poor hold a much larger fraction of their savings in the form of liquid assets (like money) than the rich. 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.” A reason for this pattern could be that the “better” inflation-shielded saving instruments are costly and the poor cannot afford to access them.² Mulligan and Sala-i-Martin (2000), for example, find that 59% of US households do not hold any interest-bearing assets. 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 \$25,000.³ Based on the aforementioned evidence, it is then clear that inflation is “cruel” because it taxes the savings of those who cannot afford to avoid the tax. To that extent, it seems likely that in any society, inflation will be especially disliked by the poorest segments of society.⁴

Standard monetary models are ill-equipped to capture the likes and dislikes of various people for inflation. In most models in the general equilibrium tradition, the money growth rate (more generally monetary policy) is either exogenously given, or picked by an independent central bank

¹This line of argument dates back at least to Keynes (1940) who discussed the distributional consequences of high inflation.

²Gomis-Porqueras (2001) considers a setting where, as a consequence of regulation, the poor have limited access to financial intermediaries, and hence, “high quality” savings instruments.

³Interestingly, 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.

⁴Easterly 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.

or a revenue-seeking government, or determined by a benevolent social planner.⁵ This is a clear departure from reality. After all, the inflation rate of a country is never determined by a mythical social planner, or in a vacuum by the monetary authority. Central banks routinely face political pressure from the electorate in their country to adhere to clearly stated mandates on the inflation rate.⁶ Even the most independent central banks, as Fed Chairman Alan Greenspan has said, are not in any position to “shut down the political pressure valve”.^{7/8} The implication we draw from all this is that if a democracy is populated by large number of poor people who view inflation as a cruel tax, then we should expect the combined political pressure from the poor to weigh heavily in the overall decision making of the central banks. It is in this vein that we pose the following broad question: if the central bank in a country faces stiff political pressure from the electorate, what kind of monetary policies would get the support of the voting public? Does the answer depend on the extent of inequality in the income distribution of the electorate?

As a first pass, we consider a baseline model of pure-exchange overlapping generations with two-period lived agents. There is income heterogeneity among the young; the old have no endowment. There is a single saving instrument called money. A democratically-elected government has to raise revenue to finance a fixed exogenous level of spending (that benefits no one). There are two instruments for revenue generation: a lump-sum tax on young incomes, and the 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. The timing assumptions in the model are such that the old do not care about this

⁵In many cases, the models admit no heterogeneity, and hence cannot capture crucial elements of reality such as the overall distribution of asset holdings mentioned in the previous paragraph.

⁶Bob 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.”

⁷From 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.”

⁸“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*.” [Gary Stern, President Federal Reserve Bank of Minneapolis, *Formulating a Consistent Approach to Monetary Policy, 1996*]

election. Suppose the precise policy-package combination is chosen by a simple majority decision rule. Restricting attention to stationary states, would the median voter prefer that the inflation tax partly or fully pay for the spending? Generically, if the median voter is poor, the answer turns out to be in the affirmative. The intuition is clear. The rich hold a large portion of the inflation tax base. A poor median voter would like to pass on the burden of paying for the government's spending on the rich. She can do so successfully by voting for partial use of the inflation tax especially when the alternative is a highly regressive lump-sum tax. As is well-known, the social optimum involves zero use of the inflation tax. This suggests the presence of an "inflation bias" on the part of the median voter which is conceptually very similar to the high-tax-and-high-redistribution bias of the median voter in Meltzer and Richard (1981).

Specializing to a lognormal distribution for young-age endowments, we prove that voting equilibria are characterized by preference for higher inflation as the level of income inequality increases. In fact, the relationship is non-linear; the rate at which reliance on the inflation tax increases is falling with increases in income inequality. The baseline model thus produces a testable implication concerning the extent of income inequality and the elected reliance on seigniorage. We conduct cross-country regressions for a set of 69 countries with data from the period 1971-90. For this sample period, across the countries we have data for, seigniorage accounts for, on average, 11% of government expenditures. We regress measures of the fraction of government spending paid for by inflation tax revenues across these countries on the Gini coefficient (a measure of income inequality), the squared value of the Gini coefficients, and a host of other controls, like including government expenditure to GDP ratio, an index of civil liberties, initial GDP per capita in 1960, an index of central bank independence etc. We find that the fraction of government spending paid by seigniorage revenues is negatively associated with the Gini and positively associated with the square of the Gini.⁹ We conclude that there is a robust non-linear relationship between the reliance on seigniorage and the Gini coefficient. The fitted econometric relationship is however U-shaped. The implication is that the reliance on seigniorage in the data actually falls beyond a certain level of income inequality. The baseline model cannot account for this.

⁹The relevant coefficients are always significant at the 5% level, and the magnitudes of the coefficients are the same across all sets of control variables that we have employed.

Almost all the “action” in the baseline model comes from the distribution of money holdings that is induced by the underlying distribution of income in the population. A critical yet unrealistic feature of this distribution is that holdings of money balances increase with income. After all, as Kennickell and Starr-McCluer (1996) document for the US, the fraction of household wealth held in liquid assets decreases with income and wealth. 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. In a related vein, Mulligan and Sala-i-Martin (2000) report, using SCF 1989 data that, “...59% of US households do not hold any interest bearing assets”. Additionally, they 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 of such assets at all.” 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. We ask: Will the aforementioned inflation-bias in elected policy disappear if some agents could avoid the inflation tax?

In a variation on the baseline setup, we allow all agents to access an interest-bearing (and perfectly inflation-indexed) asset but only at a cost. Agents choose whether to pay this fixed upfront cost and hold the better asset or not pay the cost and simply hold money. They compute their overall lifetime utility under these two choices and vote for the income-tax-inflation-tax combination that maximizes their lifetime utility. This in turn, implies a certain “ex-ante” distribution of only-money holders and only-interest-bearing asset holders. Under a voting equilibrium, people who are sufficiently rich do not hold any money and hence prefer that the inflation tax pay for the entire government spending. The more of them there are, though, the smaller is the inflation tax base. Voters, through the government’s budget constraint, understand the implications this has for the inflation tax rate (and hence the return on money holdings), which in turn has implications for the decision of individuals to hold money or hold the interest-bearing asset in the first place. In such a setting, the median voter theorem is no longer applicable; as such, we resort to “counting votes”.

Numerical simulations (using the US household income distribution for 1992) reveal the following general flavor of results. Some agents with high enough incomes choose to hold only the

interest-bearing inflation-indexed asset. Others hold only money. The former would like inflation to pay for the spending, and so do the really poor among the latter.¹⁰ The “middle-class” are left with the tension of balancing the regressivity of the lump-sum tax against the regressivity of the inflation tax. Again, generically, it turns out that the elected policy outcome involves partial use of the inflation tax. The voting equilibrium depends on the distribution of overall asset holdings not just on the distribution of money holdings. It matters whether someone is holding money when they do not want to. In other words, for the vast majority of people, the decision to hold money as an asset when interest-bearing assets are available is an important one, and we establish that the circumstances under which that decision is taken has serious implications for the type of monetary policy that is favored by the electorate as a whole.

Two sets of results stand out. First, we establish that the relationship between the elected policy-package combination and the level of income inequality in this augmented model is non-monotone. In other words, the winning inflation rate increases with increases in income inequality up to a point; beyond that, further increases in income inequality actually reduce the elected inflation rate. Numerical simulations reveal that the predicted relationship between reliance on seigniorage and income inequality is U-shaped. The resemblance to the fitted econometric relationship is quite good. Parenthetically, we show that the inflation-bias in elected monetary policy may vanish once income inequities cross a certain threshold. The second important result is that the likelihood of non-existence of majority voting equilibria increases once the level of income inequality becomes too high. This seemingly technical observation has a profound implication. An economy with a very high level of income inequality may not be able to reach a national consensus on the type of monetary policy that ought to be followed; such economies will presumably benefit most from establishing a truly independent central bank.

Our paper may be viewed as being part of a line of work that tries to address monetary issues in models with heterogenous agents (like the overlapping generations model) using insights from political economy models.¹¹ The papers that are closest in spirit to our current endeavor are those

¹⁰Cardoso (1992) argues that the poor really do not care about the inflation tax as they have very little savings (in the form of money or otherwise) anyway.

¹¹An 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

by Dolmas, Huffman, and Wynne (2000) and Bullard and Waller (2001). The former study a model very similar to our baseline model except that the electorate (only young voters) directly votes on the inflation rate. They uncover a inflation bias on the part of the median voter. However, they do not study the possibility of allowing the rich to avoid the inflation tax. Bullard and Waller (2001) 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 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. Erosa and Ventura (1999) 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. Albanesi (2000) analyzes a setup where the poor are more vulnerable to inflation than the rich. Since the former stand 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.

The rest of the paper is organized as follows. Section 2 describes our baseline model where the only asset is money. Voting equilibria are computed and their properties are discussed. In particular, the positive relationship between elected reliance on seigniorage and income inequality is established. Section 3 describes our main empirical findings and discusses the fitted econometric relationship between reliance on seigniorage and income inequality. Section 4 outlines a model where some agents can opt out of holding money by paying a fee to hold an asset that is immune to inflation. Section 5 concludes. The more important proofs are relegated to the appendices.

Board of Governors in the United States (Chappell, Havrilesky, McGregor, 1993), b) whether political parties have an incentive to initiate “monetary surprises” that increase consumption and GDP temporarily right before an election, (van der Ploeg, 1995), c) whether the median voter likes inflation because inflation erodes the cost of servicing a high debt (Beetsma and van der Ploeg, 1996).

2 The baseline model with money as the only asset

Consider a simple pure-exchange overlapping generations model where at any discrete date $t = 1, 2, 3, \dots$, a new generation of unit measure is born, and lives two periods.¹² There is a considerable amount of intragenerational income heterogeneity among young agents. Each young agent draws his first period endowment, y , of the single consumption good from a probability distribution, $f(\cdot)$ with support $[y_{\min}, y_{\max}]$. Agents have no endowment of the good when old. The preferences for 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. All agents have the same preferences. For analytical tractability, we will assume a specific functional form for U namely:¹³

$$U(c_1, c_2) = \ln c_1 + \ln c_2. \quad (1)$$

Because agents like old age consumption but have no old age income, they have to save. There exists an asset, called fiat money, which may be used for transferring income across periods.

When young, agents potentially pay a lump-sum tax, T , to the government before making any kind of consumption-saving decisions. A typical agent's budget constraints therefore look like:

$$c_1 = y - T - m \quad c_2 = R_m \cdot m \quad (2)$$

where R_m is the gross real return on money between periods, and m is real money balances. Agents maximize (1) subject to (2) to compute their optimal money holdings, m^* :

$$m^*(y) = \frac{y - T}{2}. \quad (3)$$

Given the intragenerational heterogeneity, it is not necessary to impose non-negativity restrictions on m^* . In effect, we allow for money to be traded within members of a generation.¹⁴ Equation (3)

¹²The basic structure of the model follows Dolmas, Huffman, and Wynne (2000) and Bhattacharya and Haslag (forthcoming).

¹³Numerical computations confirm that the general flavor of the results is retained under a more general constant elasticity of substitution specification. The additive log formulation and much of the general environment draws heavily from Dolmas, Huffman, and Wynne (2000).

¹⁴The invariance of money demand to changes in the return to money is entirely a consequence of our assumption of logarithmic preferences (with no second period endowment). Obviously, this is a simplification made solely to obtain simple analytical results. Empirical studies of the demand for money often report low sensitivity to changes in the interest rate which makes our assumption of logarithmic preferences not too unrealistic.

in turn implies that optimal consumption demand for an agent with income y will be given by

$$c_1^* = \frac{1}{2} [y - T], \quad (4)$$

and

$$c_2^* = \frac{1}{2} [R_m(y - T)]. \quad (5)$$

where,

$$c_2^* = R_m \cdot c_1^*. \quad (6)$$

Agents are capable of substituting current consumption for future consumption at the rate given by the return on money. We now turn to the issue of determination of this return.

