Inflation and Inequality

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Abstract

Cross-country evidence on inflation and income inequality suggests that they are positively correlated. I explore the hypothesis that this correlation is the outcome of a distributional conflict underlying the determination of fiscal policy.

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1. Introduction

Observations from a large sample of countries reveal a positive correlation between average inflation and measures of income inequality in the post-war period. I explore the hypothesis that this correlation is the outcome of a distributional conflict underlying the determination of fiscal policy. I describe a political economy model in which equilibrium inflation is positively related to the degree of inequality in income due to the relative vulnerability to inflation of low income households.

I consider a monetary economy in which income inequality is an increasing function of exogenous differences in human capital and the nature of the transaction technology gives rise to the result that low income households are more vulnerable to inflation. In addition, I model the political process as a bargaining game over the determination of fiscal policy, following Bassetto (1999). I assume that fiscal policy is given by a linear income tax and that the level of public spending is exogenous. Furthermore, taxes cannot be raised and the government must resort to inflation if an agreement is not reached. Since high inflation is costly for all types of households, there is an incentive to reach an agreement. Low income households stand to lose more than high income households if an agreement is not reached, given their relative vulnerability to inflation. Consequently, their bargaining position is weaker. Higher inequality, arising from greater differences in income across households, leads to a greater relative vulnerability to inflation of low income households and a further weakening in their bargaining position. I show that these features of the environment imply that equilibrium inflation is positive and increasing in the degree of inequality in human capital. For a plausibly parametrized version of the economy, I find that the correlation between inflation and inequality predicted by the model is quantitatively significant and can account for a significant fraction of the one in the data.

Two elements are key in this framework: the relative vulnerability to inflation of low income households and the fact that the distributional conflict underlying the determination of fiscal policy is described as a bargaining game. I now provide a brief description of the economy and discuss the role of these features.

The economy builds on Lucas and Stokey's (1983) cash-credit good model. There are two types of households who differ in their exogenous endowment of human capital. I assume that larger human capital results in higher labor productivity[1]. Households supply labor and purchase consumption goods. They perform transactions either with previously accumulated currency or by using a costly payment technology, produced by a transaction services sector. Households trade-off the cost of transaction services against the foregone interest income associated with holding currency. Following Erosa and Ventura (2000), I assume that there are economies of scale in the costs of the alternative payment technology. This implies that low income households face a higher average cost of transaction services than those with high income. Accordingly, they hold more currency and are more vulnerable to inflation.

[1] Inequality in human capital is interpreted as resulting from socio-economic and istitutional characteristics, such as access to public primary education. I presume that these characteristics change at a lower frequency than fiscal and monetary policy, see Sokoloff and Engerman (2000), and I take them as given.

The assumption of economies of scale in the cost of acquiring transaction services implies that the model is consistent with cross-sectional evidence on household transaction patterns and with indirect evidence on the distributional consequences of inflation. Descriptive evidence from the Federal Reserve Bulletin in Sprenkle (1993) supports the notion of substantial economies of scale in cash management. Erosa and Ventura (2000) report that in the US low income households use cash for a greater fraction of their total purchases relative to high income households. Mulligan and Sala-i-Martin (2000) estimate the probability of adopting financial technologies that hedge against inflation and find that is positively related to the level of household wealth and inversely related to the level of education. Attanasio, Guiso and Jappelli (2001) find that the probability of using an interest bearing bank account increases with educational attainment, income and average consumption, based on cross-sectional household data for Italy. Easterly and Fischer (2000) use household polling data for 38 countries and find that the poor are more likely than the rich to mention inflation as a top national concern. This suggests that low income household perceive inflation as being more costly. They also find that the likelihood of citing inflation as a concern is inversely related to educational attainment.

I model the political process as a sequential bargaining game. There are two main reasons to adopt a bargaining model. First, a bargaining scheme is applicable to any situation in which government decisions emerge from the consensus between different constituencies. In addition, it is capable of capturing an important feature of most political systems, that minorities are able to exert significant pressure on the policy outcome. In the bargaining equilibrium I study, the political power of different groups of households is a function of their economic attributes. Specifically, the relative vulnerability to inflation of low income households implies that high income households have a greater weight in the political process. Extending the arguments in Coughlin and Nitzan (1981) and Persson and Tabellini (2000), one can show that models of electoral competition based on probabilistic voting and costly lobbying also display this feature and would yield similar predictions.

Alternative strategies have been used to formalize a distributional conflict ultimately resulting in high inflation. Alesina and Drazen (1991) study a war of a attrition between political groups over the timing of a fiscal reform. In the interim, public expenditures are financed with seignorage. The distribution of the burden of the reform is exogenous and asymmetric information on the costs of inflation for each group delays the reform. A bargaining framework has the advantage that the allocation of the fiscal burden is determined endogenously as a function of the distribution of economic characteristics in the population. Moreover, positive inflation occurs in equilibrium even with perfect information on the costs of inflation. Mondino, Sturzenegger and Tommasi (1996) consider a model in which identical pressure groups set government transfers financed with seignorage. A pressure group approach, however, is better suited to describe conflict over policies that target narrow segments of the population. More recently, Dolmas, Huffman and Wynne (2000) and Bhattacharya, Bunzel and Haslag (2001) describe overlapping generations economies with majority voting on taxes and seignorage, in which larger inequality gives rise to higher equilibrium inflation. In Dolmas, Huffman and Wynne's model the correlation is driven by the fact that inflation is a "progressive" tax since high income households hold more currency. In Bhattacharya, Bunzel and Haslag high income households have a larger share of their savings in a real asset, so low income households are more vulnerable to inflation. However, since the alternative to inflationary financing is lump-sum taxation, which is more regressive than the inflation tax, larger inequality leads to higher inflation.

The plan of the paper is as follows. I document the correlation between inequality and inflation in Section 2. In Section 3, I describe the economic environment and illustrate the distributional consequences of inflation. In Section 4, I study the Ramsey equilibrium for this economy. This establishes a benchmark useful for understanding the properties of the environment and interpreting the results. Section 5 describes the bargaining equilibrium in detail and characterizes the sufficient conditions for inflation to be positively correlated with inequality. Section 6 concludes.

2. The Correlation between Inflation and Inequality

Figure 1 is a scatter plot of the average "inflation tax", defined as $\pi/(1+\pi)$ where π is the inflation rate, and the Gini coefficient[2] for pre-tax income, in a sample of 51 industrialized and developing countries, averaged over the time period from 1966 to 1990. Constraints from availability, quality and comparability of the data on inequality, analyzed in Atkinson and Brandolini (2001), restrict sample size. A more detailed description of the data and the list of included countries is provided in the Data Appendix. Figure 1 shows a strong positive correlation between inequality and inflation. Figure 2 is a scatter plot of inflation on an alternative measure of inequality, $y40/y60$, given by the ratio of the average income per capita in the top 40% of the population to average income per capita in the bottom 60% of the population, computed based on the share of total income accruing to each quintile[3]. The same positive relation emerges. Figures 3 and 4 plot the inflation tax against the Gini coefficient for OECD[4] and developing countries, respectively. Again a positive correlation between inflation and inequality is present in both sub-samples.

I report some descriptive statistics on inflation and inequality for the sample in Table 1.A. The simple correlation between inflation and the Gini coefficient is 0.21 for the full sample, while the correlation between inflation and $y40/y60$ is 0.34[5]. A group of four countries, Morocco, Tunisia, Malaysia and Honduras, stand out for having low inflation but very high inequality. Excluding these countries from the sample increases the correlation between inflation and the Gini coefficient to 0.39.

[2] The Gini coefficient is a summary statistic for inequality in income derived from the Lorenz curve.

[3] I choose this measure instead of the more common index of social distance, defined as the ratio of the percentage of total income accruing to the top 20% of the population to the percentage of total income accruing to the bottom 20% of the population, because I am interested in focussing on inequality between broader income categories. The measure I adopt and the social distance index are positively related, however, implying that inflation is also positively correlated to the index of social distance.

[4] The sample of OECD countries comprises countries members of the OECD as of 1973. This excludes Mexico and the Republic of Korea which are included in the group of developing countries.

[5] The simple correlation between the Gini coefficient and $y40/y60$ is equal to 0.62.

I also compute OLS estimates of the relation between the inflation tax and inequality. Findings are reported in Table 1.B. The estimated slope coefficient is 0.4561 (the t-statistic[6] is 5.07 and the R-squared 0.425) for the full sample. This corresponds to a 2% rise in the inflation tax rate associated with a one standard deviation (7 points) increase in the Gini coefficient. The corresponding increase in the inflation rate is given by $2 * (1 + \pi)^2$. The inflation tax transformation reduces the extent to which extreme rates of inflation dominate the estimates and captures the non-linearity of the relation between inflation and inequality. The non-linearity of the relation between inflation and inequality can also be captured by splitting the sample between high and low inflation countries and using the rate of inflation as a dependent variable. An increase in inequality corresponding to a 7 point rise in the Gini coefficient corresponds to an increase in the average inflation rate of 45.8 percentage points for the full sample and of 7.84 percentage points for OECD countries[7].

I also evaluate the conditional correlation between inflation and inequality. I first condition on GDP per capita, which is an important indicator of the ability to collect revenues from direct taxation and presumably is negatively correlated with inflation. I find that the correlation between inflation and inequality after conditioning on GDP per capita is still strong and positive, as shown in figure 5 which plots the residuals from a regression of inflation on GDP per capita against residuals from regressing the Gini coefficient on GDP per capita. Institutional variables have been found to be important determinants of inflation. Edwards and Tabellini (1993) find a positive correlation between political instability and inflation and Cukierman (1992), among others, documents a negative correlation between inflation and central bank independence. In figures 6-8 I display the scatter plot if the residuals from regressing inflation and the Gini coefficient on political instability and central bank independence. The correlation between inequality and inflation is robust to conditioning on these institutional variables. For developing countries it increases substantially, together with the significance of the estimated coefficient on inequality.

These findings are consistent with previous studies of the relation between inequality and inflation. Beetsma (1992) presents evidence of a strong positive correlation between inequality and inflation for democratic countries. He finds that conditioning on measures of political instability and of the degree of political polarization, as well as on the level of government debt outstanding, increases the ability of differences in inequality to explain variations in inflation rates across countries. Al-Marhubi (1997) also conditions on openness.

Romer and Romer (1998) find a strong positive relation between inflation and inequality, with quantitatively similar results obtained by regressing inequality on inflation. They also find that there is no significant relation between inflation and inequality in the short run over time for the US. Easterly and Fischer (2000) find that direct measures of improvement in the well-being of the poor and inflation are negatively correlated in pooled cross-country regressions. They also find that there

[6] Standard errors are White-heteroskedasticity consistent.

[7] The slope of the regression of percentage inflation on the Gini coefficient is 6.55 (t-statistic 2.80) for the full sample. Results are similar with the alternative measure of income distribution. For OECD countries, the slope coefficient is 1.1285 (t-statistic 4.1438).

is no significant relation between the change in inflation and measures of improvements in the well-being of low income households. They also present a novel set of empirical evidence on the redistributional impact of inflation. Using household level polling data for 38 countries, they find that the poor are more likely than the rich to mention inflation as a top national concern. The estimated probability of mentioning inflation as a top national concern by income categories is 0.36 for the "very poor", 0.31 for the "poor" and 0.28 for households "just getting by"[8]. It is substantially lower for high income categories, with an estimated probability of 0.15 for "comfortable" households and 0.03 for the "very comfortable". This suggests that low income households perceive inflation as being more costly.

3. An Economy with Costly Transactions and Income Inequality

The economy is populated by households, firms producing consumption goods, financial firms and a government. Households consume a variety of differentiated goods and supply an endogenous quantity of labor to firms. They are identical but for their endowment of human capital. Larger human capital translates into higher labor productivity. Households can purchase consumption goods with previously accumulated currency or with a costly payment technology, as in the models of Prescott (1987), Cole and Stockman (1991), Dotsey and Ireland (1996), Lacker and Schreft (1996) and Freeman and Kydland (2000). Financial firms provide the services required to use the alternative payment technology. I will refer to these as "transaction services". The cost of providing transaction services may depend on the type of good and on the size of the purchase. Households trade-off the cost of transaction services against the foregone interest income associated with holding currency. At low levels of expected inflation households use cash for a relative large number of transactions, while at high levels of expected inflation little cash is used. As in Erosa and Ventura (2000), I assume that the average cost of transaction services is non-increasing in the level of total purchases. This implies that in equilibrium low human capital households will make a greater fraction of their purchases with cash. This property is consistent with the patters of transactions across households for the US reported in Avery et al. (1987) and Kennickell et al. (1987).

The government in this economy finances an exogenous stream of spending by printing money, issuing nominal debt and taxing labor income at a uniform proportional rate. In each period fiscal and monetary policy are determined first. Households then purchase transactions services and the goods and labor markets open. Finally, the assets market takes place. In the asset market, households receive labor income and pay for purchases made with transaction services, they purchase or issue nominal risk-free bonds and accumulate currency. There is no uncertainty.