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 it does not affect agents’ utility or their budget sets.¹⁵ 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 must be raised via seigniorage. The central bank controls the nominal money stock changing it to raise the requisite revenue.¹⁶

Then, the government budget constraint implies that

$$T = \phi g, \quad (7)$$

and

$$S \equiv M(1 - R_m) = (1 - \phi)g, \quad (8)$$

where S stands for seigniorage, and M stands for the aggregate money demand in the economy. Higher values of ϕ represent the will of the electorate to raise more of the revenue from taxes and less

¹⁵The assumption of “purposeless” spending allows us to abstract away from considering the distributional effects of government spending.

¹⁶The 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.

from seigniorage. Notice that if (7) and (8) hold, then the government's budget is balanced at each date. Aggregate money demand (the base for the inflation tax) is given by $M \equiv \int_y m(y)f(y)dy$. From the government budget constraint, it follows that

$$\int_y m^*(y)f(dy)(1 - R_m) = (1 - \phi)g.$$

Use (3) and (7) to get

$$R_m = 1 - \frac{(1 - \phi)g}{\int_y m^*(y)f(dy)} = 1 - \frac{(1 - \phi)g}{\int_y \left[\frac{y-T}{2} \right] f(dy)}$$

Denoting $\int_y yf(dy) \equiv \bar{y}$ (the average level of income) and noticing that $\int_y f(y)dy = 1$, it follows (after some algebra) that

$$R_m = 1 - \frac{2(1 - \phi)g}{\bar{y} - \phi g} \tag{9}$$

Equation (9) embodies 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 to figure out the value of ϕ they wish to vote for. Parenthetically, note that if the nominal money stock grows at the constant gross rate θ , then in a stationary equilibrium, $R_m = \frac{1}{\theta}$ holds. In other words, the outcome of the election on ϕ indirectly (through eq. 9)) determines the money growth rate which is then passively implemented by the central bank.¹⁷ It is in this precise sense that the central bank is not independent.¹⁸ Higher values of ϕ imply more reliance on income taxes and hence a lower money growth rate. In passing, note that R_m and hence the money growth rate θ depend on the mean income \bar{y} . For future reference, also note that

$$\frac{\partial R_m}{\partial \phi} = \frac{2g(\bar{y} - g)}{(\bar{y} - \phi g)^2} \geq 0 \tag{10}$$

under the assumption that $\bar{y} > \phi g$ (an assumption that guarantees a positive aggregate demand for money and is maintained henceforth).

¹⁷Dolmas, Huffman, and Wynne (2000) allow agents to vote directly on R_m . Our formulation is isomorphic to theirs.

¹⁸Alesina 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.

2.2 Welfare

Use (9) in (4) and (5) to get

$$c_1(\phi; g, y, \bar{y}) = \frac{1}{2} [y - \phi g] \quad (11)$$

$$c_2(\phi; g, y, \bar{y}) = \frac{(y - \phi g)}{2} \left[1 - \frac{2(1 - \phi)g}{\bar{y} - \phi g} \right]. \quad (12)$$

Using (11) and (12), one can write out the indirect utility function as

$$W(\phi; g, y, \bar{y}) = \ln \frac{1}{2} (y - \phi g) + \ln \left\{ \frac{(y - \phi g)}{2} \left[1 - \frac{2(1 - \phi)g}{\bar{y} - \phi g} \right] \right\}. \quad (13)$$

The function $W(\phi; g, y, \bar{y})$ computes the maximum amount of lifetime utility that an individual with first-period income y can achieve as a function of the decision variable ϕ , given a fixed level of government spending g .

2.3 Voting

The timeline in the model is as follows. Each young agent (indexed by a different income y) takes part in the voting process.¹⁹ We think of agents as voting on ϕ before making their consumption-savings decisions.²⁰ An agent arrives at her most-preferred choice of ϕ by maximizing $W(\phi; g, y, \bar{y})$ with respect to ϕ where $\phi \in [0, 1]$. Agents vote for their most preferred ϕ .²¹ Once the results of the election on ϕ becomes known, the central bank picks the money growth rate that implements the winning value of ϕ .²² 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

¹⁹ 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.

²⁰ As Dolmas, Huffman, and Wynne (2000) note, this is the most interesting case to look at.

²¹ Given the assumption of a continuum of voters, we assume that voting is sincere, that is, there are no strategic considerations that concern any voter.

²² At the start of period t , there are M_{t-1} dollars in the economy being held by the current old. Once the election on ϕ is over, and the winning gross money growth rate for period t (call it θ_t) becomes known, the central bank prints $(\theta_t \cdot M_{t-1})$ new money. The government uses the new money to purchase $(\theta_t \cdot M_{t-1})/p_t = (M_t - M_{t-1})/p_t$ amount of goods from the young during period t . This pays for the winning fraction ϕ of government spending. The current old sells the nominal money stock of M_{t-1} to the current young and get M_{t-1}/p_t goods in exchange. In all, at the end of period t , there are $M_{t-1} + (M_t - M_{t-1}) = M_t$ outstanding in the economy. Notice that $M_{t-1}/p_t = \frac{M_{t-1}}{p_{t-1}} \cdot \frac{p_{t-1}}{p_t} = \frac{M_{t-1}}{p_{t-1}} \cdot \theta_{t-1}$. Since θ_{t-1} is pre-determined, the amount of goods the current old get from the sale of their M_{t-1} dollars to the current young does not depend on the results of the election of θ_t . Hence the current old do not care about the the results of the election of θ_t .

going on during the period. This in turn implies that the standard commitment problem of getting the future young to implement the election outcomes reached by the current young does not arise here.²³

As stated above, the agent computes her most preferred choice of ϕ by maximizing $W(\phi; g, y, \bar{y})$ with respect to ϕ where $\phi \in [0, 1]$. Suppose the solution is in the interior. Then, standard first order conditions reveal:

$$W'(\phi) = \frac{1}{c_1^*} \left(\frac{-g}{2} \right) + \frac{1}{c_2^*} \left[\left(\frac{-g}{2} \right) R_m + \left(\frac{y - \phi g}{2} \right) \frac{\partial R_m}{\partial \phi} \right] = 0. \quad (14)$$

Using (6) and (10), we can rewrite (14) as

$$2 \left[1 - \frac{2(1 - \phi)g}{\bar{y} - \phi g} \right] = \frac{1}{g} \left[(y - \phi g) \frac{2g(\bar{y} - g)}{(\bar{y} - \phi g)^2} \right]$$

This yields a quadratic in ϕ , a valid solution to which is easily checked to be:

$$\phi^*(y) = \frac{-g(g + \bar{y}) + \sqrt{[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y\bar{y} + gy]}}{-2g^2} \quad (15)$$

An agent with pre-tax income y will have a most preferred choice of ϕ given by $\phi^*(y)$. Notice also that ϕ^* is unique for a given y , i.e., preferences are single-peaked in ϕ . The following lemma outlines some properties of the function $\phi^*(y)$.

Lemma 1 a) $\frac{\partial \phi^*}{\partial y} \geq 0$, b) $\frac{\partial \phi^*}{\partial \bar{y}} \geq 0$

Part (a) of Lemma 1 provides the basis for invoking the median voter theorem as we will demonstrate below. It shows that there is a monotonic link between a person's income and her most preferred choice of the voting parameter. Moreover, it suggests a voting pattern: richer individuals (those with high y) will vote for higher values of ϕ (lower inflation rates) than poorer individuals. Why? The rich, in their attempt to smoothen their consumption, save large amounts in the form of liquid assets. Anything that reduces the return to their saving hurts them more than it would hurt a person with little savings. Hence, the rich prefer a low inflation rate.

²³Bullard 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 [there 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).

Part (b) implies that, *ceteris paribus*, at every income level, people will vote for higher values of ϕ (and hence, lower inflation rates) in economies with higher average incomes than in economies with lower average incomes. This is a consequence of the fact that a higher mean income implies a larger inflation tax base and hence a lesser need for high inflation rates.

We now go on to characterize the precise dependence of a person's choice of ϕ on their income.

Proposition 1 *Define*

$$\hat{y} \equiv \frac{\bar{y}(\bar{y} - 2g)}{(\bar{y} - g)} < \bar{y}. \quad (16)$$

Then,

$$\phi^*(y) = \begin{cases} 0 & \forall y \leq \hat{y} \\ (0, 1) & \forall y \in (\hat{y}, \bar{y}) \\ 1 & \forall y \in [\bar{y}, y_{\max}] \end{cases} \quad (17)$$

When $y \in (\hat{y}, \bar{y})$, $\phi^*(y)$ is computed using (15).

For this simple economy, it is the case that people with sufficiently low incomes all prefer that 100% of the government's spending be raised via the inflation tax. Similarly, people with sufficiently high incomes (here incomes above the mean income) all prefer that 100% of the government's spending be raised via lump-sum taxes. The intuition for this result is clear. The really rich have high young-age incomes and "large" holdings of money. The lump-sum tax option does not hurt them nearly as much as any amount of inflation (which reduces the return on their saving and hence, their old-age income). So, they vote for 100% use of the lump-sum tax. The situation is exactly the opposite for the really poor who find the lump-sum tax a much bigger burden than an inflation tax on their meager savings. People with incomes in between these extremes, all face the same trade-off: a marginal increase in the lump-sum tax reduces their young-age income (and hence their effective saving) but raises the return on saving; on the other hand, more inflation reduces the return to saving and hence old-age income, leaving current income and saving unaltered.

2.4 Leaving out government expenditures

Could we have left government expenditures out of the model at no cost? Do our results derive from the optimal-tax considerations that arise because the government is financing a real expenditure

through seigniorage? A way to check this would be to consider a setup very similar to the one described above except that the government rebates any seigniorage it earns to young agents in the form of a lump-sum transfer. If all agents get the same lump-sum transfer, then it is apparent that the poorer agents will value the transfer more than the rich and vote for policies that maximize the size of the transfer (as in Meltzer and Richard, 1981). Hence, the poor median voter will vote for substantial inflation. The details are briefly sketched below.

When seigniorage is rebated, (2) is replaced by

$$c_1 + m = y + \Gamma \quad c_2 = R_m \cdot m \quad (18)$$

where Γ is the lump-sum transfer. Agents compute their optimal demands for money and consumption by maximizing (1) subject to (18). These are easily checked to be

$$m^*(y) = \frac{y + \Gamma}{2}, \quad c_1^* = \frac{1}{2}(y + \Gamma), \quad c_2^* = \frac{1}{2}[R_m(y + \Gamma)] \quad (19)$$

In a steady state, $R_m = \frac{1}{\theta}$. Also, since the government rebates any seigniorage it earns,

$$\int_y m(y) f(y) dy \left(1 - \frac{1}{\theta}\right) = \Gamma$$

must hold. From this budget constraint, it follows, using (19) that the size of the transfer depends on the money growth rate (the inflation rate) and the size of the mean income:

$$\Gamma = \frac{(1 - \frac{1}{\theta})\bar{y}}{(1 + \frac{1}{\theta})}. \quad (20)$$

Indirect utility (analogous to (13)) can be written as

$$W(\theta; y, \bar{y}) = \ln \frac{1}{2} \left[y + \frac{(1 - \frac{1}{\theta})\bar{y}}{(1 + \frac{1}{\theta})} \right] + \ln \left\{ \frac{1}{2\theta} \left[y + \frac{(1 - \frac{1}{\theta})\bar{y}}{(1 + \frac{1}{\theta})} \right] \right\}.$$

The function $W(\theta; y, \bar{y})$ computes the maximum amount of lifetime utility that an individual with first-period income y can achieve as a function of the decision variable θ . It is easy to check that $W(\theta; y, \bar{y})$ may be simplified to yield

$$W(\theta) = \ln \left[\frac{\theta(y + \bar{y}) + (y - \bar{y})}{2(1 + \theta)} \right] + \ln \left[\frac{(y + \bar{y}) + \frac{(y - \bar{y})}{\theta}}{2(1 + \theta)} \right].$$

To compute the value of the money growth rate (also the inflation rate here) that an agent most prefers, we compute $\operatorname{argmax}_{\theta} W(\theta)$.