I now describe the problems faced by the agents in this economy in more detail.

[8] Income categories are self-declared.

3.1. Production Sector

A perfectly competitive production sector hires labor to produce a continuum of consumption goods $\{c(j)\}$ with $j \in [0,1]$ subject to a linear technology:

$$\int_0^1 c(j)\,dj \leq n,$$

where n is labor supplied to the production sector in efficiency units. By symmetry and perfect competition:

$$P(j) = P = W,\ \ j \in [0,1],$$

where $P(j)$ is the retail price of good j and W is the nominal wage rate per efficiency unit of labor.

A perfectly competitive financial sector hires labor to produce transaction services. The cost of producing transaction services in efficiency units of labor for good j is:

$$\theta(j) = \theta_0 \left(\frac{j - \underline{z}}{\bar{z} - j}\right)^{\theta_1}, \tag{3.1}$$

where $\theta_0, \theta_1 > 0$. Goods $j \in [0, \underline{z}]$ with $\underline{z} \in [0,1)$ can be purchased with the alternative payment technology free of charge, while goods $j \in [\bar{z}, 1]$ with $\bar{z} \in (0,1)$ cannot be purchased with the alternative payment technology. Perfect competition ensures:

$$q(j) = W\theta(j),$$

where $q(j)$ is the price charged for providing transaction services for the purchase of good j.

3.2. Households

There are two types of households of measure $0 < \nu_i < 1$, $i = 1, 2$, with $\nu_1 + \nu_2 = 1$. All households have identical preferences. Type i households have labor productivity, ξ_i, for $i = 1, 2$, with $\xi_2 > \xi_1$.

Preferences are defined over consumption goods and labor:

$$\sum_{t=0}^{\infty} \beta^t u^i(c_i, n_i),$$

$$u^i(c_i, n_i) = \frac{c_i^{1-\sigma} - 1}{1 - \sigma} - \gamma n_i, \tag{3.2}$$

$$c_i = \left[\int_{j=0}^1 c_i(j)^{\rho}\,dj\right]^{1/\rho}, \tag{3.3}$$

$$\rho \in (0,1),\ \gamma > 0,$$

for $i = 1, 2$, where $c_{it}(j)$ denotes consumption of good j by type i and n_{it} labor supplied by type i at time t.

Households enter the period with M_{it} units of currency and B_{it} units of outstanding bonds. They can purchase goods with currency or with the alternative payment technology. They pay a dollar amount equal to $q_t(j)$ for each good j they elect to buy with the alternative payment technology. The assumption on the technology for the provision of transaction services and perfect competition in the financial sector ensure that $q_t(j)$ is increasing in j. This implies that households optimally adopt a cut-off rule, choosing to purchase goods $j \leq z_{it}$ with transaction services and goods $j > z_{it}$ with currency. Concavity implies that consumption levels will be the same for goods purchased with the same transaction technology. Consequently, the expression for the consumption aggregator in equilibrium is:

$$c_{it} = \left[(1 - z_{it})\, c_{i1t}^{\rho} + z_{it} c_{i2t}^{\rho}\right]^{1/\rho}, \tag{3.4}$$

where c_{i1t} denotes the level of consumption of goods purchased with cash and c_{i2t} the level of consumption of goods purchased with transaction services, for $i = 1, 2$[9].

Households face the constraint:

$$P_t c_{i1t} (1 - z_{it}) \leq M_{it}, \tag{3.5}$$

on the goods market. During the asset market session, households receive labor income net of taxes, clear consumption liabilities and trade one-period risk-free discount bonds issued by other households or by the government. The bonds entitle their holders to one unit of currency delivered in the following period's asset trading section. I assume that neither households or the government default on their debt. This implies that households are indifferent between holding privately and government issued bonds which both trade at the price Q_t. Total holdings of debt by agent i at the end of time t are denoted with B_{it+1} for $i = 1, 2$. Households face the following constraint on the asset market:

$$M_{it+1} + Q_t B_{it+1} \leq M_{it} + B_{it} - P_t (1 - z_{it})\, c_{i1t} - P_t z_{it} c_{i2t} - \int_0^{z_{it}} q_t(j)\, dj + W_t (1 - \tau_t)\, \xi_i n_{it}, \tag{3.6}$$

for $i = 1, 2$, where n_{it} is total labor supply by type i. The following no-Ponzi game condition is also required for the households' intertemporal optimization problem to be well defined:

$$\left(Q_t^{-1} M_{it+1} + B_{it+1}\right) \Phi_{t+1} + \sum_{s=1}^{\infty} \Phi_{t+s} W_{t+s} (1 - \tau_{t+s})\, \xi_i \geq 0, \tag{3.7}$$

where

$$\Phi_t = \prod_{t'=0}^{t-1} Q_{t'}, \;\; \Phi_0 = 1,$$

is the discount factor.

[9] In this set up, the cost of transaction services varies across consumption goods while the utility weight on each type of consumption good is constant so that all goods with the same price are consumed in equal amounts. An alternative specification in which the optimal level of consumption varies across goods but the cost of credit services is constant for all goods is equivalent under certain conditions and would not alter any of the findings.

3.3. Government

The government finances an exogenous stream of spending $\{\overline{g}_t\}_{t\geq 0}$ by taxing labor income at the rate $\tau_t \in [0,1]$, issuing debt, B_{t+1},and changing the money supply, M_{t+1}. The government is subject to the following dynamic budget constraint:

$$M_{t+1} + Q_t B_{t+1} + W_t n_t \tau_t = P_t \bar{g}_t + M_t + B_t, \tag{3.8}$$

where Q_t is the price of nominal bonds and n_t is aggregate labor supply in efficiency units given by:

$$n_t = \sum_{i=1,2} \nu_i \xi_i n_{it}.$$

3.4. Private Sector Equilibrium

The timing of events in each period is as follows:

1. Households come into the period with holdings of currency and debt given by M_{it} and B_{it}.
2. Households decide to purchase z_{it} goods on credit.
3. Households, firms and the government trade in the goods and labor markets. Household consumption purchases are subject to (3.5). Equilibrium on the goods market requires:

$$\sum_{i=1,2} \nu_i \left((1 - z_{it}) c_{i1t} + z_{it} c_{i2t} + C(z_{it}) - \xi_i n_{it} \right) + \bar{g}_t = 0, \tag{3.9}$$

   where $C(z) = \int_0^z \theta(j)\, dj$.

4. Asset markets open. Households purchase bonds and acquire currency to take into the following period subject to the constraint (3.6). The government is subject to (3.8).

Definition 3.1. *A private sector equilibrium is given by a government policy $\{\bar{g}_t, \tau_t, M_{t+1}, B_{t+1}\}_{t\geq 0}$, a price system $\{P_t, W_t, Q_t, q_t(j)\}_{t\geq 0, j\in[0,1]}$ and an allocation $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, M_{it+1}, B_{it+1}\}_{i=1,2,t\geq 0}$ such that:*

1. *given the policy and the price system households and firms optimize;*
2. *government policy satisfies (3.8);*
3. *markets clear.*

The following proposition displays necessary and sufficient conditions for a private sector equilibrium.

Proposition 3.2. *For $t \geq 0$, a government policy $\{\bar{g}_s, \tau_s, M_{s+1}, B_{s+1}\}_{s\geq t}$, an allocation*

$\{c_{i1s}, c_{i2s}, n_{is}, z_{is}, M_{is+1}, B_{is+1}\}_{i=1,2,s\geq t}$, *with $n_{is} > 0$ for $i = 1,2$,and a price system $\{P_s, W_s, Q_s, q_s(j)\}_{s\geq t, j\in[0,1]}$ constitute a private sector equilibrium,if and only if the conditions (3.8), (3.9) and:*

$$W_s = P_s, \tag{3.10}$$

$$q_s(j) = W_s \theta(j) \ \text{ for } j \in [0,1], \tag{3.11}$$

$$Q_s = \beta \frac{P_s}{P_{s+1}} \frac{(1-\tau_s)}{(1-\tau_{s+1})}, \tag{3.12}$$

$$\sum_{i=1,2} \nu_i B_{is+1} = B_{s+1}, \quad \sum_{i=1,2} \nu_i M_{is+1} = M_{s+1}, \tag{3.13}$$

$$\left(\frac{c_{i1s+1}}{c_{i2s+1}}\right)^{\rho-1} = R_{s+1} \equiv Q_s^{-1} \geq 1, \tag{3.14}$$

$$\frac{\xi_i u_{i2s}}{z_{is}} = \frac{\gamma}{(1-\tau_s)} \ \text{ for } s \geq t, \tag{3.15}$$

$$\begin{aligned} (R_{s+1} - 1)\left(P_{s+1} c_{i1s+1}(1 - z_{is+1}) - M_{is+1}\right) &= 0, \\ P_{s+1} c_{i1s+1}(1 - z_{is+1}) &\leq M_{is+1}, \end{aligned} \tag{3.16}$$

$$\left[\left(\frac{1}{\rho} - 1\right)\left(1 - R_s^{\frac{\rho}{\rho-1}}\right) - \frac{\theta(z_{is})}{c_{i2s}}\right] \begin{cases} \leq 0 \text{ for } z_{is} = \underline{z}, \\ = 0 \text{ for } z_{is} \in (\underline{z}, \bar{z}), \\ \geq 0 \text{ for } z_{is} = \bar{z}. \end{cases} \tag{3.17}$$

hold for $s \geq t$, and:

$$c_{i1t} = \min\left\{c_{i2t}, \frac{M_{it}}{P_t(1 - z_{it})}\right\}, \tag{3.18}$$

$$\sum_{s=t}^{\infty} \beta^{s-t} \left[u_{i1s} c_{i1s} + u_{i2s} c_{i2s} + u_{i2s} \frac{C(z_{is})}{z_{is}} - \gamma n_{is}\right] = \frac{u_{i1t}}{(1-z_{it})} \frac{M_{it}}{P_t} + \frac{u_{i2t}}{z_{it}} \frac{B_{it}}{P_t}, \tag{3.19}$$

hold for given M_{it}, B_{it} with $i = 1,2$.

Equation (3.19) is the households' implementability constraint at time t. It is given by the intertemporal budget constraint in which prices have been substituted using optimality conditions and it incorporates the transversality condition. The proof of this proposition is in Appendix A.

3.5. Distributional Impact of Inflation

Households choose the optimal payment structure by balancing the opportunity cost of holding currency and the cost of acquiring transaction services for the marginal good bought with currency. This trade-off is captured by equation (3.17). The gain from acquiring transaction services for the marginal good bought with currency is given by the increase in the level of consumption of that good due to the decrease in its relative price and the reduction in the foregone interest income associated with holding currency. This gain is increasing in the nominal interest rate and roughly proportional to the level of consumption. The cost of acquiring credit services for the marginal consumption good is decreasing in the level of consumption. Consequently, the per unit gain of adopting transaction services is greater for high human capital households and for a given level of the nominal interest rate they make a greater fraction of their purchases with the alternative payment technology[10]. Figure 9 illustrates this trade-off for high and low human capital households at a given interest rate.

To understand the redistributional implication of this feature of the transaction technology, it is useful to define a household specific consumption price index, $\tilde{P}_t^i$ for $i = 1, 2$. It is the total cost in efficiency units of labor of one unit of the consumption aggregator c_i, given by:

$$\tilde{P}_t^i = P_t^i + \frac{\int_{j=0}^{z_{it}} \theta(j)\, dj}{c_{it}}, \tag{3.20}$$

$$P_t^i = \left[(1 - z_{it}) (R_{t-1})^{\frac{\rho}{\rho-1}} + z_{it} \right]^{\frac{\rho-1}{\rho}}, \tag{3.21}$$

where z_{it} solves (3.17)[11].

For a given level of inflation, $P_t^1 > P_t^2$, since $z_{2t} > z_{1t}$ by (3.17). Household optimization implies $\tilde{P}_t^i \leq R_{t-1}$ and $\tilde{P}_t^1 \geq \tilde{P}_t^2$, since high income households always have the option of choosing the same structure that is optimal for low income households. This implies that the "actual" net real wage in efficiency units is higher for

[10] Erosa and Ventura (2000) illustrate that this property holds for a large class of marginal costs that have been adopted in the literature on costly credit.

[11] This price index is derived from the solution of the following static optimization problem:

$$\max_{c_{i1}, c_{i2}, z_i} \left[(1 - z_i) c_{i1}^{\rho} + z_i c_{i2}^{\rho} \right]^{1/\rho} \text{ subject to}$$
$$w = R c_{i1} (1 - z_i) + c_{i2} z_i + C(z_i),$$

where w is an exogeous endowment of real wealth. Let:

$$c_i = \left[(1 - z_i) c_{i1}^{\rho} + z_i c_{i2}^{\rho} \right]^{1/\rho},$$

and denote the expenditure function with $e(R; \theta)$ and the value function with $v(R; w, \theta)$. Then, the optimal value of c_i solves $c_i = v(R; w, \theta)$ and:

$$\tilde{P}^i = \frac{e(R; w, \theta)}{c_i}.$$

high income households:

$$\frac{W_t(1-\tau_t)}{P_t}\frac{1}{\tilde{P}_t^2} > \frac{W_t(1-\tau_t)}{P_t}\frac{1}{\tilde{P}_t^1}. \tag{3.22}$$

So a positive nominal interest rate is equivalent to a higher net real wage in efficiency units for high human capital households relative to low human capital households, since the latter make a greater fraction of their purchases with the alternative payment technology.

4. The Ramsey Equilibrium

If the government can pre-commit to policy announcements made at time 0, the choice of optimal fiscal and monetary policy can be characterized as the choice of a particular private sector equilibrium at time 0 subject to constraints originating from the class of policy instruments available to the government. The government's objective function is given by

$$\sum_{i=1,2}\eta_i\sum_{t=0}^{\infty}\beta^t u^i(c_{it}, n_{it}), \tag{4.1}$$

where c_i is defined in (3.3) and η_i is the time-invariant Pareto weight on type i agents, with $\eta_1+\eta_2=1$. The case $\eta_i=\nu_i$ corresponds to a utilitarian government. Henceforth, I will assume that government policy is given by $\{\tau_t, R_t\}_{t\geq 0}$ for $i=1,2$, that the money growth process is determined in equilibrium from money market clearing and the government budget constraint.

Definition 4.1. *A Ramsey equilibrium is given by an allocation* $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, M^d_{it+1}\}_{i=1,2,t\geq 0}$, *a price system* $\{P_t, W_t\}_{t\geq 0}$ *and a government policy* $\{\tau_t, R_t\}_{i=1,2,\ t\geq 0}$*such that, for given* M_{i0} *and* B_{i0}, $i=1,2$, *the allocation maximizes (4.1) and jointly with the price system and government policy it constitutes a private sector equilibrium.*

I characterize the Ramsey equilibrium as the solution to the "Ramsey allocation problem", described in Appendix B, under the assumption $B_{i0}=0^{12}$. In this problem, the government chooses an allocation at time 0 subject to the constraint that it be a private sector equilibrium.

I first show that, if the consumption aggregator is homothetic, the Friedman rule is not satisfy the necessary conditions for government optimization if the government favors high human capital households and (4.2) is imposed. I then present numerical results to illustrate the dependence of the Ramsey equilibrium inflation rate on the degree of inequality in human capital.

[12] The government's controls are given by $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}\}_{i=1,2,t\geq 0}$ and P_0. The level of P_0 determines the real value of outstanding nominal wealth, defined as the sum of currency and debt, and thus defines the boundary of the households' intertemporal budget set. I restrict attention to the case in which $B_{i0}=0$ to minimize the influence of the exogenous initial distribution of debt on the Ramsey equilibrium.

The Ramsey policy at time 0 is in general different from the Ramsey policy for $t>0$ due to different elasticity of relevant tax bases. This aspect of the Ramsey equilibrium is analyzed in Albanesi (2000).

4.1. Conditions for Optimality of the Friedman Rule

The necessary conditions for optimality of the Friedman rule critically depend on the constraints imposed on the labor income tax schedule. Assuming that the government can impose different tax rates on households of different types, denoted with τ_{it}, $i = 1, 2$. the following proposition holds.

Proposition 4.2. *If the government has access to individual specific labor income taxation, the Friedman rule is optimal.*

The proof is in Appendix B and, as in Chari, Christiano and Kehoe (1996), it relies on the homotheticity and separability assumptions on preferences. The proof of Proposition 4.2 encompasses the proof that the Friedman rule is optimal for the representative agent version of this economy.

Now assume that the constraint

$$\tau_{2t} \geq \tau_{1t}, \tag{4.2}$$

is imposed. Let $\bar{\eta}_i$ denote the "neutral" Pareto weight. It is defined as the value of η_i for which constraint (4.2) is not binding. Redistributional consideration have no first order effect on the optimal policy for this value of η_i. The following result holds.

Proposition 4.3. *Optimality of the Friedman rule requires $\eta_1 \geq \bar{\eta}_1$ under (4.2).*

The proof is in Appendix B. The intuition for these results lies in the trade-off between efficiency and distribution confronted by the government. Efficiency requires equalization of the relative price of goods purchased with currency and with credit. This outcome is achieved under the Friedman rule. However, by equation (3.22), a departure from the Friedman rule amounts to a transfer in favor of high human capital households. Therefore, if the government cannot tax households' labor income at different rates based on their productivity, it has an incentive to violate the Friedman rule, when the Pareto weight on high human capital households is sufficiently high.

Based on the proof of Proposition 4.3, I conjecture that if the tax rate on labor is allowed to differ across households but is subject to constraints of the type:

$$\kappa(\tau_2) \geq \tau_1, \tag{4.3}$$

where κ is a non-decreasing function of τ_2, a version of Proposition 4.3 holds[13].

[13] In an evironment with imperfectly observable labor productivity, maximization of revenues from labor income taxation would result in a restriction of average taxes like (4.3). See for example, Atkinson and Stiglitz (1980), Lecture 14. Then, the finding in proposition 4.3 is a version of the uniform taxation result shown by Atkinson and Stiglitz (1976). They show that access to a sufficiently unconstrained income tax schedule is enough to guarantee optimality of a uniform commodity tax, if preferences are weakly separable in leisure and the other goods, independently of the distributional objectives of if the government. Proposition 4.3 is also consistent with results in da Costa and Werning (2000), who study necessary conditions for optimality of the Friedman rule when labor productivity is unobservable. In this paper, I abstract from screening problems.

4.2. Properties of Ramsey Policy

I now study optimal government policy for a version of this economy calibrated to match features of money demand for the US in the post-war period. These features are reported in Table 2 and the corresponding parameter values are displayed in Table 3. I set ξ_2/ξ_1 to match the ratio of average income per capita accruing to the top 40% to the average income per capita accruing to the bottom 60% of the population. The details of the calibration are illustrated in Appendix D.

The results are displayed in Table 4. Here, the neutral Pareto weight is $\bar{\eta}_1 = \nu_1$ (and $\bar{\eta}_2 = 1 - \nu_1$) for the baseline preference specification, so that the government wishes to distribute in favor of high human capital households when $\eta_1 < \bar{\eta}_1$. In this case, the Ramsey inflation rate is positive and it decreases with η_1, the Pareto weight on low human capital households. The same result holds for other parameterizations with a sufficiently low value of the interest elasticity of aggregate money demand.

To trace the relation between inequality and inflation, I compute the Ramsey equilibrium inflation for increasing values of ξ_2 keeping the value of ξ_1 fixed[14]. I chose a value of the Pareto weight for which inflation is positive in equilibrium for a low value of ξ_2 and I adjust government spending so that it is constant as a fraction total employment. I find that equilibrium inflation increases with ξ_2. The nominal interest rate increases from 15% to 18% in equilibrium, when ξ_2 increases to 3.67 from 1.84.

To gauge sensitivity, I perturb the parameters that determine the distributional impact and the aggregate costs of inflation. Results are displayed in Table 5.

I compute the Ramsey equilibrium at $\eta_1 = 0.40$ for different values of θ_0. For the benchmark specification of $\theta(\cdot)$, the parameter θ_0 determines the level of marginal cost of increasing the fraction of goods purchased without currency. I find that equilibrium inflation varies inversely with θ_0 for the baseline values of $\xi_1$and ξ_2. Reducing θ_0 by 50% causes the equilibrium nominal interest rate to rise to 60% from 15%, doubling θ_0 causes the nominal interest rate to fall to 8% in equilibrium[15].

Results for values of ρ between 0.15 and 0.75, with $\eta_1 = 0.40$, are reported in Table 5. Equilibrium inflation varies inversely with ρ, starting at 15% for $\rho = 0.15$ and falling to 0 for ρ greater than 0.55. A lower value of ρ leads to a lower elasticity of substitution between consumption goods. Households increase the fraction of purchases made without currency for lower ρ, which causes the ratio $\tilde{P}^2/\tilde{P}^1$ to fall for a given nominal interest rate, due to the economies of scale on the costs of trans-

[14] Two alternative comparative statics exercises determine an increase in inequality. The first is a decrease in the value of ξ_1 for constant ξ_2 and ν_1. I conjecture that with this alternative experiment the same qualitative results would obtain. An additional excercise consists in keeping both ξ_1 and ξ_2 fixed and increasing the percentage of low productivity households in the population. In the latter case, the redistributional impact of inflation does not change with equilibrium inequality. In addition, it cannot easily be mapped into the available data on income quintiles.

[15] Adopting a more general specification of the transaction technology, of the form:

$$v(c, j) = c\theta(j) + \kappa,$$

where $\theta(\cdot)$ is defined in (3.1) and c is the level of consumption of the goods purchased with credit does not alter the results qualitatively, provided that the average cost of transaction services decreases with the size of the purchase.

actions. This effect strengthens the distributional effect of inflation in favor of high productivity households. Since the interest elasticity of aggregate money demand is not very sensitive to ρ, the variation in Ramsey inflation is mostly to be attributed to the different distributional effect of inflation for different values of ρ.

Summing up, if the necessary conditions for optimality of the Friedman rule are not satisfied, government incentives are shaped by a trade-off between efficiency and distribution. The terms of this trade-off depend on the interest elasticity of aggregate money demand, which determines the size of the deadweight loss associated with inflation, and on the degree of inequality. Larger inequality is associated with a greater relative vulnerability to inflation of low human capital households and a larger redistributional impact of inflation in favor of high human capital households. Since the government's objective function is linear in the households' welfare, an increase in the redistributional gain for high income households corresponds to a greater incentive to use inflation.

5. The Bargaining Equilibrium

In this section, I assume that inflation and the tax rate on labor are the outcome of a political process that can be represented as a sequential Nash bargaining game between households of different types, following Bassetto (1999). In each period, representatives are selected at random from each type of household and bargain over the tax rate on labor. The government budget constraint determines the corresponding equilibrium nominal interest rate. For simplicity, I assume that the government faces a balanced budget constraint[16] and that the labor income tax is the same for both types of households. Agreement requires unanimity. If the negotiating parties cannot reach an agreement, a relatively low default tax rate on labor income is applied and the government must resort to the inflation tax to finance spending. This choice of threat point reflects the idea that the inflation tax is easy to implement, since it doesn't require parliamentary approval and it is always feasible, if the government can costlessly run the printing press.

To build intuition, I first describe a simple one period economy for which it is possible to derive the key properties of the bargaining equilibrium analytically. I then analyze stationary sequential bargaining equilibria for the economy described in section 3. Here, representatives of different types of households bargain in each period over the policy which will be employed in the next period. If an agreement is not reached, the threat-point tax rate on labor income is applied for one period only. I restrict attention to stationary Markov equilibria of this game in which the policy proposals and their acceptance do not depend on the past history of implemented, proposed or accepted/rejected policies. This implies that failure to agree in any period does not influence the equilibrium policies in future periods. The bargaining equilibria I consider are stationary, in the sense that the threat point policy is constant and equilibrium policy is time independent.

[16] I interpret currency as a nominal liability for the government. Since I study a closed economy, foreign debt is excluded. I also assume that the government cannot confiscate goods from the households

5.1. A One-Period Example

Consider the following one period economy, where government policy is given by $\{\tau, R\}$, with $R \geq 1$. Households indexed by their labor productivity ξ_i solve the problem:

$$
\begin{aligned}
U^i(\{\tau, R\}) &= \max_{c_{i1}, c_{i2}, z_i, n_i} \log c_i - \gamma n_i, && (5.1)\\
& \quad \text{subject to} \\
(1-\tau)\,\xi_i n_i &= R c_{i1}(1-z_i) + c_{i2} z_i + \int_0^{z_i} \theta dj, && (5.2)
\end{aligned}
$$

for $i = 1, 2$, with $\theta > 0$. Let $\{c_{i1},\, c_{i2},\, z_i,\, n_i\}(\{\tau, R\})$ for $i = 1, 2$ denote the policy functions corresponding to problem (5.1). In addition, the resource constraint must be satisfied at $\{\tau, R\}$:

$$
\sum_{i=1,2} \nu_i [c_{i1}(1-z_i) + c_{i2} z_i + \int_0^{z_i} \theta dj - \xi_i n_i] + \bar{g} = 0. \qquad (5.3)
$$

Equation (5.3) implicitly defines the function $R = R(\tau, \bar{g})$[17].

Assume that representatives of each type of household are selected at random at the beginning of the period to Nash-bargain over $\{\tau, R\}$. If they do not reach an agreement, a policy rate $\{\tau^T, R^T\}$ is employed, with $R^T = R(\tau^T, \bar{g})$.