Lemma 2 *Agents with incomes $y < \bar{y}$ most prefer $\theta \in (1, \infty)$ while agents with incomes $y > \bar{y}$ most prefer $\theta = 1$.*

As in Meltzer and Richard (1981), the rich do not benefit from the lump-sum transfer as much as the poor and hence they vote to keep the return on their saving undistorted (i.e., zero inflation). The poor median voter cares about the transfer and votes for inflation. The bottom line is that our main results are unaffected by the assumption of seigniorage financed government spending.

2.5 Policy outcomes

Using (17), we can compute the most preferred value of ϕ for any agent in the economy. To map the preferred ϕ for each agent into a *policy* outcome, we invoke the median voter theorem. Define the median voter as a person whose income y_m satisfies

$$\int_{y_{\min}}^{y_m} f(y)dy = \frac{1}{2}.$$

By Lemma 1, there is a direct link between peoples' incomes and their most preferred ϕ s. Moreover, the link is unique [see (15)], i.e., preferences over ϕ are single-peaked. Under a majority voting system, it is the most preferred ϕ of the median income person that can not be defeated by any other alternative if preferences over ϕ are single-peaked. Hence, the ϕ elected by the economy (call it ϕ_m) is the one that corresponds to the ϕ^* chosen by the person with the median income, y_m . If $y_m \in (\hat{y}, \bar{y})$, then $\phi_m \in (0, 1)$. That is, if the median income lies in the range (\hat{y}, \bar{y}) , then society would choose to adopt a policy regime that uses the inflation tax to pay for a strictly *positive* fraction of the government's spending even though lump-sum (nondistortionary) taxes are available. In other words, the elected gross money growth rate or (the gross steady-state inflation rate) would be

$$\theta_m = \frac{2(1 - \phi_m)g}{\bar{y} - \phi_m g - 2(1 - \phi_m)g}, \quad (21)$$

where $\theta_m > 1$ if $\phi_m \in (0, 1)$. Figure 2 is an illustration of such a voting equilibrium.

The important thing to note here is that this result does not require any distortion on saving to be present. Our result is completely a consequence of the income heterogeneity among the population, and the fact that a lump-sum tax is a regressive tax. In this connection, also note that

the social optimum requires the government to impose (person-specific) lump-sum income taxes to raise the revenue and not use the inflation tax at all. That is, the social optimum would involve zero inflation. In this sense, the social optimum here is not implementable as a political equilibrium if the alternative revenue source to inflation is a lump-sum income tax.

We now turn to a study of how the elected choice of ϕ differs across income distributions with different levels of income inequality.

2.6 Inflation and inequality

Does the model deliver a relationship between the elected inflation rate and the extent of income inequality in the economy? To make some progress toward answering this question, we assume that the model economy is populated by a continuum of agents $i \in [0, 1]$ whose first-period incomes are distributed as $\ln y^i \sim N(\mu, \sigma^2)$ or that y^i is lognormally distributed. Such a direct assumption is made by Benabou (2000) or Glomm and Ravikumar (1992). The lognormal distribution is a particularly nice choice in that the Gini coefficient depends only on σ , i.e., an increase in σ directly increases inequality (the Gini coefficient goes up). At the same time, an increase in σ would cause the Lorenz curve to shift outward too. For future reference, we collect some relevant information about the lognormal below.²⁴

Lemma 3 *Suppose $\ln y \sim N(\mu, \sigma^2)$. Then,*

$$\bar{y} = e^{\mu + \frac{\sigma^2}{2}},$$

$$y_m = e^{\mu},$$

and the Gini coefficient is

$$\gamma = 2\Phi\left(\frac{\sigma}{2}\right) - 1.$$

where Φ is the c.d.f of a standard normal distribution.

²⁴The Gini coefficient is a summary measure of inequality that is derived from the Lorenz curve. A gini of 1 implies perfect inequality and a gini of 0 implies perfect equality. For details, see Ray (1998).

Under the assumption of lognormal incomes, it is then easy to check that the condition (16) in Proposition (1) implies

$$y_m < \hat{y} \Rightarrow g < \frac{e^{\mu+\sigma^2} - e^{\mu+\frac{\sigma^2}{2}}}{e^{\frac{\sigma^2}{2}} - 1} \equiv \hat{g}$$

Using the expression in (15), it then follows that the median voter would choose

$$\phi^*(y_m) = \frac{-g(g + \bar{y}) + \sqrt{[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m]}}{-2g^2} \quad (22)$$

where \bar{y} and y_m are defined as in Lemma 3. Then, we can write $\phi^*(y_m)$ solely as a function of σ and ask how the median voter's choice of ϕ would vary as σ (and hence the Gini) increases.

Proposition 2 *Suppose $g < \hat{g}$. Then,*

a)

$$\frac{\partial \phi^*(y_m)}{\partial \sigma} \leq 0$$

b)

$$\frac{\partial^2 \phi^*(y_m)}{\partial \sigma^2} \leq 0$$

Part (a) of Proposition 2 states that an increase in the income inequality would result in the median voter choosing a policy wherein a larger fraction of the government's spending is supported via seigniorage. In other words, increases in income inequality are associated with higher inflation rates. The intuition is as follows. For a lognormal income distribution, as is clear from Lemma 3, an increase in σ increases the average income, but leaves the median income unchanged. This implies that the gap between the mean income and the median income increases. It can be shown that the distribution with higher σ has a *larger* percentage of people with incomes less than or equal to the mean income (which is higher) than a distribution with lower σ . In plain terms, the distribution with higher σ has fewer rich people (those with incomes higher than the mean) and hence, the poor median voter has to call for a higher inflation rate so as to compensate for the smaller inflation tax base.

Part (b) suggests that the theoretical relationship between the elected policy-package combination and income inequality is non-linear. This follows from the following. The rate at which the number of rich people falls as σ increases is falling in σ . The poor median voter has to compensate by electing higher and higher inflation rates to compensate for the smaller inflation tax base. But the rate at which the elected inflation rate increases therefore falls as σ increases.

Corollary 1 $\frac{\partial \theta_m}{\partial \sigma} \geq 0$, or that the elected inflation rate is increasing in the extent of income inequality.

2.7 Numerics

We now turn to some numerical examples illustrating how the elected policy outcome and its various characteristics changes as the income distribution becomes more unequal. Our exercise is not intended to be a full-blown attempt at calibration. The starting point is a baseline model economy where the endowments of the young are distributed as a lognormal distribution with mean, $\mu = 3.606$ and standard deviation, $\sigma = 0.615$. Barse, 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. Higher σ will correspond to higher inequality numbers. Implicitly, we are assuming that the pre-tax income distribution is time-invariant. We also fix $g = 8$; this corresponds to a government spending-to-GDP ratio of about 20%.

Figure 3 plots the elected ϕ , i.e., the policy-package combination most-preferred by the median voter, ϕ_m , for a range of Ginis. When the extent of income inequality is very low (Gini ≈ 0.2), the median voter would vote for near 80% of the spending to be paid for by the lump-sum tax. This corresponds to a low inflation rate. As the level of inequality rises, the median voter votes for more and more use of the inflation tax. When the Gini reaches 0.38, the median voter elects inflation to pay for 100% of the government's spending. Figure 3 is a numerical illustration of Proposition 2. The winning policy-package combination includes more and more use of the inflation tax as inequality increases but the desire for inflationary finance increases at a decreasing rate.

Suppose one asks the question: under the elected ϕ , what fraction of the government's spending

is “financed” by the direct (income tax) and indirect (inflation tax) taxes that are collected from the richest 5% and the poorest 5%? And how does that change as the inequality increases? Figure 4 reports the results. When inequality is very low, almost all the revenue is raised via the lump-sum tax; hence, the richest 5% of the income distribution and the poorest 5% pay more or less the “same share”. However, as inequality increases, the gap widens; the richest 5% of the population end up financing about 20% of the spending when the Gini is about 0.44. Figure 5 illustrates how this financing gap behaves for the richest and poorest 10% of the population. The richest 10% of the population end up financing about 32% of the spending when the Gini is about 0.44; the poorest 10% pay for about 2%. The message is clear. The poor median voter passes on much of the burden of paying for the government spending on the rich.

It seems clear from our previous discussions that the elected political outcome for the inflation rate in the economy is a function of the extent of pre-tax income inequality. Higher levels of income inequality are associated with higher levels of inflation in this simple economy. Income inequality affects various agents insofar as the elected outcome differs from their own preferred positions. The rich (those with incomes above the mean income) are strongly affected by this: while they would all like zero inflation, the elected outcome generically involves a substantial amount of inflation. Similarly, the very poor suffer from the burden of the lump-sum tax that the median voter imposes on them. They would have liked a 0% lump-sum tax. In an effort to capture these “costs of inequality”, we ask the following question: In an utility sense, how does the welfare of an agent with pre-tax income y compare under a) the median voter’s policy choice of ϕ , and b) a regime where her own most-preferred ϕ had been chosen by society? In the appendix, (see eq. (38)-(40)) we compute the formulae for the “cost of inequality” for the various participants.

Figure 6 reports how the cost of inequality varies with income. We uncover somewhat of a U-shape; the utility cost is high (of the order of 8-12%) for the people with incomes well below the median. It is of course near zero for people with incomes right near the median. The utility cost is again positive for the “rich” but the cost never crosses 4% or so. In other words, in this setup, inequality in the income distribution is more costly to the poor (in utility terms) than it is for the rich.

3 Empirics

Proposition 2 produces a simple testable implication for cross-section data: countries with high degrees of income inequality will rely more on seigniorage than those with more equal incomes. Additionally, the predicted relationship is non-linear.

In order to proceed with the empirical testing of this implication, we first need a direct way to measure the reliance on seigniorage, or indirectly, a way to measure ϕ . In principle, ϕ can be computed from the expression for the inflation rate [say using (21)]; however, this is a complicated relationship and one that depends on the parameters of the specific model (i.e., the model with or without storage). Instead, we compute ϕ as follows: from the government budget constraint, total income taxes collected must satisfy $T = \phi g$ and total seigniorage revenue collected must satisfy $S = (1 - \phi)g$, and so,

$$\frac{\frac{\text{Taxes}}{\text{GDP}}}{\frac{\text{seigniorage}}{\text{GDP}}} = \frac{T}{S} = \frac{\phi}{(1 - \phi)}$$

or,

$$\phi = \frac{\frac{\frac{\text{Taxes}}{\text{GDP}}}{\frac{\text{seigniorage}}{\text{GDP}}}}{1 + \frac{\frac{\text{Taxes}}{\text{GDP}}}{\frac{\text{seigniorage}}{\text{GDP}}}}.$$

This method of calculating ϕ is invariant to the model details as well as changes in the scale of government spending. The principal advantage of this method is that the same data set can be used for different versions of the model.

Table 1 reports the summary statistics for the tax-reliance variable, ϕ , and the Gini coefficient. The data used for this purpose is from a cross-country sample with 69 countries. Unless otherwise indicated, the data are sample means for the period 1974-89.

Table 1

Variable	Mean	Std. Dev
Gini	41.96	9.09
ϕ	0.909	0.087

For this sample period, 89% of the expenditures come from direct income taxes. Thus, across the countries in the data set, seigniorage accounts for an average of 11% of government expenditures.²⁵ 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 -0.14. 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).

The complete set of countries used for the regressions below are listed in Table 4. The exact number of countries used in any given regression varies from 49 to 76 depending on the availability of data on different variables across countries. The number of countries included in any given regression is reported in Table 2 and 3. The initial control variables employed includes the level of real GDP in 1960 and level of literacy in 1960 (taken from Barro, 1991) 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 Barro’s (1991) measure of mixed government (MIX), a dummy variable for a socialist government (SOC) and an index of civil liberties (CIVIL) (to measure the importance and overall power of democratic institutions). In addition, we included either the average ratio of conventional tax revenue to GDP (T/Y) or the average ratio of government spending to GDP (G/Y) (they are highly correlated and hence are not included in the same regression). These control or conditioning variables serve to capture inherent differences between the countries that are not included in our model.