The equilibrium policy solves the following problem:

$$
\begin{aligned}
\mathcal{N}(p, \bar{g}) &= \arg \max_{\{\tau, R\}} \mathcal{V}_1^p \mathcal{V}_2 \text{ subject to} && (5.4)\\
\tau &\geq \tau^T, \\
R^T &= \mathcal{R}(\tau^T, \bar{g}) \geq 1, \\
R &= \mathcal{R}(\tau, \bar{g}) \geq 1.
\end{aligned}
$$

Here:

$$
\mathcal{V}_i \equiv \max\left\{0, U^i(\{\tau, R\}) - U^i\left(\{\tau^T, R^T\}\right)\right\},
$$

for $i = 1, 2$, and p is an exogenous bargaining weight.

Definition 5.1. *A Nash Bargaining equilibrium for the one-period economy is given by a government policy $\{\tau^*, R^*\}$ and an allocation $\{c_{i1}^*,\, c_{i2}^*,\, z_i^*,\, n_i^*\}_{i=1,2}$ such that $\{\tau^*, R^*\} = \mathcal{N}(p, \bar{g})$ and $\{c_{i1}^*,\, c_{i2}^*,\, z_i^*,\, n_i^*\} = \{c_{i1},\, c_{i2},\, z_i,\, n_i\}(\{\tau^*, R^*\})$ for $i = 1, 2$.*

The following proposition provides an analytical characterization of the sufficient conditions for the bargaining equilibrium inflation rate to be positively correlated with the degree of inequality in the case of logarithmic preferences in consumption.

[17] The government budget constraint holds if (5.2) and (5.3) are satisfied.

Proposition 5.2. *Assume that* $\frac{\partial R}{\partial \tau} \leq 0$. *Let* $\{\tau, R\} = \mathcal{N}(p, \bar{g})$ *and* $\left\{\hat{\tau}, \hat{R}\right\} = \mathcal{N}(p, \widehat{g})$ *for* $\hat{\xi}_2 > \xi_2$, $\hat{\xi}_1 = \xi_1$ *and* $\widehat{g}$ *satisfying:*

$$\mathcal{R}\left(\tau^T, \widehat{g}\right)\big|_{\hat{\xi}_2} = R^T, \tag{5.5}$$

Then, if:

$$\frac{dU^1\left(\{\tau, R\}\right)}{d\tau} \geq 0, \tag{5.6}$$

$\hat{\tau} \leq \tau$ *and* $\hat{R} \geq R$.

The proof is in Appendix C. It proceeds by showing that if certain policy solves the bargaining problem for a given value of ξ_2, the same policy cannot be a solution to the bargaining problem for an economy with higher ξ_2[18] for given ξ_1. By (5.5), government consumption is adjusted so that the threat point policy is the same in the two economies.

Assumption $\frac{\partial R}{\partial \tau}(\tau, \bar{g}) \leq 0$ selects the set of tax rates on the upward sloping side of the Laffer curve for labor income taxation and for the equilibrium inflation tax. To see this, consider that a lower τ decreases the government's fiscal revenues and increases the equilibrium level of consumption for both types of households for a given interest rate, inducing them to choose a higher value of z_i and reduce their holdings of currency. If $\frac{\partial R}{\partial \tau} \leq 0$, a decrease in the labor tax rate corresponds to a fall in fiscal revenues and an increase in the nominal interest rate corresponds to a rise in inflation tax revenues in equilibrium. Condition (5.6) states that households of different type have conflicting views over fiscal policy. Low human capital households would prefer an increase in the tax rate from the current level, while the converse is true for high human capital households.

The result in proposition 5.2 falls from the first order condition for the bargaining problem, given by:

$$p\left[\frac{\mathcal{V}_2}{\mathcal{V}_1}\right]\frac{dU^1\left(\{\tau, R\}\right)}{d\tau} + \frac{dU^2\left(\{\tau, R\}\right)}{d\tau} = 0. \tag{5.7}$$

Here, $\frac{dU^i}{d\tau}$ is the total derivative of U^i with respect to τ,i.e. $\frac{dU^i}{d\tau} = \frac{\partial U^i}{\partial \tau} + \frac{\partial U^i}{\partial R}\frac{\partial R}{\partial \tau}$.

If policy were chosen to maximize type i's utility only, the term $\frac{dU^i}{d\tau}$ would be set to 0. Loosely speaking this term can be taken to represent type i's preferences over policy. A higher weight on $\frac{dU^1}{d\tau}$ corresponds to a bargaining outcome closer to the one preferred by type 1 agents. Two factors affect this weight: type 1 agents' exogenous bargaining weight, p, and the term in square brackets, which represents how much type 2 households stand to loose in case of non-agreement relative to type 1 households.

Given that $\xi_2 > \xi_1$, type 2 households consume a larger amount of all goods and face a lower average cost of transactions. This implies that they stand to loose less in case an agreement over tax policy is not reached, if the private sector equilibrium

[18] The proof also holds for a decrease in ξ_1 for a given ξ_2.

nominal interest rate varies inversely with the tax rate on labor. It follows that the term in square brackets is smaller than 1 for the bargaining problem in (5.4) and the bargaining outcome is closer to the one preferred by high human capital households. Such an outcome will involve a relatively low tax rate and positive nominal interest rate, given their better ability to elude the inflation tax. Larger inequality in human capital across households, corresponding to a higher value of ξ_2/ξ_1, reduces the value of agreement for high human capital households relative to low human capital households. If there is a conflict between households of different types, as is the case when (5.6) holds, a weakening of the bargaining position of low income households results in an equilibrium policy which is closer to the one preferred by high income households. Increased inequality generates such a weakening, resulting in lower taxes and higher inflation in equilibrium[19].

5.2. Stationary Sequential Bargaining Equilibrium

I now describe the stationary Nash bargaining equilibrium for the economy described in section 3.

Let government policy in each period be given by $\{\tau, R\}$. The sequence of events in each period is as follows:

1. Households enter the period with currency holdings given by M_i for $i = 1, 2$ and chose z_i based on current policy $\{\tau, R\}$.
2. Representatives of each type of households bargain over policy in the next period $\{\tau', R'\}$ taking as given government policy for all periods other than the next and the threat point policy $\{\tau^T, R^T\}$.
3. Goods market and labor market trading occurs.
4. Receipts from goods and labor market trading are received on the asset market. Households leave the period with $M_i\prime$ units of currency, $i = 1, 2$.

It is useful to illustrate certain properties of private sector equilibria for given government policy before providing a formal definition of bargaining equilibrium.

5.2.1. Characterizing Private Sector Equilibria

Let $X_t = [\{\tau_s, R_s\}]_{s \geq t}$ denote government policy from period t onwards, for any $t \geq 0$. Then, given X_t and M_t, the money supply process $\{M_s\}_{s>t}$ is determined in equilibrium by the government budget constraint and the money market clearing condition.

[19] The same results would follow in an model in which the households bargaing over the tax rate on labor and the level of spending on a public good which additively enters their utility function. In this case, the threat point would involve inability to provide the public good and collect labor income taxes.

Proposition 5.3. *Consider a private sector equilibrium with government policy given by* $X_t = [\{\tau_s, R_s\}]_{s\geq t}$ *for* $t \geq 0$ *and let* M_{it} *for* $i = 1, 2$ *be given. Then:*

$$\begin{aligned} c_{jis} &= \mathfrak{c}_{ij}(\tau_s, R_s) \ \text{ for } s > t, &(5.8)\\ z_{is} &= \mathfrak{z}_i(\tau_s, R_s) \ \text{ for } s \geq t, &(5.9)\end{aligned}$$

for $i, j = 1, 2$.

If the cash in advance constraint hold with equality for both types of households for $s \geq t$:

$$M_{i,s+1} = \mathfrak{M}_i(\tau_{s+1}, R_{s+1}) \ \text{ for } s \geq t, \tag{5.10}$$

for $i = 1, 2$. *In addition, if* $M_{i,t} = \mathfrak{M}_i(\tau_t, R_t)$ *for* $i = 1, 2$, *then* $c_{jit} = \mathfrak{c}_{ij}(\tau_t, R_t)$. *Otherwise,* $c_{ijt} = \mathfrak{c}_{ij}(M_{it}, P_t; \tau_t, R_t)$, *with* $\mathfrak{c}_{ij}(\cdot)$ *implicitly defined by:*

$$\begin{aligned} c_{i1} &= \min\{c_{i2}, \frac{M_i}{(1-z_i)P}\}, &(5.11)\\ c_{i2} &= \mathfrak{c}_{i2}\left(\tau, \left(\frac{c_{i1}}{c_{i2}}\right)^{\rho-1}\right), &(5.12)\end{aligned}$$

for $z_{it} = \mathfrak{z}_i(\tau, R)$ *for* $i, j = 1, 2$.

Furthermore, if $B_{it} = 0$ *for* $i = 1, 2$ *and* $B_s = 0$ *for all* $s > t$, *there exists a private sector equilibrium with:*

$$B_{is} = 0, \tag{5.13}$$

and $n_{is} = \mathfrak{n}_i(\tau_s, R_s; \tau_{s+1}, R_{s+1})$ *,for* $s > t$ *and* $n_{it} = \mathfrak{n}_i\left(\tau_t, \left(\frac{c_{i1t}}{c_{i2t}}\right)^{\rho-1}; \tau_{t+1}, R_{t+1}\right)$, *with:*

$$\mathfrak{n}_i(\tau, R; \tau', R') = \frac{\beta}{\gamma}u'_{i1}c'_{i1} + \frac{u_{i2}}{\gamma}\left(c_{i2} + \frac{C(z_i)}{z_i}\right). \tag{5.14}$$

Proof Equations (3.14), (3.15) and (3.17) determine (5.8)-(5.9). Equations (3.12), which can be used to determine P_{s+1} for any $s \geq t$, (3.16), together with (5.8)-(5.9) imply (5.10). (5.11)-(5.12) follow from (3.15) and (3.18). Finally, imposing (5.13) on (3.19) yields (5.14). ■

Proposition 5.3 illustrates some key properties of the private sector equilibrium allocation for given policy. First, in any period, $\{c_{i1s}, c_{i2s}, z_{is}\}$ for $i = 1, 2$ only depend on government policy in the current period $\{\tau_s, R_s\}$, due to the absence of wealth effects on the level and composition of consumption. The functions $\mathfrak{c}_{ij}(\cdot)$ and $\mathfrak{z}_i(\cdot)$ are implicitly defined by (3.14), (3.15) and (3.17), for $i, j = 1, 2$. Second, the end-of-period distribution of currency only depends on government policy for next period $\{\tau_{s+1}, R_{s+1}\}$. The function $\mathfrak{M}_i(\cdot)$ is derived from $\mathfrak{c}_{i1}$ and $\mathfrak{z}_i$. Third, for given X_t, the equilibrium value of c_{ijt} depends on M_{it}, which determines the shadow price of cash goods relative to credit goods. M_{it} is exogenous from the standpoint of time t since households cannot adjust currency holdings at the beginning of the period (Svensson timing) and R_t is only relevant to the extent that it influences the choice of z_{it}. However, if $M_{it} = \mathfrak{M}_i(\tau_t, R_t)$, then c_{ijt} is also determined according to (5.8). In this case, shadow price of cash goods relative to credit goods is exactly equal to R_t. Finally, I restrict attention to equilibria in which (5.13) holds since, due the constant marginal utility of labor, the distribution of debt is not pinned down in equilibrium.

Conditions (5.8)-(5.14) guarantee that household optimization is satisfied for a given policy X_t. Policies consistent with a private sector equilibrium must also satisfy the resource constraint. Then, a policy X_t is part of a private sector equilibrium if $R_s = \mathcal{R}(\tau_s; \{\tau_{s+1}, R_{s+1}\}, \bar{g})$ for all $s \geq t$, where $\mathcal{R}(\cdot)$ is implicitly defined by the resource constraint:

$$\begin{aligned} & \sum_{i=1,2} \nu_i \xi_i \mathfrak{n}_i (\tau, R; \tau', R') \qquad (5.15) \\ = \quad & \bar{g} + \sum_{i=1,2} \nu_i [\mathfrak{c}_{i1} (\tau, R) (1 - \mathfrak{z}_i (\tau, R)) + \mathfrak{c}_{i2} (\tau, R) \mathfrak{z}_i (\tau, R) + \int_0^{\mathfrak{z}_i(\tau,R)} \theta (j) \, dj]. \end{aligned}$$

Given that (3.19) holds under the assumptions of proposition 5.3, (5.15) implies that the government's dynamic and intertemporal budget constraints are also satisfied.

The determination of $\{P_s\}_{s \geq t}$ must be specified to complete the characterization of private sector equilibria corresponding to policies X_t. Equation (3.12) determines $\{P_s\}_{s>t}$,for given P_t, since $R_s = Q_s^{-1}$ for $s > t$. In addition:

$$P_t = \frac{\sum_{i=1,2} \nu_i \mathfrak{M}_i (\tau_t, R_t)}{\sum_{i=1,2} \nu_i \mathfrak{c}_{i1} (\tau_t, R_t) (1 - \mathfrak{z}_i (\tau_t, R_t))},$$

if $M_{i,t} = \mathfrak{M}_i (\tau_t, R_t)$ for $i = 1, 2$. Otherwise, $P_t = \mathfrak{P} (M_{1t}, M_{2t}; \{\tau_t, R_t\}, \{\tau_{t+1}, R_{t+1}\}, \bar{g})$, where $\mathfrak{P}(\cdot)$ is implicitly defined by:

$$\begin{aligned} & \sum_{i=1,2} \nu_i \xi_i \mathfrak{n}_i \left(\tau, \left(\frac{c_{i1}}{c_{i2}} \right)^{\rho-1}; \tau', R' \right) \qquad (5.16) \\ = \quad & \bar{g} + \sum_{i=1,2} \nu_i [c_{i1} (1 - \mathfrak{z}_i (\tau, R)) + c_{i2} \mathfrak{z}_i (\tau, R) + \int_0^{\mathfrak{z}_i(\tau,R)} \theta (j) \, dj], \end{aligned}$$

where c_{ij} are determined according to (5.11)-(5.12).

Under the assumptions of Proposition 5.3, the present discounted value of household utility from $s \geq t$ in a private sector equilibrium with policy $\{\tau_s, R_s\}_{s \geq t}$, current price level P_t and initial distribution of currency M_{it}, $i = 1, 2$ can be written as:

$$V^i (M_{it}, X_t, P_t) = \frac{c_{it}^{1-\sigma} - 1}{1 - \sigma} - \gamma n_{it} + \sum_{s=t+1}^{\infty} \beta^{s-t} \mathcal{P}^i (\tau_s, R_s; \tau_{s+1}, R_{s+1}), \qquad (5.17)$$

for all $t \geq 0$. Here: $n_{it} = \mathfrak{n}_i \left(\tau_t, \left(\frac{c_{i1t}}{c_{i2t}} \right)^{\rho-1}; \tau_{t+1}, R_{t+1} \right)$, with c_{jit} determined from (5.11)-(5.12) and

$$\mathcal{P}^i (\tau, R; \tau', R') = \left[\frac{(c_i)^{1-\sigma} - 1}{1 - \sigma} - \gamma \mathfrak{n}_i (\tau, R; \tau', R') \right], \qquad (5.18)$$

with c_{ij} for $i, j = 1, 2$ given by (5.8)-(5.9). c_i is determined from (3.3) for $i = 1, 2$.

5.2.2. Bargaining Problem and Equilibrium

To characterize the Markov sequential bargaining equilibrium, I analyze one period deviations from a candidate equilibrium policy. I consider equilibria that are stationary in the sense that the threat point policy is constant, and the equilibrium policy for the current period is the same as the one expected to prevail in all periods after the next.

The linear-in-leisure preference specification, which implies no wealth effects on consumption, has an important simplifying role. It implies that the distribution of currency at the beginning of any given period is a function of expected policy for that period only, as shown in proposition 5.3. For a given candidate equilibrium policy $\{\tau, R\}$, the distribution of currency at the beginning of the period is determined by (5.10). In addition, since the distribution of currency across households at the end of the period only depends on government policy in the next period, the Nash bargaining problem in the next period is unaffected by the outcome of the bargaining problem in the current period. It follows that there are no state variables for the bargaining problem.

To describe the bargaining problem and characterize the bargaining equilibrium, it is necessary to evaluate households' utility along paths for government policy that will not be outcomes. To do this, I rely on the characterization in section 5.2.1.

Assume that households anticipate that government policy from the current period onwards will be given by $X = [\{\tau, R\}, \{\tau, R\}, ...]$, but actual policy is instead equal to $X' \equiv [\{\tau, R\}, \{\tau', R'\}, \{\tau, R\}, \{\tau, R\}...]$. Since currency holdings at the beginning of the current period and transaction patterns are chosen before actual policy is determined, they will be equal to $M_i = \mathfrak{M}_i(\tau, R)$ and $z_i = \mathfrak{z}_i(\tau, R)$ for $i = 1, 2$, by proposition 5.3. The current price level will be given by:

$$P = \mathfrak{P}\left(M_1, M_2; \{\tau, R\}, \{\tau', R'\}, \bar{g}\right) = \overline{\mathfrak{P}}\left(\{\tau, R\}, \{\tau', R'\}, \bar{g}\right). \tag{5.19}$$

Then, the value function for a household in a private sector equilibrium corresponding to a one period deviation from a candidate equilibrium policy X, is given by:

$$\hat{V}^i(X') = V^i\left(\mathfrak{M}_i(\tau, R), X', \overline{\mathfrak{P}}\left(\{\tau, R\}, \{\tau', R'\}, \bar{g}\right)\right). \tag{5.20}$$

for $i = 1, 2$. $\hat{V}^i(\cdot)$ incorporates the fact that M_i and households's choice of z_i are based on expectations that policy will be given by X from the current period onward, while other household choices are determined by actual policy X', given M_i and z_i. In addition, P and R, R' are determined in a private sector equilibrium, according to the functions $\mathfrak{P}$ and $\mathcal{R}$, respectively. Notice that for any two policies, X' and X'', that constitute a one-period deviation from a policy X, $\hat{V}^i(X')$ and $\hat{V}^i(X'')$ do not differ beyond the second term.

Definition 5.4. *A private sector equilibrium corresponding to a one-period deviation from policy $X = [\{\tau, R\}, \{\tau, R\}, \{\tau, R\}...]$, is given by a policy $X' \equiv [\{\tau, R\}, \{\tau', R'\}, \{\tau, R\}, ...]$, a price level for the current period P, M_i and functions $\mathfrak{P}(\{\tau, R\}, \{\tau', R'\}, \bar{g})$ and $\mathfrak{M}_i(\{\tau, R\})$, $z_i(\{\tau, R\})$, $\hat{V}^i(X')$ for $i = 1, 2$, such that $P = \overline{\mathfrak{P}}(\{\tau, R\}, \{\tau', R'\}, \bar{g})$,*

$R = \mathcal{R}(\tau; \{\tau, R\}, \bar{g})$, $R' = \mathcal{R}(\tau'; \{\tau, R\}, \bar{g})$, *where* $\mathcal{R}(\cdot)$ *is defined by (5.15), and* $\hat{V}^i(X')$ *is defined by (5.20) and (5.17).*

Let $\{\tau^T, R^T\}$ be the policy in case of no agreement for next period.

Definition 5.5. *A sequential bargaining equilibrium is a government policy* $\{\tau, R\}$ *and a collection of functions* $\{\mathfrak{M}_i(\{\tau, R\}), \hat{V}^i(X^*)\}$ *for* $i = 1, 2$ *and* $\overline{\mathfrak{P}}(\cdot)$, $\mathcal{R}(\cdot)$, *such that, if* $X^* = [\{\tau, R\}, \{\tau^*, R^*\}, \{\tau, R\}...]$:

1. $\{\tau^*, R^*\} = \mathcal{N}(\{\tau, R\}; p, \bar{g})$, *where:*

$$\mathcal{N}(\{\tau, R\}; p, \bar{g}) = \arg\max_{\{\tau', R'\}} [\hat{V}^1(X') - \hat{V}^1(X^T)]^p [\hat{V}^2(X') - \hat{V}^2(X^T)],$$

subject to

$$\begin{aligned} \tau' &\geq \tau^T, \\ R &= \mathcal{R}(\tau; \{\tau, R\}, \bar{g}) \\ R' &= \mathcal{R}(\tau'; \{\tau, R\}, \bar{g}), \\ X^T &= [\{\tau, R\}, \{\tau^T, R^T\}, \{\tau, R\}...], \\ R^T &= \mathcal{R}(\tau^T; \{\tau, R\}, \bar{g}); \end{aligned}$$

2. $\{\tau, R\} = \{\tau^*, R^*\}$.

5.3. Findings

Figure 10 illustrates the key features of the bargaining problem for the benchmark parameterization, displayed in Table 6, for $\xi_1 = 1$ and $\xi_2 = 1.8$. The top-left panel plots the derivative of the household value function with respect to the tax rate against the set of feasible candidate equilibrium tax rates[20]. It corresponds to $dU^i/d\tau$ in the one-period economy. A $*$ points to the tax rate where this derivative is set to 0 for each type. The value function for households of type 1 is maximized at a higher tax rate than for households of type 2, so that there is conflict over government policy between households of different types. The top-right panel plots the derivative of the bargaining objective with respect to the tax rate for the set of candidate equilibrium tax rates. This derivative is set to 0 at a value of τ which is intermediate between the one preferred by type 1 households and the one preferred by type 2 households. The bottom-left panel plots $\mathcal{R}(\tau; \{\tau, R\}, \bar{g})$ as defined by (5.15). The bottom-right panel plots the fraction of government consumption financed with labor income tax revenue for the set of feasible candidate equilibrium tax rates.

I fix $\xi_1 = 1$ and compute the bargaining equilibrium for increasing values of ξ_2. Government spending is set to equal approximately 25% of total output in private

[20] For values of τ that are too low, a finite value of R such that the resource constraint is satisfied cannot be found. For values of τ that are too high, $R = 1$ and τ must be reduced for the resource constraint to be satisfied. The set feasible candidate equilibrium tax rates is determined so that, with policy $X = [\{\tau, R\}, \{\tau, R\}, ..]$, the resource constraint is satisfied exactly, $R \geq 1$ and finite.

sector equilibrium with $\tau = 0.25$. I set τ^T as the lowest positive tax rate for which a private sector equilibrium exists for each value of ξ_2 considered. In general, this corresponds to labor tax revenues covering approximately 80% of government consumption.

The results for the benchmark parametrization are presented in Table 6. Larger differences in labor productivity across types of households give rise to higher inflation in the stationary bargaining equilibrium. The equilibrium nominal interest rate increases from 2 to 7% if ξ_2 varies from 1.8 to 3.6. It increases further to 12% if ξ_2=5.5. This corresponds to an equilibrium inflation rate of 0, 3.84 and 9.10 %, respectively. The weaker bargaining position of type 1 agents can be seen from the value of agreement in equilibrium. For low human capital households it is approximately 3 times greater than for high human capital households at $\xi_2 = 1.8$, and becomes approximately 10 and 100 times greater for $\xi_2 = 3.6, 5.5$.

Table 7 reports results for the same parametrization with $\theta_0 = 0.042$, double the value in the previous exercise. A higher value of θ_0 reinforces the effect of scale in reducing the cost of transaction services and increases the relative vulnerability to inflation of low human capital households. A higher value of θ_0 also corresponds to a smaller interest elasticity of aggregate money demand. The first effect should increase the correlation between inequality and inflation predicted by the model. The second effect is associated with a larger inflation tax base and generally produces a smaller value of the inflation rate at the threat point. A lower threat point inflation rate partially offsets the increase in the redistributional effects of inflation stemming from the higher fixed cost of transaction services. The results reported in Table 7 show that the equilibrium inflation rate is consequently more responsive to an increase in ξ_2/ξ_1 relative to Table 6, especially at high values of ξ_2,which is consistent with a greater redistributional impact of inflation. For an increase in ξ_2 from 2.1 to 4, the equilibrium inflation rate reaches 4.6% from 0.49%; a further increase in ξ_2 to 4.8 causes inflation to rise to 8.64%. However, comparison of the equilibrium rate of inflation for the same degree of inequality across Table 6 and Table 7 shows that the effect of a smaller value of threat point inflation is dominant for low levels of inequality, giving rise to lower equilibrium inflation rates.

6. Concluding Remarks

This paper has explored the hypothesis that the observed cross-country correlation between average inflation and income inequality is the outcome of a distributional conflict underlying the determination of fiscal policy. The analysis relies on the assumption that government policy, that is labor income taxation and the degree of monetary financing of government consumption, is the outcome of a bargaining game. The bargaining power of different categories of households in the political process depends on their economic characteristics. Low income households are more vulnerable to inflation, since in equilibrium they hold more cash as a fraction of their total purchases. This weakens their bargaining position, since in case of no agreement a low labor income tax and a relatively high inflation rate are assumed to prevail. I show that this implies that inflation is positive in equilibrium and larger inequality corresponds to higher equilibrium inflation.

It is important to acknowledge the limitations of this framework. First, the distributional impact of inflation is exclusively a function of differences in transaction patterns. This determines an upper bound for the degree of distribution achievable through inflation in this economy and poses a limit to the correlation between inequality and inflation predicted by the model. Second, the degree of distribution achievable with means other than inflation is limited by the fiscal constitution. Extensions to the fiscal constitution would likely moderate the findings. The Ramsey equilibrium results, however, suggest a class of political-economic environments with weaker restrictions on the fiscal constitution, in which a positive correlation between inequality and equilibrium inflation would arise. These environments have the feature that in equilibrium low human capital households have lower weight in the political process and that the fiscal constitution or distortions associated with the unobservability of relevant characteristics of households limit the degree of distribution achievable via direct taxation.