Table 2 presents OLS estimates of the linear relationship between ϕ and income inequality along with the control variables mentioned above. The usual standard errors are reported in

²⁵Seigniorage to GDP ratio is measured as the average ratio of the change in the monetary base to GDP. The taxes to GDP ratio is the average ratio of conventional tax revenue to GDP for the sample period. The data are taken from Click (1998). The Gini data are time-averages computed from Deininger and Squire’s (1996) high-quality inequality data set.

parenthesis.²⁶ In an attempt to capture the non-linearity of the relationship as suggested by Proposition 2, we included both the Gini-coefficient, and the square of the Gini-coefficient. Thus, we are approximating the functional form by a second degree polynomial, a procedure which is typically fairly accurate if the functional form is reasonably smooth.

Table 2 reports a negative coefficient on the Gini and a positive coefficient on the square of the Gini. These coefficients are always significant at the 1% level; moreover, the magnitudes of the coefficients are the same across all sets of control variables that we have employed. These results are quite robust to inclusion of additional conditioning variables. In particular, we included a measure of central bank independence (CBI), the 1974-89 average government expenditure to GDP (Tex), the time-averaged fraction of people at or above the age of 65 before 1970 (Old) to capture the differences in initial demographics and the resultant bias toward redistribution, and the bank deposit rate (Drate), a measure of the return on a safe asset. The results from those regressions can be found in Table 3. Not much changes with the alterations in the conditioning set. The *positive* coefficient on the Gini and the *negative* coefficient on the square of the Gini are still significant and of the same order of magnitude. In addition, note that the adjusted R^2 is around 0.3 for all the regressions, substantially higher than the values typically reported in the inflation-inequality literature cited above. About 30% of this explanatory ability is contributed by Gini-squared, yet another indication that the non-linear component of the econometric model is essential.²⁷ Based on this, we conclude that there is a robust non-linear relationship between ϕ and the Gini coefficient.

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

$$\phi = 1.522 - 0.025 \cdot \text{Gini} + 0.0003 \cdot \text{Gini}^2 + \text{other variables.} \quad (23)$$

The relationship is illustrated in Figure 7.²⁸ To get a rough sense of the magnitudes implied by (23), consider the fact that the US Gini index increased from 34.4 in 1975 to 37.26 in 1985. A

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

²⁷In (unreported) regressions performed without the Gini-squared variable, we found that the adjusted R^2 drops to around 0.2.

²⁸The results from Table 2, Regression V is used. Other than gini and gini², the only other significant variable was CIVIL; only significant variables were used. The coefficient on CIVIL was multiplied by its mean.

change in income inequality of this magnitude alone would have been associated with an additional 1% of government spending (roughly 0.2% of US GDP) being financed via seigniorage.

From (23), it follows that:

$$\frac{\partial \phi}{\partial \text{Gini}} = -0.025 + 0.0006 \cdot \text{Gini}$$

This implies that when the Gini is less than $41.\bar{6}$ (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 certain threshold, the reliance on seigniorage falls with further increases in income inequality. The implication is that there are important features of the data that are not accounted for by our simple baseline model.

4 The model with money and a costly indexed asset

4.1 Motivation

The baseline model produced a relationship between the extent of income inequality and an economy’s political taste for a certain amount of inflation. Higher levels of income inequality was always associated (see Figure 3) with higher elected reliance on inflation. When placed against the empirical findings in Section 3, it is clear that the baseline model was only partly successful in capturing reality. While it could account for the positive relationship between reliance on seigniorage and income inequality, it could not account for the negative relationship between the same for high levels of income inequality. Put simply, the relationship between reliance on seigniorage and income inequality in the data is somewhat U-shaped and the baseline model is incapable of capturing the upward-sloping portion of the graph.

There is another bothersome aspect to the baseline model. Almost all the “action” there came from the distribution of money holdings that was induced by the underlying distribution of income in the population. A critical feature of the distribution of money holdings is that holdings of money balances increased with income, a feature that is also present in the setup of Dolmas, Huffman, and Wynne (2000). In the real world, however, holdings of purely liquid assets (like money) fall

with income. Kennickell and Starr-McCluer (1996) document that for the US, the fraction of household wealth held in liquid assets decreases with income and wealth. The poor hold a much larger fraction of their wealth in the form of money than do the rich. The implication is that the rich, in the real world, hold a large fraction of their wealth in the form of interest-bearing assets.²⁹ This suggests that even when interest-bearing assets are available, not everyone makes (or can make) use of them. In fact, Mulligan and Sala-i-Martin (2000) report, using SCF 1989 data that for a country as financially evolved as the United States, “...59% of US households do not hold any interest bearing assets”. Additionally, they 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 of such assets at all.” This “decision to adopt the financial technology” depends largely on the opportunity cost in terms of interest-income foregone and other physical costs.

Below, we present a variation on the baseline setup that incorporates some of the features that Mulligan and Sala-i-Martin (2000) describe. In particular, we allow all agents to access an interest-bearing (and perfectly inflation-indexed) asset but at a cost. Agents choose whether to pay this cost and hold the better asset or not pay the cost and simply hold money. Agents compute their overall lifetime utility under these two choices and vote for the income-tax-inflation-tax combination that maximizes their lifetime utility. This in turn, implies a certain “ex-ante” distribution of only-money holders and only-interest-bearing asset holders. Under a voting equilibrium, people who are rich enough, do not hold any money and hence prefer that the inflation tax pay for the entire government spending. The more of them there are, the smaller is the inflation tax base. Voters, through the government’s budget constraint, understand the implications this has for the inflation tax rate (and hence the return on money holdings), which in turn has implications for the decision of individuals to hold money or hold the interest-bearing asset in the first place and hence the size of the money or storage holders.

Why do we think that the baseline model augmented with costly access to a storage technology has the potential to produce newer insights? The main point here is that it ought to matter

²⁹The richest 1% of US households held almost 80% of their savings in investment real estate, businesses, corporate stock and financial securities in 1998. Liquid assets (checking and saving accounts, time deposits, money market funds etc.) comprised only 5% of their savings. In sharp contrast, the “middle class” (the middle three quintiles) held 11.8% of their savings in liquid assets and about 60% in their homes. Source: Wolfe (2001).

whether, in an equilibrium, some agents are holding money because circumstances (their budget constraints) are forcing them to do so; otherwise, they would be switching to holding only storage if they could. In our augmented model, *only* the really rich are somewhat unconstrained. Such a model is likely to produce voting equilibria that are quite different from the baseline model where *everyone* holds whatever amount of money they wish to in a relatively unconstrained manner. The augmented model recognizes that for the vast majority of people, the decision to hold money as an asset when interest-bearing assets are available is an important one. To foreshadow, our results indicate that the circumstances under which that decision is taken has profound implications for the type of monetary policy that is favored by the electorate as a whole. We describe the details below.

4.2 Outline

Consider a structure identical to the baseline one except that alongside fiat money, 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. In this sense, the real return to storage is perfectly invariant to inflation and hence the voting outcome. Money is dominated in rate of return by storage, i.e., $x > R_m$, where R_m is the stationary return to money. This storage technology is available to anyone who is willing to pay a fixed upfront cost of $\delta > 0$ to access/adopt the technology.³⁰ In an equilibrium, agents will of course 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.

As in the first model, the government finances a fixed “useless” spending of $g > 0$ every period. When young, agents also pay a lump-sum tax, T , to the government. Consider the problem of an individual with income y who is considering accessing the storage technology by paying the fixed cost. Then, her budget constraints are given by

$$c_1 = y - S - T - \delta \quad c_2 = xS \tag{24}$$

³⁰One may think of this as the fixed cost of accessing financial markets or the cost of adopting financial technologies that Mulligan and Sala-i-Martin (2000) and Lucas (2000) discuss.

where S is her saving. 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 (24) to get at their optimal investment in the storage technology:

$$S(y) = \frac{y - \delta - T}{2}. \quad (25)$$

This implies that an agent contemplating investing in storage will enjoy first and second period consumption given by

$$c_1^s = \frac{y - \delta - T}{2}, \quad (26)$$

$$c_2^s = x \left(\frac{y - \delta - T}{2} \right). \quad (27)$$

Her indirect utility would be

$$U^s(y) = \ln \left[\frac{y - \delta - T}{2} \right] + \ln \left[x \left(\frac{y - \delta - T}{2} \right) \right] \quad (28)$$

where the superscript s stands for storage.

Now, consider a person who is contemplating holding only money. Such an agent's budget constraints are given by:

$$c_1^m = y - T - m \quad c_2^m = R_m \cdot m \quad (29)$$

where R_m is again the gross real return on money between periods. Such money-holding agents maximize (1) subject to (29) to get at their optimal money holdings:

$$m(y) = \frac{y - T}{2}. \quad (30)$$

This implies that their consumption in the first and second periods will be:

$$c_1^m = \frac{1}{2} [y - T] \quad (31)$$

$$c_2^m = \frac{1}{2} [R_m(y - T)]. \quad (32)$$

and their indirect utility will be:

$$U^m(y) = \ln \left[\frac{y - T}{2} \right] + \ln \left[R_m \left(\frac{y - T}{2} \right) \right] \quad (33)$$

where the superscript m stands for money.

Who are the people who hold no money? Obviously, agents with income y for whom

$$U^s(y) \geq U^m(y) \quad (34)$$

hold will not hold any money. It can be shown that (34) reduces to

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

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

$$y - T \leq \delta \left[\frac{x - \sqrt{xR_m}}{(x - R_m)} \right] \quad (35)$$

and

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

Note however that

$$\frac{x - \sqrt{xR_m}}{(x - R_m)} < \frac{x - \sqrt{(R_m)^2}}{(x - R_m)} = 1$$

Then, (35) implies that

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

implying that individuals with post-tax income less than $\delta \left[\frac{x - \sqrt{xR_m}}{(x - R_m)} \right]$ would want to use the storage technologies, but cannot afford to because their disposable incomes are less than δ . Define

$$y^\dagger \equiv \delta \left[\frac{x + \sqrt{xR_m}}{(x - R_m)} \right]. \quad (36)$$

Then, it is clear that only agents with incomes $y - T > y^\dagger$ will access the storage technology. All others will hold only money. Note that y^\dagger is a function of ϕ . This is because the number of people holding money depends on the return to money which depends on the seigniorage tax base which again depends on the number of people holding money.

4.3 Equilibrium

How much seigniorage revenue will the government raise? As before, total seigniorage raised must satisfy

$$H \equiv M(1 - R_m) = (1 - \phi)g$$

while the residual $T = \phi g$ is raised through taxes. Aggregate money demand is computed from

$$M = \int_{\underline{y}}^{y^\dagger} m(y)f(y)dy$$

where $m(y)$ is computed using (30). Then, it follows that

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

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

$$R_m = 1 - \frac{2(1 - \phi)g}{\int_{\underline{y}}^{y^\dagger} yf(y)dy - \phi g \int_{\underline{y}}^{y^\dagger} f(y)dy} = 1 - \frac{2(1 - \phi)g}{\int_{\underline{y}}^{y^\dagger} yf(y)dy - \phi g F(y^\dagger)}. \quad (37)$$

Note that eqs. (37) and (36) jointly determine y^\dagger and R_m which are both functions of ϕ . That is, given a ϕ , any agent can immediately use (37) and (36) to jointly compute y^\dagger and R_m which in turn tells him if for that value of ϕ , he would be happier holding storage or holding money.

It is important to note here that the median voter theorem can no longer be used to move from individual decisions to policy outcomes. To see this, consider an agent who is holding only storage. Such a person has a most preferred $\phi = 0$. If this person is asked to choose between $\phi = 0.3$ and $\phi = 0.5$, the single-peakedness condition in the median voter theorem requires him to choose the ϕ nearer to 0, i.e., he ought to vote for $\phi = 0.3$. But, in the current model, it is possible that in the equilibrium with $\phi = 0.5$, this same agent would switch from holding storage to holding money and as a result may actually prefer $\phi = 0.5$ to $\phi = 0.3$. The link between incomes of agents and their votes is lost (the really rich and the really poor vote along similar lines; they both favor inflation, albeit for very different reasons). As such, we resort to “counting votes” in a manner described below.