Despite these limitations, the political-economic environment described in this paper predicts a quantitatively significant correlation between inequality and inflation. It is then interesting to evaluate the fraction of the correlation between inequality and inflation in the data accounted for by the model. Results are reported in Table 8. For the parametrization used for Tables 4 and 6, the model predicts a slope of 1.13 in the Ramsey equilibrium and of 1.07 in the bargaining equilibrium. For the bargaining equilibrium in Table 7, corresponding to higher costs of transactions, the slope is 1.06. For the available data, excluding countries with average inflation above 60% per annum, the slope coefficient of a regression of inflation on $y40/y60$ is 4.46. Therefore, the model is able to account for approximately 24% of the correlation between inequality and inflation for countries with average inflation below 60% per annum. The relation between inflation and inequality is non-linear in the sample, with a higher slope of the relation at higher inequality. The model also accounts for this effect for the benchmark parameterization, as shown in Table 8. The slope of the relation between inequality and inflation is 0.90 for low inequality and 1.09 for high inequality. Results are similar for the Ramsey equilibrium, with the slope given by 0.25 and 1.19 at low and high initial inequality. The parameterization with higher transaction costs does not give rise to this prediction. Figure 11 is a graphical representation of these findings. The linear relation predicted by the bargaining (line with $+$) and Ramsey (line with $\times$) equilibrium is plotted against a scatter the data for countries with average yearly inflation below 60% [21]. For the bargaining equilibrium, both parameterizations are reported.

[21] The intercept is backed out from the data for this exercise.

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7. Appendix A: Proof of Proposition 3.2

Assume that an allocation $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, M_{it+1}, B_{it+1}\}_{i=1,2,t\geq 0}$, with $n_{it} > 0$ for $i = 1, 2$ and $t \geq 0$, and a price system $\{P_t, W_t, Q_t, q_t(j)\}_{t\geq 0, j\in[0,1]}$ constitute a private sector equilibrium for a given policy $\{\bar{g}_t, \tau_t, M_{t+1}, B_{t+1}\}_{t\geq 0}$. Then, conditions (3.10) and (3.11) derive from optimality of firm behavior, conditions (3.9) and (3.13) from clearing in the goods and assets markets. The other conditions follow from household optimization.

The Lagrangian for the household problem is given by:

$$
\begin{aligned}
L &= \sum_{t=0}^{\infty} \beta^t \left\{ u^i(c_{it}, n_{it}) - \mu_{it}\left(P_t c_{i1t}(1 - z_{it}) - M_{it}\right) - \lambda_{it}\left[M_{it+1} + Q_t B_{it+1} \right.\right. \\
&\quad \left.\left. -M_{it} - B_{it} - W_t(1 - \tau_t)\xi_i n_{it} + P_t c_{i1t}(1 - z_{it}) + P_t c_{i2t} z_{it} + \int_0^{z_{it}} q_t(j)\, dj\right]\right\},
\end{aligned}
$$

where c_{it} is defined in (3.4) and μ_{it}, λ_{it} are the multipliers on the cash in advance constraint and the wealth evolution equation, respectively. Denote with u_{ijt} and u_{int} the marginal utility of good j and of labor for households $i = 1, 2$.

The necessary conditions for household optimization are given by:

$$u_{i1t} = P_t(\mu_{it} + \lambda_{it})(1 - z_{it}), \tag{7.1}$$

$$\mu_{it}\left(P_t c_{it}(1 - z_{it}) - M_{it}\right) = 0, \;\; \mu_{it} \geq 0, \tag{7.2}$$

$$u_{i2t} = P_t \lambda_{it} z_{it}, \tag{7.3}$$

$$-u_{int} = W_t(1 - \tau_t)\xi_i \lambda_{it}, \tag{7.4}$$

$$P_t c_{i1t}(\mu_{it} + \lambda_{it}) - P_t c_{i2t}\lambda_{it} - q_t(z_{it})\lambda_{it} \begin{cases} < 0 \text{ for } z_{it} = \underline{z}, \\ = 0 \text{ for } z_{it} \in (\underline{z}, \bar{z}), \\ > 0 \text{ for } z_{it} = \bar{z}, \end{cases} \tag{7.5}$$

$$\lambda_{it} = \beta\left(\lambda_{it+1} + \mu_{it+1}\right), \tag{7.6}$$

$$\lambda_{it} Q_t = \beta \lambda_{it+1}, \tag{7.7}$$

$$\lim_{T\to\infty} \beta^T \lambda_{iT} M_{iT} = 0, \;\; \lim_{T\to\infty} \beta^T \lambda_{iT} B_{iT} = 0, \tag{7.8}$$

as well as (3.5) and (3.6). To see that (7.8) is a necessary condition for household optimization, suppose it does not hold and

$$\lim_{T\to\infty} \beta^T \lambda_{iT} M_{iT} > 0, \;\; \lim_{T\to\infty} \beta^T \lambda_{iT} B_{iT} > 0.$$

(The strictly smaller case is rule out by (3.7).) Then, it is possible to construct a consumption sequence such that the budget constraint is satisfied in each period and utility for each type of household is greater, violating optimality.

Combining (7.1)-(7.3) yields (3.14), while (7.3) and (7.4) determine (3.15). The expression in (3.12) follows from (7.4) and $u_{int} = \gamma$, (7.7) and (3.10), while (3.18) follows from (7.1)-(7.3) at $t = 0$. To derive (3.19), multiply (3.6) by λ_{it} and apply (7.2) and (7.6). This yields:

$$\begin{aligned} 0 &= (\lambda_{it} + \mu_{it}) M_{it} + \lambda_{it} B_{it} + W_t (1 - \tau_t) \xi_i \lambda_{it} n_{it} - P_t c_{i1t} (\mu_{it} + \lambda_{it}) (1 - z_{it}) \\ &\quad - P_t c_{i2t} z_{it} \lambda_{it} - \lambda_{it} \int_0^z q_t (j) \, dj - \beta \left(\lambda_{it+1} + \mu_{it+1} \right) M_{it+1} - \beta \lambda_{it+1} B_{it+1}. \end{aligned}$$

Now use (7.1), (7.3)-(7.5), multiply by β^t and sum over t from 0 to T. Let T go to infinity and apply (7.8).

Now assume that an allocation $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, M_{it+1}, B_{it+1}\}_{i=1,2,t\geq 0}$, with $n_{it} > 0$ for $i = 1, 2$ and $t \geq 0$, and a price system $\{P_t, W_t, Q_t, q_t (j)\}_{t\geq 0, j\in[0,1]}$ satisfy (3.10)-(3.19) and (3.9) for a given policy $\{\bar{g}_t, \tau_t, M_{t+1}, B_{t+1}\}_{t\geq 0}$ for which (3.8) holds. Then, by (3.10) and (3.11) industrial and credit services firms optimize.

To see that household optimization conditions are satisfied consider an alternative candidate plan $\{c'_{i1t}, c'_{i2t}, n'_{it}, z'_{it}\}_{i=1,2,t\geq 0}$ which satisfies the intertemporal budget constraint for the price system $\{P_t, W_t, Q_t, q_t (j)\}_{t\geq 0, j\in[0,1]}$. This implies that:

$$\Delta \equiv \lim_{T\to\infty} \beta^t \left\{ u_{i1t} (c_{i1t} - c'_{i1t}) + u_{i2t} \left(c_{i2t} + \frac{C(z_{it})}{z_{it}} - c'_{i2t} - \frac{C(z'_{it})}{z'_{it}} \right) - \gamma (n_{it} - n'_{it}) \right\} \geq 0,$$

using (3.12) and the fact that $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}\}_{i=1,2,t\geq 0}$ satisfies (3.14)-(3.19) and that the intertemporal budget constraint holds as a weak inequality using (3.7) and (3.6) for the price system $\{P_t, W_t, Q_t, q_t (j)\}_{t\geq 0, j\in[0,1]}$. By concavity of u^i :

$$D \equiv \lim_{T\to\infty} \sum_{t=0}^{T} \beta^t \left(u^i (c_{it}, n_{it}) - u^i (c'_{it}, n'_{it}) \right) \geq \Delta,$$

where c'_{it} is defined by (3.4). This establishes the result since (3.13) and (3.9) guarantee market clearing.

8. Appendix B: Proof of Propositions 4.2 and 4.3

For the purpose of characterizing the Ramsey equilibrium, it is useful to redefine household utility as follows:

$$\begin{aligned} U^i \left(h^i (c_{i1}, c_{i2}; z_i), n_i \right) &= \frac{c_i^{1-\sigma} - 1}{1-\sigma} - \gamma n_i, \text{ for } i = 1, 2, \\ c_i &= h^i (c_{i1}, c_{i2}; z_i), \end{aligned}$$

where h^i is defined in (3.4) and n_{it} is the quantity of labor sold on the market.

The Ramsey allocation problem, expressed in Lagrangian form, is given by:

$$\max_{\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, m_{i0}, r_t\}_{i=1,2,t\geq 0}} \sum_{t=0}^{\infty} \beta^t \sum_{i=1,2} \eta_i W^i (c_{i1t}, c_{i2t}, z_{it}, n_{it}) \qquad (8.1)$$

$$
\begin{aligned}
&-\sum_{t=0}^{\infty}\beta^t\left[\mu_{it}\left(\frac{u_{11t}/\left(1-z_{it}\right)}{u_{12t}/z_{it}}-r_t\right)+\chi_t\left(1-r_t\right)+\zeta_t\left(\frac{u_{12t}}{z_{1t}}\xi_1-\frac{u_{22t}}{z_{2t}}\xi_2\right)\right] \qquad (8.2)\\
&-\sum_{t=0}^{\infty}\beta^t\omega_t\left[\sum_{i=1,2}\nu_i\left(\left(1-z_{it}\right)c_{i1t}+z_{2t}\left(c_{i2t}+C\left(z_i\right)\right)-\xi_i n_{it}\right)+\bar{g}_t\right]\\
&+\sum_{i=1,2}\lambda_i u_{i10}m_{i0}
\end{aligned}
$$

where

$$
W^i\left(c_{i1t,}c_{i2t},z_{it},n_{it}\right)=U^i\left(h^i\left(c_{i1t,}c_{i2t}\right),z_{it},n_{it}\right)+\frac{\lambda_i}{\eta_i}\left(u_{i1t}c_{i1t}+u_{i2t}\left(c_{i2t}+C\left(z_i\right)\right)-\gamma n_{it}\right)
$$

$$
m_{20}=\phi_m m_{10},
$$

$$
m_{it}=\frac{M_{it}}{P_t},
$$

for $t\geq 0$ and $i=1,2$.

The variables λ_i and ω_t are the multipliers on the implementability constraints and on the resource constraint for $i=1,2$ and $t\geq 0$, respectively. The multipliers μ_{it} correspond to the constraint that the ratio of the marginal utility of consumption goods bought with cash and on credit be the same for both types, while χ_t is the multiplier on the constraint that the nominal interest rate be non-negative. Since μ_i correspond to equality constraints, they can be either positive or negative. The non-negative multiplier ζ_t corresponds to the constraint $\tau_{2t}\geq\tau_{1t}$. This constraint imposes that the net real wage in efficiency units for low human capital households is at least as high as for high human capital households:

$$
\frac{U_1^1 h_2^1}{z_1}\xi_1\leq\frac{U_1^2 h_2^2}{z_2}\xi_2.
$$

The first order necessary conditions for c_{i1}, c_{i2}, and r_t in (8.1) for $t>0$ are as follows (I drop time subscripts to simplify notation):

$$
\begin{aligned}
0 &= \left(\eta_i+\lambda_i\right)u_{i1}+\lambda_i\sum_{j=1}^{2}\left(U_1^i h_{1j}^i+U_{11}^i h_1^i h_j^i\right)\tilde{c}_{ij} \qquad (8.3)\\
&\quad -\mu_i\frac{z_{it}}{1-z_{it}}\left(\frac{h_{11}^i}{h_1^i}-\frac{h_{21}^i}{h_2^i}\frac{h_1^i}{h_2^i}\right)-\tilde{\zeta}_i\left[U_1^i h_{21}^i+U_{11}^i h_2^i h_1^i\right]-\omega\nu_i\left(1-z_i\right),
\end{aligned}
$$

$$
\begin{aligned}
0 &= \left(\eta_i+\lambda_i\right)u_{i2}+\lambda_i\sum_{j=1}^{2}\left(U_1^i h_{2j}^i+U_{11}^i h_2^i h_j^i\right)\tilde{c}_{ij} \qquad (8.4)\\
&\quad -\mu_i\frac{z_{it}}{1-z_{it}}\left(\frac{h_{12}^i}{h_1^i}-\frac{h_{22}^i}{h_2^i}\frac{h_1^i}{h_2^i}\right)-\tilde{\zeta}_i\left[U_1^i h_{22}^i+U_{11}^i\left(h_2^i\right)^2\right]-\omega\nu_i z_i,
\end{aligned}
$$

$$
\begin{aligned}
& \sum_{i=1}^{2} \mu_i \frac{1-z_i}{z_i} + \chi \begin{cases} \leq 0 \\ = 0 \text{ for } r > 1, \end{cases} && (8.5) \\
0 \quad = \quad & \chi \left(1-r\right), \ \chi \geq 0 \text{ and } r \geq 1,
\end{aligned}
$$

where i indexes agents and j indexes goods. For $i = 1, 2$:

$$
\begin{aligned}
\tilde{\zeta}_i &= \left(-1\right)^{i-1} \zeta \frac{\xi_i}{z_i}, && (8.6) \\
\tilde{c}_{i1} &= c_{i1}, \ \tilde{c}_{i2} = c_{i2} + C\left(z_i\right), \\
h^i_j &= \frac{\partial h^i}{\partial c_{ij}} \text{ for } j = 1, 2, \ h^i_z = \frac{\partial h^i}{\partial z_i}, \\
h^i_{jk} &= \frac{\partial h^i_j}{\partial c_{ik}} \text{ for } k = 1, 2, \\
U^i_1 &= \frac{\partial U^i}{\partial c_i}, \ U^i_{11} = \frac{\partial^2 U^i}{\partial c_i^2}.
\end{aligned}
$$

By definition of $\bar{\eta}_i$ and (8.4), $\zeta_t > 0$ for $\eta_2 > \bar{\eta}_2$ and $\zeta_t = 0$ for $\eta_1 \geq \bar{\eta}_1$. From the first order condition for z_i it is straightforward to verify that $z_2 \geq z_1$ follows from $\xi_2 > \xi_1$.