Elections are held between pairwise competing values of ϕ . Then, for any two values of ϕ , say ϕ_a and ϕ_b , an agent can determine if he gets more utility under ϕ_a or ϕ_b and votes for the one that gives him more utility. Votes are tallied up and the value of ϕ selected by the majority wins that election. The winning ϕ is then pitted against another feasible choice of ϕ . If there is a single value

of ϕ that remains undefeated in every pairwise election with every other feasible value of ϕ , it is declared the winner. This is what we will call the voting equilibrium or the political equilibrium.

As is well-known, in models of this type, voting equilibria may not exist. Similarly, the possibility of Condorcet cycles emerges [ϕ_a wins against ϕ_b and ϕ_b wins against ϕ_c but ϕ_c wins against ϕ_a]. Following standard practice, we quickly resort to numerical computations.

4.4 Computational Experiments

The starting point of our exercise is the same lognormal distribution with mean $\mu = 3.606$ and standard deviation $\sigma = 0.615$ that was employed in the computations presented in Section 2.7. Draws of 25,001 people are taken from this distribution. The unit interval for ϕ is converted into a grid of 101 points. We set $x = 4.5$, $\delta = 55$, and $g = 8$. The corresponding Gini is 0.34. For this baseline set of parameters, the voting equilibrium has the following features. In this equilibrium, only 4.76 % of the electorate ends up accessing the storage technology. The winning policy-combination is given by $\phi = 0.69$ which implies that the electorate votes for 31% of the government's revenue to be raised via seigniorage. The implied elected inflation rate is 17.9%. 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%, and the government expenditures to GDP ratio is 18 %.

We are particularly interested in the relationship between the winning policy-combination and the extent of income inequality. Figure 8 plots the elected ϕ against the Gini coefficient. As is clear from the figure, the relationship is non-linear. Of particular interest is the U-shaped nature of the plot. ³¹This suggests that for 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. This is exactly analogous to what we observed in Figure 3. However, as inequality crosses a certain point, the elected reliance on inflation starts to fall. People start to elect governments that rely more and more on direct taxes and less and less on inflation. The intuition for the upward sloping portion of Figure 8 is as follows. As the level

³¹This U-shaped feature of the plot is quite robust to changes in parameters.

of inequality continues to rise, the number of people who earn less than the mean income rises. If however, the number of storage holders rise, the size of the inflation tax base will fall. The money-holders will then face the prospect of a relatively high inflation tax rate (which is regressive, since it is not paid by the rich) versus the regressive lump-sum tax which is paid by all. The equilibrium may then shift toward greater use of lump-sum taxes.

A comparison of Figure 8 with the fitted econometric relationship in Figure 7 is revealing. The baseline model augmented with costly access to storage comes reasonably close to accounting for the relationship between reliance on seigniorage and inequality that is observed in the data.

Figure 9 plots the elected inflation rate as a function of the level of inequality. The picture tells a similar story to that in Figure 8. The important thing to note here is that the elected inflation rate increases as inequality increases up to a Gini of 0.45 or so. This is the part of the picture that corresponds well with the received wisdom on the connection between inflation and income inequality that has empirical support. The novelty of what we find here is that there is a part of the curve beyond a Gini of 0.45 where the elected reliance on inflation actually starts to decrease.

Figure 10 plots the percentage of g that is paid for by the richest and the poorest 10% of the population.

We now turn to some welfare comparisons. Recall that the efficient monetary policy is to hold the money stock fixed and raise the revenue required through person-specific lump-sum taxes. 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 11 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 (0.35-0.5) in which society, as a whole, is “better off” with some positive inflation.

4.5 Nonexistence of voting equilibria

Consider an alternative example using the same lognormal distribution that was employed earlier. Once again, draws of 25,001 agents are taken from this distribution. Now, suppose we set $x = 3.8$, $\delta = 40$, and $g = 8$. For this set of parameters, the voting equilibrium has the following features. In this equilibrium, about 10 % of the electorate ends up accessing the storage technology. The winning policy-combination is given by $\phi = 0.78$ which implies that the electorate votes for 22% of the government's revenue to be raised via seigniorage. The implied elected inflation rate is 14.3%. The seigniorage to real GDP ratio is about 3.9%, and the government spending to GDP ratio is 18 %. Figure 12 plots the elected inflation rate against the Gini. Notice that the slope of the inflation-inequality relationship is positive all the way to a Gini of about 0.38. Beyond this level of inequality, there are no voting equilibria. This is presumably because for this set of parameters, once the degree of income inequality becomes "too high", there are many people who hold no money. The inflation tax base shrinks to a point where the inflation tax rate needed to raise the government's revenue is too high. This changes the composition of money versus storage holders and so on. No equilibrium can be reached. In other words, the electorate cannot give a clear mandate to the central bank on the type of monetary policy it should implement.

There is an important policy implication that we wish to draw from this example. One way to interpret the non-existence of a political equilibrium is to say that under a certain range of parameters, the electorate, if allowed to decide on monetary policy, would not be able to reach any consensus. More specifically, a lesson from this example is that once the level of income inequality reaches a certain threshold, a democracy operating under a majority rule, may not be able to come to a decision on what type of monetary policy should be followed. It is possibly in this setting that an independent central bank is most needed.

5 Concluding remarks

This paper attempt to answering 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 heterogeneous young-age endowments, and a government that funds an exogenous spending via a combination of lump-sum income taxes and the inflation tax. In the baseline model with money as the sole asset, we find that elected reliance on seigniorage increases (at a decreasing rate) as the extent of income inequality increases. When the baseline model is augmented to allow for costly access to a fixed real return asset, we find that the relationship between elected reliance on the inflation tax and income inequality becomes non-monotonic; in particular, the winning inflation rate may actually decrease as income inequality rises. We demonstrate strong empirical backing for this hypothesis from a cross-section of countries. We also find that the likelihood of non-existence of majority voting equilibria is high in economies with a sufficiently high degree of income inequality. Our claim is that these economies would presumably benefit the most from a truly independent central bank.

An interesting direction for future research would be to calibrate a more realistic model to politico-economic features of the US economy and compute the long-run inflation rate that would get elected in such an economy. A realistic possibility that may arise is that the electorate shows no inflation-bias and elects a low inflation number. In which case, one may reasonably ask: if the electorate can effectively do the job of an independent central bank, why do we need independent central banks?

Table 2

(standard errors in parentheses)

Variable	I	II	III	IV	V
Number of Countries	76	76	76	76	76
Adjusted R^2	0.17	0.30	0.29	0.32	0.32
constant	1.491***	1.284***	1.423***	1.364***	1.522***
	(0.212)	(0.223)	(0.229)	(0.222)	(0.223)
Gini	-0.028***	-0.021**	-0.026***	-0.02**	-0.025***
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)
Gini ²	0.0003***	0.0002**	0.0003***	0.0002**	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
lit	-0.0168	-0.0193	-0.0165	-0.068	-0.074
	(0.044)	(0.043)	(0.044)	(0.054)	(0.056)
rgdp60	0.139*	0.010	0.013*	0.007	0.010
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
t/y	-	0.253**	-	0.274**	-
	-	(0.107)	-	(0.109)	-
g/y	-	-	0.074	-	0.076
-	-	-	(0.092)	-	(0.093)
CIVIL	-	-	-	-0.014	-0.018*
-	-	-	-	(0.010)	(0.010)
soc	-	-	-	-0.004	-0.009
-	-	-	-	(0.042)	(0.044)
mix	-	-	-	-0.029	-0.019
-	-	-	-	(0.020)	(0.021)

Legend: *** indicates significant at the 1% level

** indicates significant at the 5% level

* indicates significant at the 10% level

Table 3

(standard errors in parentheses)

Variable	I	II	III	IV
Number of countries	49	49	55	49
Adjusted R^2	0.31	0.32	0.25	0.31
constant	1.898***	1.818***	1.790***	1.732***
	(0.271)	(0.279)	(0.247)	(0.270)
Gini	-0.037***	-0.035***	-0.040***	-0.032***
	(0.012)	(0.117)	(0.011)	(0.011)
Gini ²	0.0004***	0.0004***	0.0004***	0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
rgdp60	0.007	0.006	-	0.005
	(0.01)	(0.01)	-	(0.01)
Lit	-0.124*	-0.157**	0.016	-0.131*
	(0.070)	(0.076)	(0.040)	(0.073)
Tex	-0.009	-0.057	-	-
	(0.113)	(0.120)	-	-
CIVIL	-0.023*	-0.021*	-	-0.023*
	(0.012)	(0.012)	-	(0.012)
CBI	-0.076	-0.079	-0.018	-0.081
	(0.096)	(0.096)	(0.089)	(0.092)
Old	-	0.765	-	0.457
	-	(0.653)	-	(0.640)
Drate	-	-	-	-0.8×10^{-5}
	-	-	-	(0.5×10^{-5})
G/y	-	-	0.023	0.013
	-	-	(0.107)	(0.113)

Legend: *** indicates significant at the 1% level

** indicates significant at the 5% level

* indicates significant at the 10% level

Table 4 (List of Countries Used)

Argentina	Algeria	Iran	Nicaragua	Togo
Australia	Ecuador	Israel	Netherlands	Thailand
Austria	Egypt, Arab Rep.	Italy	Norway	Trinidad and Tobago
Belgium	Spain	Jamaica	Nepal	Tunisia
Bangladesh	Ethiopia	Jordan	New Zealand	Turkey
Bolivia	Finland	Japan	Pakistan	Tanzania
Brazil	Fiji	Kenya	Panama	Uganda
Barbados	France	Korea, Republic of	Peru	Uruguay
Botswana	Gabon	Liberia	Philippines	United States
Central African Republic	United Kingdom	Sri Lanka	Portugal	Venezuela
Canada	Ghana	Lesotho	Paraguay	South Africa
Switzerland	Gambia, The	Luxembourg	Rwanda	Zimbabwe
Chile	Guinea-Bissau	Morocco	Sudan	
Cote d'ivoire	Greece	Madagascar	Senegal	
Cameroon	Guatemala	Mexico	Singapore	
Colombia	Guyana	Mauritania	Sierra Leone	
Costa Rica	Hong Kong	Mauritius	El Salvador	
Cyprus	Honduras	Malawi	Suriname	
Germany	Indonesia	Malaysia	Sweden	
Denmark	India	Niger	Swaziland	
Dominican Republic	Ireland	Nigeria	Chad	

Appendix

A Cost of inequality

In an utility sense, how does the welfare of an agent with income y compare under a) the median voter's policy choice of ϕ , and b) a regime where her own most-preferred ϕ had been chosen by society?