Combining (8.3) and (8.4) yields:

$$
\frac{u_{i1}/(1-z_i)}{u_{i2}/z_i} = \tag{8.7}
$$

$$
\max\left\{1, \frac{\eta_i + \lambda_i + \lambda_i \sum_{j=1}^{2} \left(\frac{U^i_1 h^i_{2j} + U^i_{11} h^i_2 h^i_j}{U^i_1 h^i_2}\right) \tilde{c}_{ij} - \tilde{\zeta}_i \left[\frac{U^i_1 h^i_{22} + U^i_{11} \left(h^i_2\right)^2}{U^i_1 h^i_2}\right] - \frac{\mu_i}{U^i_1 h^i_2} \frac{z_{it}}{1-z_{it}} \left(\frac{h^i_{12}}{h^i_1} - \frac{h^i_{22}}{h^i_2} \frac{h^i_1}{h^i_2}\right)}{\eta_i + \lambda_i + \lambda_i \sum_{j=1}^{2} \left(\frac{U^i_1 h^i_{1j} + U^i_{11} h^i_1 h^i_j}{U^i_1 h^i_1}\right) \tilde{c}_{ij} - \tilde{\zeta}_i \left[\frac{U^i_1 h^i_{12} + U^i_{11} h^i_1 h^i_2}{U^i_1 h^i_1}\right] - \frac{\mu_i}{U^i_1 h^i_1} \frac{z_{it}}{1-z_{it}} \left(\frac{h^i_{11}}{h^i_1} - \frac{h^i_{21}}{h^i_2} \frac{h^i_1}{h^i_2}\right)}\right\} \tag{8.8}
$$

Proposition 4.2 states that if household specific tax rates are available then the Friedman rule always solves the necessary conditions of the Ramsey allocation problem.

Proof of Proposition 4.2 If taxes are agent specific, the first order conditions for the Ramsey problem are the same as for (8.1) with $\zeta_t \equiv 0$ for $t \geq 0$. By homotheticity:

$$
\sum_{j=1}^{2} \left(U^i_1 h^i_{2j} + U^i_{11} h^i_2 h^i_j\right) \frac{\tilde{c}_{ij}}{U^i_1 h^i_2} = \sum_{j=1}^{2} \left(U^i_1 h^i_{1j} + U^i_{11} h^i_1 h^i_j\right) \frac{\tilde{c}_{ij}}{U^i_1 h^i_1} \text{ for } i = 1, 2. \tag{8.9}
$$

Hence, the expression in (8.8) is equal to 1 i.e. the Friedman rule solves the Ramsey problem (8.1) without the constraints (8.2). Since it also satisfies the constraints in (8.2), the Friedman rule is a necessary condition for optimality of government policy.■

I now prove Proposition 4.3, which asserts that $\eta_1 \geq \bar{\eta}_1$ is a necessary condition for optimality of the Friedman rule.

Proof of Proposition 4.3 To identify the necessary conditions for optimality of the Friedman rule analyze problem (8.1) without imposing the constraints corresponding to χ and μ_i, for $i = 1, 2$. If the Friedman rule satisfies the first order conditions for the less constrained problem, it will also solve (8.1), since at the Friedman rule the constraints corresponding to χ and μ_i, for $i = 1, 2$, are satisfied. Optimality of the Friedman rule implies that the ratio in (8.8) is equal to 1. Using (8.9), it follows that:

$$-\tilde{\zeta}_i \left[\frac{h_{22}^i}{h_2^i U_1^i} + \frac{U_{11}^i}{U_1^i} h_2^i - \frac{h_{12}^i}{U_1^i h_1^i} - \frac{U_{11}^i}{U_1^i} h_2^i \right] \leq 0,$$

which simplifies to:

$$-\frac{\tilde{\zeta}_i}{U_1^i} \left(\frac{h_{22}^i}{h_2^i} - \frac{h_{12}^i}{h_1^i} \right) \leq 0,$$

or equivalently:

$$\begin{aligned} -\frac{\zeta \xi_1}{U_1^1 z_1} \left(\frac{h_{22}^1}{h_2^1} - \frac{h_{12}^1}{h_1^1} \right) &\leq 0, \\ \frac{\zeta \xi_2}{U_1^2 z_2} \left(\frac{h_{22}^2}{h_2^2} - \frac{h_{12}^2}{h_1^2} \right) &\leq 0. \end{aligned}$$

Since:

$$\frac{h_{22}^i}{h_2^i} - \frac{h_{12}^i}{h_1^i} = 1 - \underline{z} + \frac{\underline{z}}{c_i},$$

optimality of the Friedman rule requires $\zeta = 0$, which is equivalent to $\eta_1 \geq \bar{\eta}_1$ ■

9. Appendix C: The One-Period Economy

The following proposition characterizes the private sector equilibrium as a function of government policy $\{\tau, R\}$ in the one-period economy.

Proposition 9.1. *An allocation* $\{c_{i1}, c_{i2}, c_i, n_i, z_i\}_{i=1,2}$ *and a policy* $\{\tau, R\}$ *constitute a private sector equilibrium for the one-period economy for given* $\bar{g}$*, if and only if* z_i *solves (3.17) and* c_{i1}*,* c_{i2}*,* c_i*,* n_i *are determined according to:*

$$c_i = w_i, \tag{9.1}$$

$$n_i = \frac{c_i}{w_i \gamma} \left[\left(R P^i \right)^{\frac{\rho}{\rho - 1}} + \frac{\tilde{P}^i}{P^i} \right], \tag{9.2}$$

$$c_{i2} = c_i \left(P^i \right)^{\frac{1}{1-\rho}}, \tag{9.3}$$

$$\left(\frac{c_{i1}}{c_{i2}}\right)^{\rho-1} = R, \tag{9.4}$$

$$R = \mathcal{R}\left(\tau, \bar{g}\right),$$

where

$$\begin{aligned} P^i &= \left[\left(1-z_i\right) R^{\frac{\rho}{\rho-1}} + z_i\right]^{\frac{\rho-1}{\rho}}, & (9.5)\\ \tilde{P}^i &= P^i + \frac{C\left(z_i\right)}{c_i}, & (9.6)\\ w_i &= \frac{\xi_i\left(1-\tau\right)}{\gamma P^i}, & (9.7)\end{aligned}$$

for $i = 1, 2$, with $\mathcal{R}(\cdot)$ implicitly defined by (5.3).

Proof of Proposition 9.1 The first order conditions for the household problem are given by:

$$\begin{aligned} u_{i1} - R\left(1-z_i\right)\lambda_i &= 0, & (9.8)\\ u_{i2} - z_i\lambda_i &= 0, & (9.9)\\ \gamma - \left(1-\tau\right)\xi_i\lambda_i &= 0, & (9.10)\end{aligned}$$

plus the analogous of (3.17) and (5.2), where λ_i is the Lagrange multiplier on (5.2). (9.1) follows from (9.9), (9.5) and (9.7), (9.4) follows from (9.8)-(9.9). (9.2) follows from (5.2) using (9.5), (9.6) and (9.7).■

Proposition 5.2 characterizes sufficient conditions for increased inequality to correspond to higher equilibirum nominal interest rate in the bargaining equilibrium.

Proof of Proposition 5.2 The necessary condition for the bargaining problem is:

$$p\left[\frac{\mathcal{V}_2}{\mathcal{V}_1}\right]\frac{dU^1\left(\{\tau, R\}\right)}{d\tau} + \frac{dU^2\left(\{\tau, R\}\right)}{d\tau} = 0. \tag{9.11}$$

Assume that it is satisfied at $\{\tau, R\}$ for a given value of ξ_1 and ξ_2. The proof of this Proposition requires establishing that the expression on the LHS of (9.11) is negative at $\xi_2' > \xi_2$, since U^i is quasiconvex with respect to $(1-\tau)$, which implies that U^i is quasiconcave with respect to τ. Given (5.6), it is sufficient to show that $\mathcal{V}_2$ is decreasing in ξ_2 and that $\frac{dU^i(\{\tau,R\})}{d\tau}$ is non-increasing in ξ_i.

By proposition 9.1:

$$U^i\left(\{\tau, R\}\right) = 1 - \gamma\frac{\tilde{P}^i}{P^i\gamma}.$$

This simplifies to:

$$U^i\left(\{\tau, R\}\right) = -\frac{\gamma}{\xi_i}\frac{C\left(z\left(\tau, R; \xi_i\right)\right)}{1-\tau}, \tag{9.12}$$

where $z(\tau, R; \xi_i)$ is implicitly defined by:

$$\left(\frac{1}{\rho} - 1\right)\left(1 - R^{\frac{\rho}{\rho-1}}\right)\left(\frac{\xi_i (1-\tau)}{\gamma}\right)\left(P^i\right)^{\frac{\rho}{1-\rho}} - \theta = 0, \tag{9.13}$$

for z_i interior. (9.13) is the first order condition for z_i in the household problem. Differentiating (9.13) with respect to ξ_i obtains:

$$\frac{\partial z(\tau, R; \xi_i)}{\partial \xi_i} = \frac{1}{\xi_i}\frac{\left(1 - R^{\frac{\rho}{\rho-1}}\right) z_i + 1}{\left(1 - R^{\frac{\rho}{\rho-1}}\right)} \geq 0. \tag{9.14}$$

From (9.12):

$$\mathcal{V}_i = \max\left\{0, -\frac{\gamma C(z(\tau, R; \xi_i))}{(1-\tau)\xi_i} + \frac{\gamma C\left(z\left(\tau^T, R^T; \xi_i\right)\right)}{(1-\tau^T)\xi_i}\right\}.$$

To see that $\mathcal{V}_2/\mathcal{V}_1$ is decreasing in ξ_2, it is sufficient so analyze the derivative of $\mathcal{V}_i$ with respect to ξ_i equal to:

$$\frac{\partial \mathcal{V}_i}{\partial \xi_i} = \gamma\left[-\frac{\partial z(\tau, R; \xi_i)}{\partial \xi_i}\frac{\theta(z(\tau, R; \xi_i))}{(1-\tau)\xi_i} - \frac{1}{\xi_i}\mathcal{V}_i\right] \leq 0,$$

by (9.14) and (5.5). (5.6) implies that $\frac{dU^2(\{\tau,R\})}{d\tau} \leq 0$. To show that $\frac{dU^2(\{\tau,R\})}{d\tau}$ is non-increasing in ξ_2 note that:

$$\frac{dU^i}{d\tau} = \frac{\partial U^i}{\partial \tau} + \frac{\partial U^i}{\partial R}\frac{\partial R}{\partial \tau},$$

and

$$\begin{aligned}
\frac{\partial U^i}{\partial \tau} &= \frac{-\gamma\theta}{\xi_i (1-\tau)}\left[\frac{\partial z(\tau, R; \xi_i)}{\partial \tau} + \frac{z_i}{1-\tau}\right], \\
\frac{\partial U^i}{\partial R} &= \frac{-\gamma}{\xi_i (1-\tau)}\theta\frac{\partial z(\tau, R; \xi_i)}{\partial R}.
\end{aligned}$$

From:

$$\begin{aligned}
\frac{\partial z(\tau, R; \xi_i)}{\partial R} &= \frac{\rho}{1-\rho}\frac{R^{\frac{1}{\rho-1}} z_i}{\left(1 - R^{\frac{\rho}{\rho-1}}\right)}, \\
\frac{\partial z(\tau, R; \xi_i)}{\partial \tau} &= -\frac{\left(1 - R^{\frac{\rho}{\rho-1}}\right) z_i + 1}{\left(1 - R^{\frac{\rho}{\rho-1}}\right)(1-\tau)},
\end{aligned}$$

one can show that:

$$\begin{aligned}
\frac{d\left(\frac{\partial U^i}{\partial \tau}\right)}{d\xi_i} &= \frac{-\gamma}{\xi_i^2 (1-\tau)^2} \leq 0, \\
\frac{d\left(\frac{\partial U^i}{\partial R}\right)}{d\xi_i} &= \frac{\gamma\theta}{\xi_i (1-\tau)}\frac{\partial z}{\partial R}\left(\frac{1}{\xi_i (1-\tau)} + \frac{\partial z_i}{\partial \xi_i}\frac{1}{z_i}\right) \geq 0.
\end{aligned}$$

Then, $\frac{d\left(\frac{dU^i}{d\tau}\right)}{d\xi_i} \leq 0$ follows from $\partial R/\partial\tau \leq 0.$■

10. Appendix D: Calibration

Here I describe the strategy to determine the parameters values displayed in Table 3.