Consider agents with income $y < \hat{y}$. In a utility sense, under the median voter's elected ϕ , such an agent's utility is

$$W(\phi_m; y < \hat{y}) = \ln \frac{1}{2} (y - \phi_m g) + \ln \left\{ \frac{(y - \phi_m g)}{2} \left[1 - \frac{2(1 - \phi_m)g}{\bar{y} - \phi_m g} \right] \right\}$$

where ϕ_m is computed using (22). Such an agent's welfare using her most preferred ϕ (which is 0) is

$$W(\phi_y^*; y < \hat{y}) = \ln \left(\frac{y}{2} \right) + \ln \left\{ \frac{y}{2} \left[1 - \frac{2g}{\bar{y}} \right] \right\}$$

Then, the “cost of inequality” to a person with income $y < \hat{y}$, denoted $C(y : y < \hat{y})$ may be measured by

$$C(y : y < \hat{y}) = \frac{W(\phi_y^*; y < \hat{y})}{W(\phi_m)} - 1 = \frac{\ln \left(\frac{y}{2} \right) + \ln \left\{ \frac{y}{2} \left[1 - \frac{2g}{\bar{y}} \right] \right\}}{\ln \frac{1}{2} (y - \phi_m g) + \ln \left\{ \frac{(y - \phi_m g)}{2} \left[1 - \frac{2(1 - \phi_m)g}{\bar{y} - \phi_m g} \right] \right\}} - 1 \quad (38)$$

What is the “cost of inequality” to a person with income $\hat{y} < y < \bar{y}$?

$$C(y : \hat{y} < y < \bar{y}) = \frac{W(\phi_y^*; \hat{y} < y < \bar{y})}{W(\phi_m)} - 1 = \frac{\ln \frac{1}{2} (y - \phi^*(y)g) + \ln \left\{ \frac{(y - \phi^*(y)g)}{2} \left[1 - \frac{2(1 - \phi^*(y)g)}{\bar{y} - \phi^*(y)g} \right] \right\}}{\ln \frac{1}{2} (y - \phi_m g) + \ln \left\{ \frac{(y - \phi_m g)}{2} \left[1 - \frac{2(1 - \phi_m)g}{\bar{y} - \phi_m g} \right] \right\}} - 1 \quad (39)$$

where $\phi^*(y)$ is computed using (15). For agents with income $y > \bar{y}$, their most preferred value of ϕ is 1. Hence, for them, the cost of inequality is:

$$C(y : y \geq \bar{y}) = \frac{W(\phi_y^*; y \geq \bar{y})}{W(\phi_m)} - 1 = \frac{\ln \frac{1}{2} (y - g) + \ln \frac{1}{2} (y - g)}{\ln \frac{1}{2} (y - \phi_m g) + \ln \left\{ \frac{(y - \phi_m g)}{2} \left[1 - \frac{2(1 - \phi_m)g}{\bar{y} - \phi_m g} \right] \right\}} - 1 \quad (40)$$

Obviously, the cost of inequality to a voter depends on the position of the median voter. Below, we demonstrate using numerical examples how this utility cost of inequality changes with income and with changes in income inequality.

B Proof of Lemma 1

To save on notation, we will henceforth denote

$$\Theta \equiv \sqrt{[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y\bar{y} + gy]}$$

Straightforward differentiation reveals that

$$\frac{\partial \phi^*}{\partial y} = -\frac{1}{2g^2} \left[\frac{1}{2} \Theta^{-\frac{1}{2}} \right] 4g^2 \underbrace{(g - \bar{y})}_{<0}$$

$$\frac{\partial \phi^*}{\partial \bar{y}} = \frac{1}{-2g^2} (-g\bar{y}) + \left[\frac{1}{2} \Theta^{-\frac{1}{2}} \right] [2g^2(g + \bar{y}) + 8g^2\bar{y} - 8g^2 - 4g^2y]$$

C Proof of Proposition 1

To show that $\phi^* \leq 1$ for all $y \leq \bar{y}$, we note that $\phi^* \leq 1$ requires

$$-g(g + \bar{y}) + \sqrt{[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y\bar{y} + gy]} \leq -2g^2$$

or,

$$\sqrt{[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y\bar{y} + gy]} \leq g(\bar{y} - g)$$

\Rightarrow

$$[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y\bar{y} + gy] \geq [g(\bar{y} - g)]^2$$

The r.h.s is $g^4 - 2\bar{y}g^3 + g^2\bar{y}^2$. The l.h.s is $g^4 + 2\bar{y}g^3 + g^2\bar{y}^2 + 4g^2\bar{y}^2 - 8g^3\bar{y} - 4g^2y\bar{y} + 4g^3y$. Simplifying, one gets

$$y(\bar{y} - g) \leq \bar{y}(g + \bar{y} - 2g)$$

which simplifies to $y \leq \bar{y}$.

To show that $\forall y \leq \hat{y}$, $\phi^* = 0$, we note that $\phi^* = 0$ requires that

$$\sqrt{[g(g + \bar{y})]^2 + 4g^2 [\bar{y}^2 - 2g\bar{y} - y\bar{y} + gy]} = g(g + \bar{y})$$

\Rightarrow

$$4g^2 [g(y - 2\bar{y}) + \bar{y}(\bar{y} - y)] = 0;$$

so, necessity requires that

$$[g(y - 2\bar{y}) + \bar{y}(\bar{y} - y)] = 0,$$

which after simplification leads to

$$\hat{y} = \frac{\bar{y}(\bar{y} - 2g)}{(\bar{y} - g)} < \bar{y}$$

Combining all this information, we get

$$\phi^* = \begin{cases} 0 & y \leq \hat{y} \\ (0, 1) & y \in (\hat{y}, \bar{y}) \\ 1 & y \in [\bar{y}, \infty) \end{cases}$$

D Proof of Proposition 2

a) Simple algebra yields that

$$\frac{\partial \phi^*(y_m)}{\partial \sigma} = \left[\frac{g\sigma\bar{y}}{-2g^2} \right] \left[\frac{[(g + \bar{y}) + 4\bar{y} - 4g - 2y_m]}{((g + \bar{y})^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m])^{\frac{1}{2}}} - 1 \right] \quad (41)$$

The first term is clearly negative, so what remains to be determined is the sign of the second term. For the whole thing to be negative, we'd need the numerator to be bigger. This term is positive if and only if

$$[g + \bar{y}] + 2[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m]^{\frac{1}{2}} < (g + \bar{y}) + 4\bar{y} - 4g - 2y_m \quad (42)$$

Rearranging (42) yields the inequality

$$0 < 3(\bar{y} - g)(\bar{y} - y_m) + 4g^2 + y_m^2.$$

Since $\bar{y} > g$ by assumption and the median of the log-normal distribution is less than the mean of the log-normal distribution, the inequality is clearly satisfied. This, in turn implies that the inequality in (42) is satisfied, and thus that the second term on the right hand side of (41) is positive. This proves that $\frac{\partial \phi^*(y_m)}{\partial \sigma} < 0$.

b) From (41) the second derivative of ϕ^* with respect to σ^2 is easily seen to be

$$\begin{aligned} \frac{\partial^2 \phi^*(y_m)}{\partial \sigma^2} &= \frac{\bar{y} + \sigma^2 \bar{y}}{2g} \left[1 - \frac{[(g + \bar{y}) + 4\bar{y} - 4g - 2y_m]}{((g + \bar{y})^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m])^{\frac{1}{2}}} \right] \\ &\quad - \frac{\sigma \bar{y}}{2g} \left[\frac{(\sigma \bar{y} + 4\sigma \bar{y}) + \frac{1}{2} \left([g + \bar{y}]^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m] \right)^{\frac{1}{2}}}{\left([g + \bar{y}]^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m] \right)^{\frac{1}{2}}} \right. \\ &\quad \left. \frac{[2[g + \bar{y}]\sigma \bar{y} - 2g\sigma \bar{y} - y_m\sigma \bar{y}][(g + \bar{y}) + 4\bar{y} - 4g - 2y_m]}{\left([g + \bar{y}]^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m] \right)^{\frac{1}{2}}} \right] \end{aligned} \quad (43)$$

The first term is negative, since $\frac{\bar{y} + \sigma^2 \bar{y}}{2g}$ is positive and the second term was shown to be negative in the proof of Part (a) above. What remains then is to determine the sign of the second term. This term can be rewritten as

$$\sigma \bar{y} \left[\frac{5 + \frac{1}{2} \left([g + \bar{y}]^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m] \right)^{\frac{1}{2}} [2\bar{y} - y_m] [3(\bar{y} - g) + 2(\bar{y} - y_m)]}{\left([g + \bar{y}]^2 + 4[\bar{y}^2 - 2g\bar{y} - y_m\bar{y} + gy_m] \right)^{\frac{1}{2}}} \right].$$

The denominator is clearly positive. The numerator is positive as well, since the median in the log-normal distribution is less than the mean and the individual lumpsum tax, g , is restricted to be less than the mean income, \bar{y} . The entire expression is therefore positive. This provides us with the desired result that $\frac{\partial^2 \phi^*(y_m)}{\partial \sigma^2}$, since the right hand side of (43) consists of a negative term with a positive term subtracted off.

References

- [1] Albanesi, S. "Inflation and inequality", Universita' Bocconi, IGER working paper #199 (2000)
- [2] Alesina, Alberto and Lawrence H. Summers, "Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence," *Journal of Money, Credit, and Banking* 25 (May), 151-63 (1993)
- [3] Azariadis, C, and V. Galasso "Discretion, rules, and volatility", Federal Reserve Bank of St. Louis *Review*, May/June (1996)
- [4] Bearnse, P., G. Glomm, and E. Janeba "Why poor countries rely mostly on redistribution in-kind", *Journal of Public Economics*, 75: 463-481, (2000)
- [5] Beetsma, R. M. and van der Ploeg, F. "Does Inequality Cause Inflation?: The Political Economy of Inflation, Taxation and Government Debt", *Public Choice*, v87, n1-2 : 143-62, (1996)
- [6] Benabou, R "Unequal Societies: Income Distribution and the Social Contract", *American Economic Review*; 90(1), 96-129 (2000)
- [7] Bullard, J, and C.J. Waller "Central bank design in general equilibrium", mimeo Federal Reserve Bank of St. Louis (2001)
- [8] Cardoso, E "Inflation and poverty", *National Bureau of Economic Research* working paper W4006 (1992)
- [9] Click, Reid W "Seignorage in a Cross-Section of Countries", *Journal of Money, Credit, and Banking*, 30 (2), 154-170 (1998)
- [10] Deininger, K and L. Squire. "A New Data Set Measuring Income Inequality", *World Bank Economic Review* 10 (3): 565-591. (1996)
- [11] Dolmas, J, G. W. Huffman, and M.A. Wynne "Inequality, inflation, and central bank independence", *Canadian Journal of Economics*, 33 (1) (2000)

- [12] Easterly, W., and S. Fischer “Inflation and the poor”, *Journal of Money, Credit, and Banking*, Volume 33, Number 2, Part 1, 160-178 (2001)
- [13] Erosa, A., and G. J. Ventura “On inflation as a regressive consumption tax” mimeo, University of Western Ontario, 1999
- [14] Gomis-Porqueras P “When should bank regulation favor the wealthy?”, *Journal of Economic Theory*, 99, 327-337 (2001)
- [15] Glomm, G., and R. Ravikumar “Public versus Private Investment in Human Capital Endogenous Growth and Income Inequality”, *Journal of Political Economy*; 100(4), 813-34, (1992)
- [16] Hannan, Timothy H. “Retail Fees of Depository Institutions, 1994-99”, *Federal Reserve Bulletin*, June 2001
- [17] Kennickell Arthur B., Martha Starr-McCluer, and Brian Surette “Recent Changes in U.S. Family Finances: Results from the 1998 Survey of Consumer Finances”, *Federal Reserve Bulletin*, January (2000)
- [18] Keister, L *Wealth in America*, Cambridge University Press (2000)
- [19] Keynes, J.M. *How to Pay for the War*, Macmillan, London (1940)
- [20] Loewy, M. B “Equilibrium Policy in an Overlapping Generations Economy”, *Journal of Monetary Economics*, 22(3), 485-99 (1988)
- [21] Meltzer A. and S. Richard “A Rational Theory of the Size of Government”, *Journal of Political Economy* 89: 914-927 (1981)
- [22] Mulligan, C.B., and X. Sala-i-Martin “Extensive margins and the demand for money at low interest rates”, *Journal of Political Economy*, 108 (5), 961-991 (2000)
- [23] Ray, D. *Development Economics*, Princeton University Press (1998)
- [24] van der Ploeg, F “Political Economy of Monetary and Budgetary Policy”, *International Economic Review*, v36, n2 (May), 427-39 (1995)

[25] Wolff, E. N. “Where has all the money gone?” *Milken Institute Review*, Third Qtr (2001)

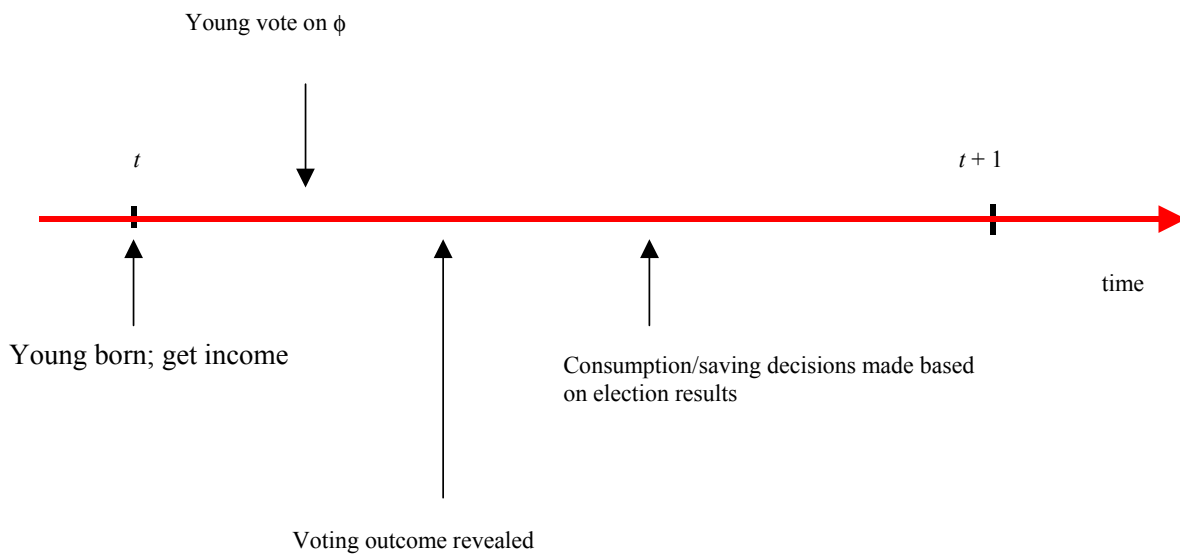


Figure 1: The timeline of events

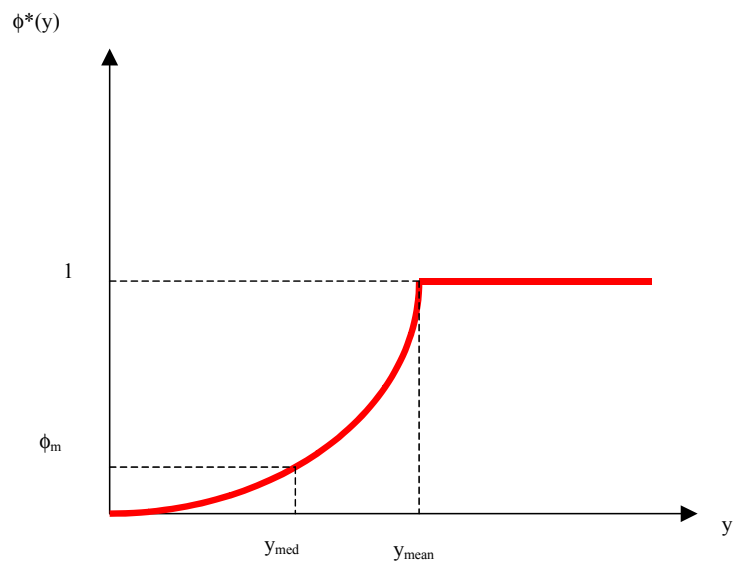


Figure 2: Most-preferred ϕ against income in the baseline model

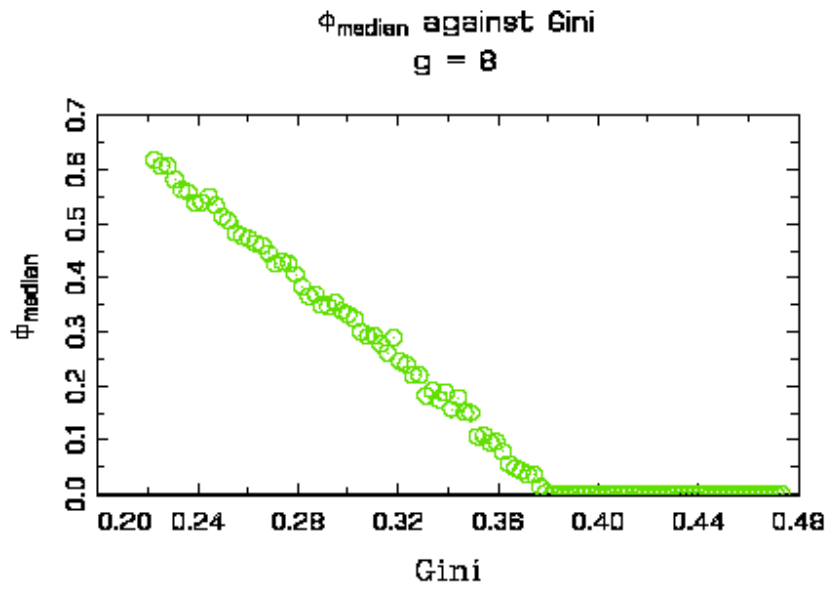


Figure 3: Median voter's choice of ϕ against Gini

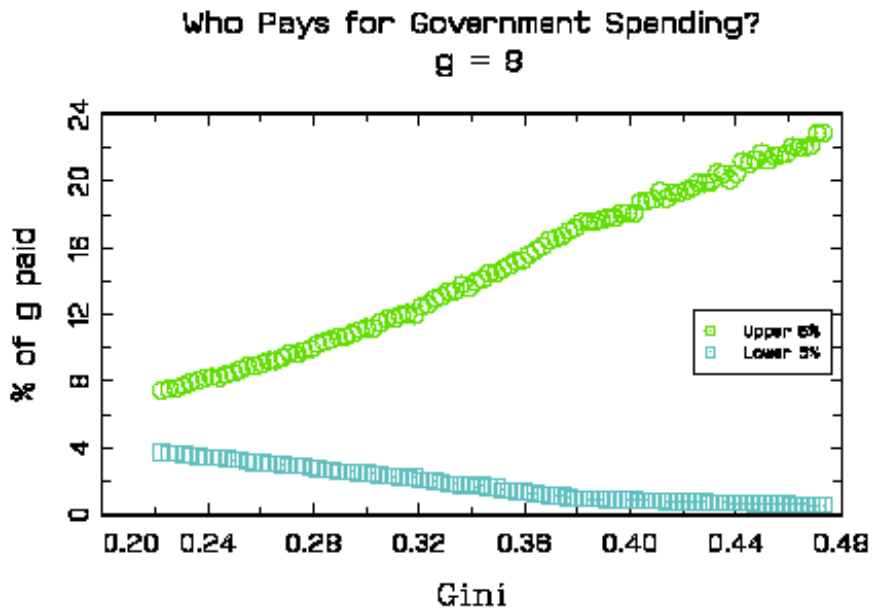


Figure 4: Extent of Redistribution in the Baseline Model (5%)

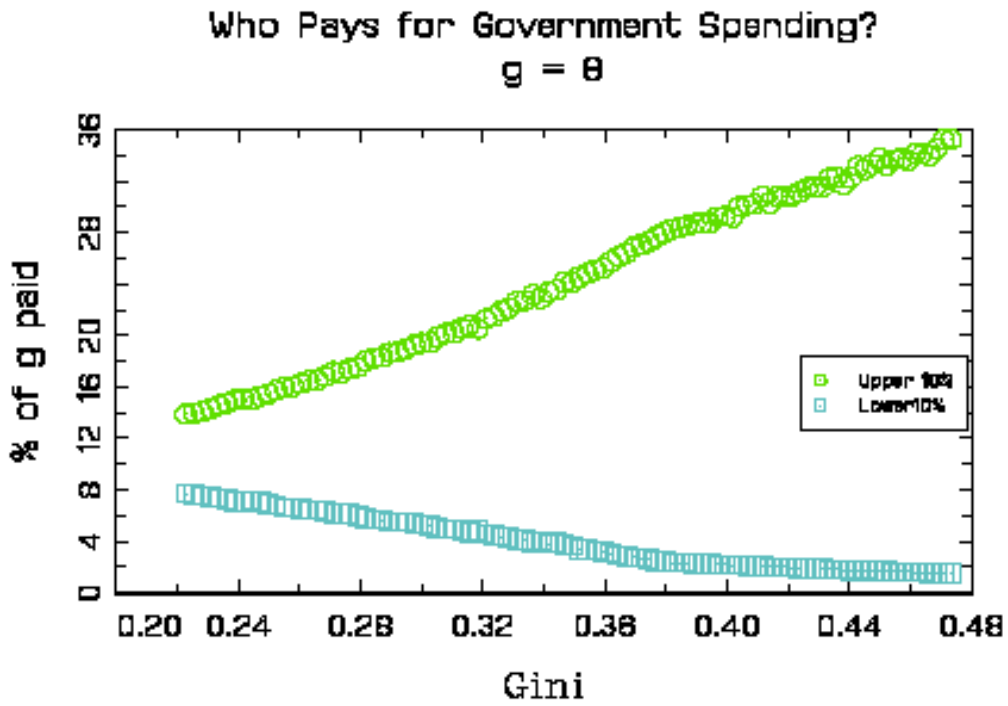


Figure 5: Extent of Redistribution in the Baseline Model (10%)

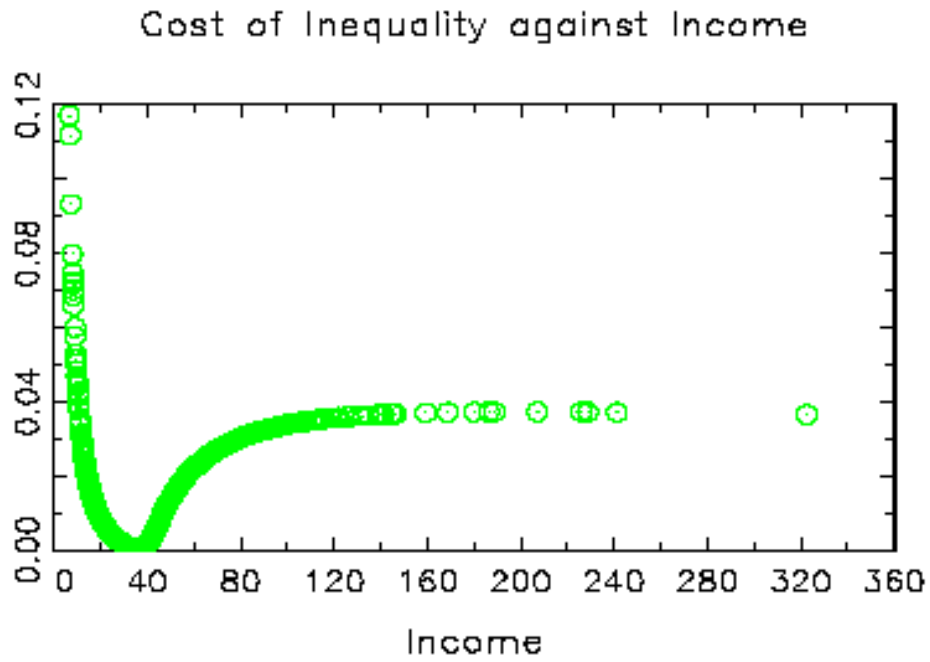


Figure 6: “Cost of Inequality” against Incomes

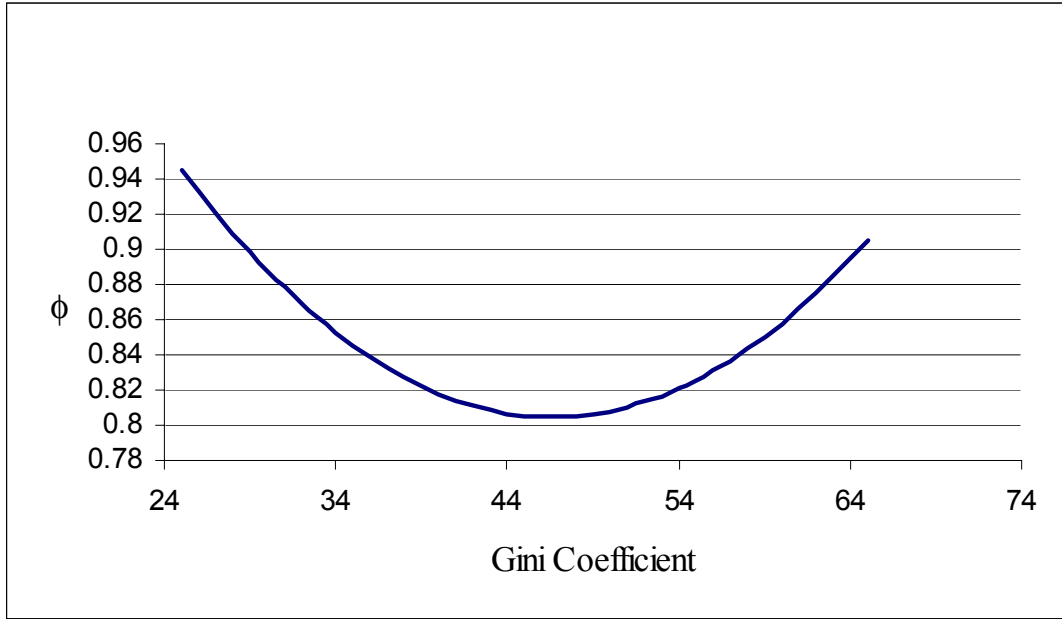


Figure 7: The estimated ϕ – Gini relationship

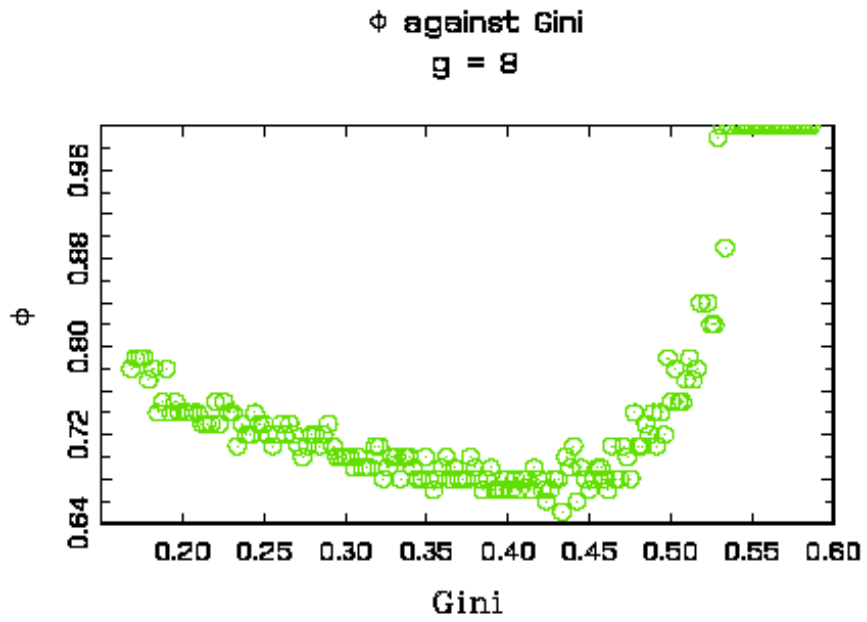


Figure 8: Elected reliance on direct taxes against Gini

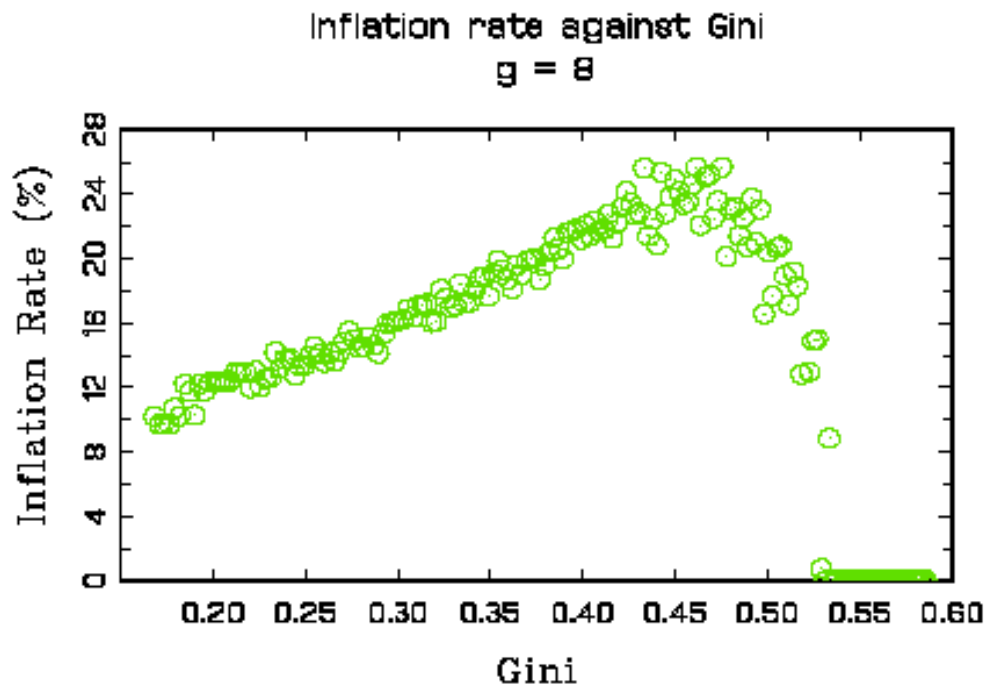


Figure 9: Elected inflation rate against Gini

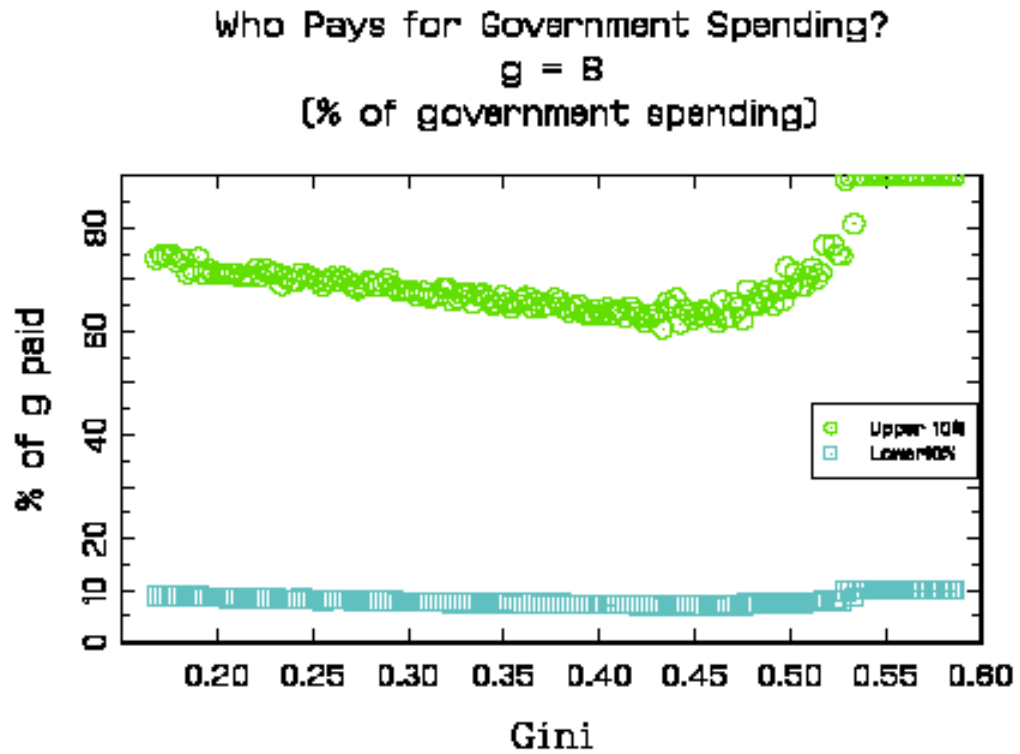


Figure 10: Extent of Redistribution (10%)

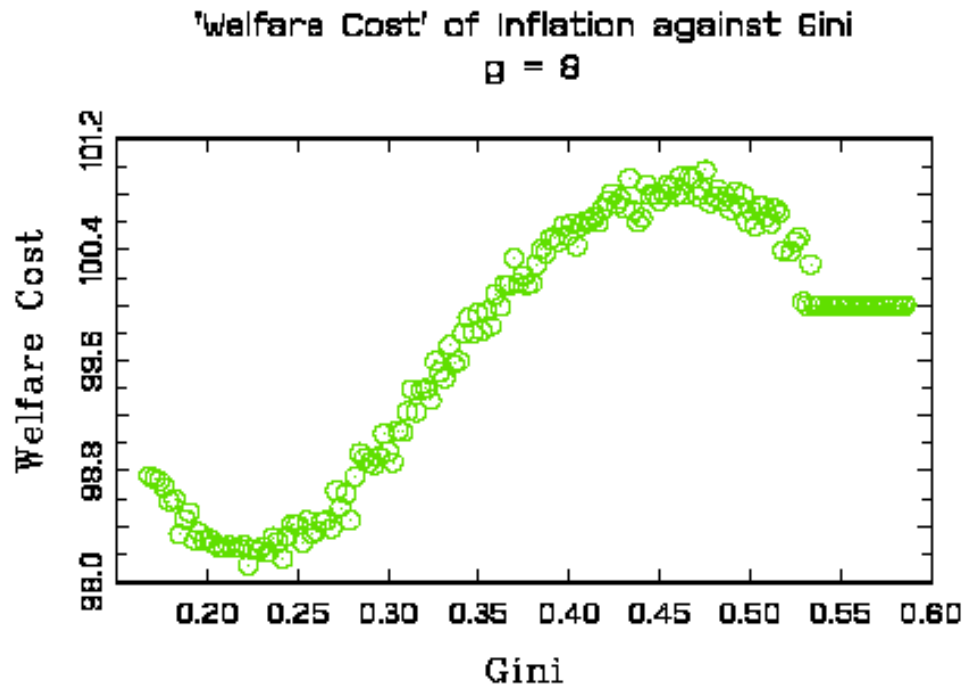


Figure 11: “Welfare Cost of Inflation” against Gini

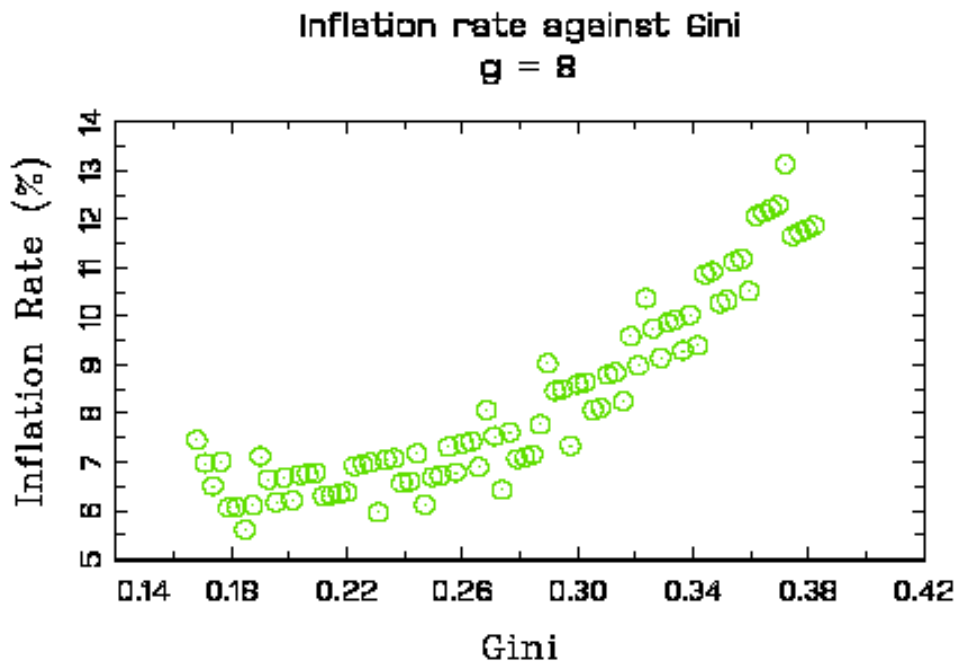


Figure 12: Non-existence of majority-voting equilibria for high levels of income inequality