To calibrate inequality, I set $\xi_1 = 1$ and $\nu = 0.60$, and vary ξ_2/ξ_1 to match the ratio of average income per capita accruing to the top 40% to the average income per capita accruing to the bottom 60% of the population in the data (denoted with $y40/y60$ in Section 2) for $\tau = 0.30$ and $R = 1.06$.

The intertemporal elasticity of substitution also determines the elasticity of labor supply with respect to the real wage. A value of σ smaller than 1 is required to ensure that consumption and labor supply are gross substitutes and that equilibrium labor supply increases with the net real wage. I set $\sigma = 0.7$ which corresponds to a value of the elasticity of household labor supply with respect to the real wage of at most 33%. Estimates of the labor supply elasticity vary greatly in the literature, as documented by Christiano, Eichenbaum and Evans (1996). Micro studies report a labor supply elasticity close to 0, corresponding to a value of σ close to 1, but estimates of up 5, corresponding to σ close to 0.16, have been used in macro studies of the labor supply elasticity. I perform a sensitivity analysis by varying this parameter between 0.60 and 1. The nominal interest rate in an equilibrium with constant tax rate is not very sensitive to the value of σ.

I set ρ, θ_0 and θ_1 to match the estimates of the interest elasticity of M1 and the ratio of the M1 to output in the US economy for the post-war period reported by Dotsey and Ireland (1996). These statistics are reported in Table 2. The substitutability between consumption goods allows an extra degree of freedom in the calibration, since ρ also needs to be pinned down. I use results in Aiyagari, Braun and Eckstein (1998) on this variable for the US to determine an upper bound for ρ. They run a regression of inverse velocity for the US on the nominal interest rate and the relative size of the banking sector (percentage of bank to total employees), interpreted as a proxy for the size of the transaction services sector. The coefficient on the nominal interest rate in this regression measures the interest elasticity of money demand for a given payment structure i.e. along the intensive margin. This corresponds to the elasticity of substitution between consumption goods in the model, given by $\rho/(\rho-1)$. Their estimate of -1.15 for the coefficient on the nominal interest rate corresponds to $\rho = 0.5349$. I take this value as an upper bound because their estimate uses $M0$ inverse velocity while M1 is used for the rest of the calibration. The estimate of the overall interest elasticity of money demand in Aiyagari, Braun and Eckstein (1998) is equal to 10.02, close to double the one found by Dotsey and Ireland (1996) for $M1$. I conjecture that the same difference would arise for the short run elasticity.

I set government spending so that it equals approximately 30% of aggregate employment in equilibrium.

11. Data Appendix

The data on inflation from Easterly, Rodriguez and Schmidt-Hebbel (1994) and the data on income inequality is from the Deinenger and Squire (1996) source file. For most countries the "high quality" data, according to their definition, was used. For countries in which such data is based on net of tax income, data from the Luxemburg Income Study based on before tax income was used instead. This adjustment is made for Belgium, Norway, Sweden, Finland and the UK. For Argentina no comparable data with national coverage is available. The measures provided are based on household surveys conducted in urban centers and the greater Buenos Aires area.

Political instability is measured as the actual frequency of transfers of power in the period 1971-1982, from Edwards and Tabellini (1992). A transfer of power is defined as a situation where there is a break in the governing political party control of executive power. It measures the instability of the political system by capturing the changes in the political leadership from the governing party or group to an opposition party. It varies between 0 and 1, where 0 represents perfect stability. Data on central bank independence is from Cukierman (1992). Legal central bank independence is measured based on a number of indicators, including the power of the central bank governor, the independence in policy formulations and in the definitions of objectives and on the presence of limitations on lending to the treasury. The included index measures overall independence for the 1980's. The values of this variable range from 0 (minimal independence) to 1 (maximum independence). The turnover rate for central bank governors is the average number of changes per annum in the period 1950-1989 and measures actual central bank independence. The IMF International Financial Statistics are used for data on GDP per capita.

I provide a list of countries and variables included in the sample below.

List of Available Data for Countries Included in the Sample

Country	Gini 66-90	y40/y60	% Inflation 66-90	Political Instability	Legal Independence	Turnover
Argentina	40.13	3.53	375.41	na	0.44	0.93
Australia	39.53	3.15	8.06	0.154	0.31	na
Austria	37.99	2.39	4.59	0.077	0.58	na
Bangladesh	35.33	2.74	13.51	0.019	na	na
Belgium	30.45	2.15	5.50	0.077	0.19	0.13
Bolivia	52.74	3.53	561.33	0.538	0.25	na
Brazil	55.91	6.43	262.26	0.000	0.26	na
Canada	31.84	2.43	6.39	0.154	0.46	0.1
Chile	53.12	4.87	83.35	0.154	0.49	0.45
Colombia	50.83	4.76	20.03	0.154	na	0.2
Costa Rica	45.02	4.18	15.84	na	0.42	0.58
Denmark	37.12	2.53	7.66	0.308	0.47	0.05
Dom.Rep.	46.27	4.15	14.82	0.154	na	na
Ecuador	51.28	3.96	21.07	0.231	na	na
Egypt	48.40	2.50	11.18	na	0.53	0.31
El Salvador	44.20	4.60	12.22	0.231	na	na
Finland	35.53	2.60	8.18	0.308	0.27	0.13
France	40.48	2.68	7.28	0.077	0.28	0.15
Germany,Fed.Rep.	32.13	2.43	3.57	0.000	0.66	0.1
Greece	40.85	na	13.91	0.308	0.51	0.18
Guatemala	57.83	5.61	10.212	na	na	na
India	37.18	na	8.13	0.154	0.33	0.33
Indonesia	40.30	2.53	21.79	0.000	0.32	na
Ireland	37.20	3.11	9.70	0.308	0.39	0.15
Israel	37.07	2.85	66.11	na	0.42	0.14
Italy	35.82	2.45	10.08	0.000	0.22	0.08
Japan	34.60	2.86	5.56	0.000	0.16	0.2
Korea, Rep. of	35.20	2.75	11.62	na	0.23	0.43
Mexico	52.62	5.68	35.08	0.000	0.36	0.15
Netherlands	30.27	2.37	4.89	0.385	0.42	0.05
Norway	32.27	2.58	7.03	0.308	0.14	0.08
Pakistan	35.81	2.23	8.67	0.231	0.19	na
Paraguay	47.40	na	14.45	0.000	na	na
Peru	49.49	6.37	504.18	0.154	0.43	0.33
Philippines	45.90	4.32	12.97	0.000	0.42	0.13
Portugal	38.70	2.87	15.38	0.385	na	na
Spain	33.70	2.18	10.81	0.154	0.21	0.2
Sweden	31.64	2.29	7.63	0.154	0.27	0.15
Tanzania	41.28	3.04	19.60	0.000	0.48	0.13
Thailand	42.15	4.13	6.26	0.385	0.26	0.2
Trinidad and Tobago	46.27	4.07	10.46	0.000	na	na
Turkey	45.29	4.81	33.42	0.692	0.44	0.4
UK	32.93	2.52	9.07	0.154	0.31	0.1
Uruguay	41.47	na	63.596	na	0.22	0.48
USA	35.58	2.87	5.89	0.231	0.51	0.13
Venezuela	42.59	3.79	13.72	0.154	0.37	0.3

Figure 1: Inflation Tax and Inequality− Full Sample

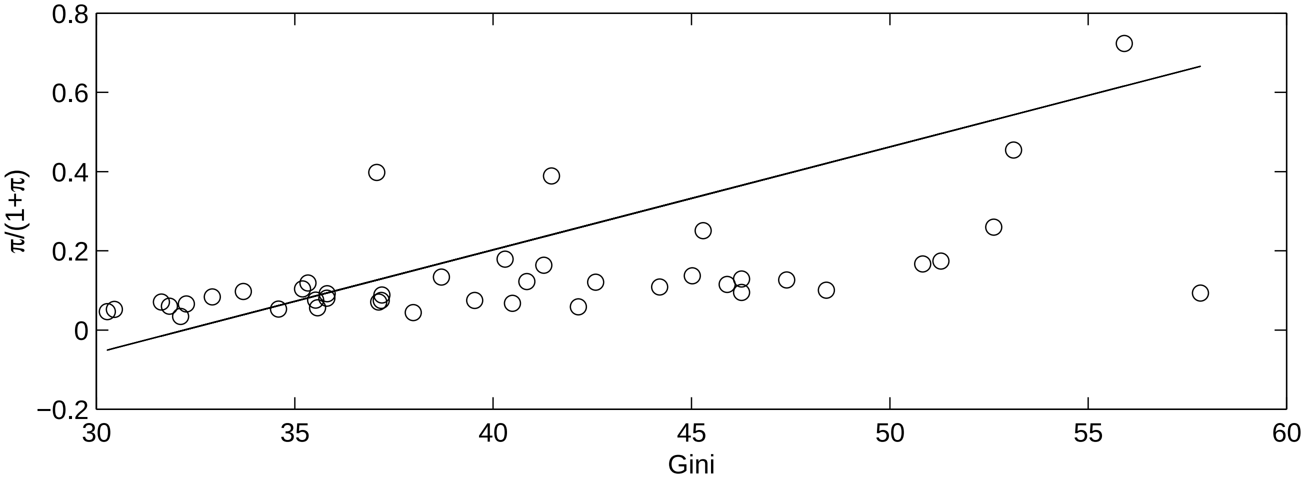


Figure 2: Inflation Tax and Income Differentials− Full Sample

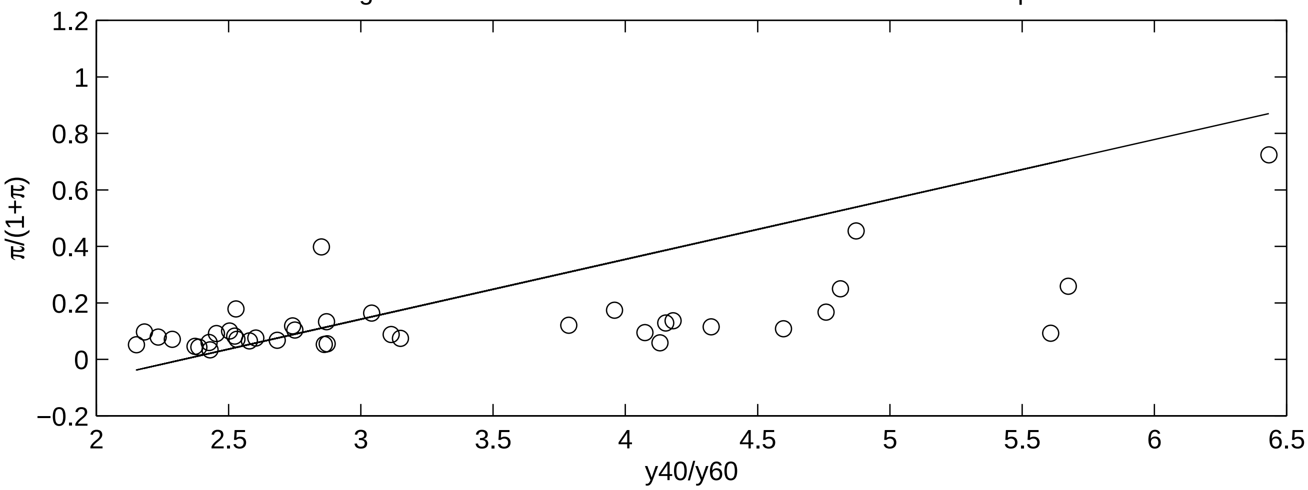


Figure 3: Inflation Tax and Inequality− OECD

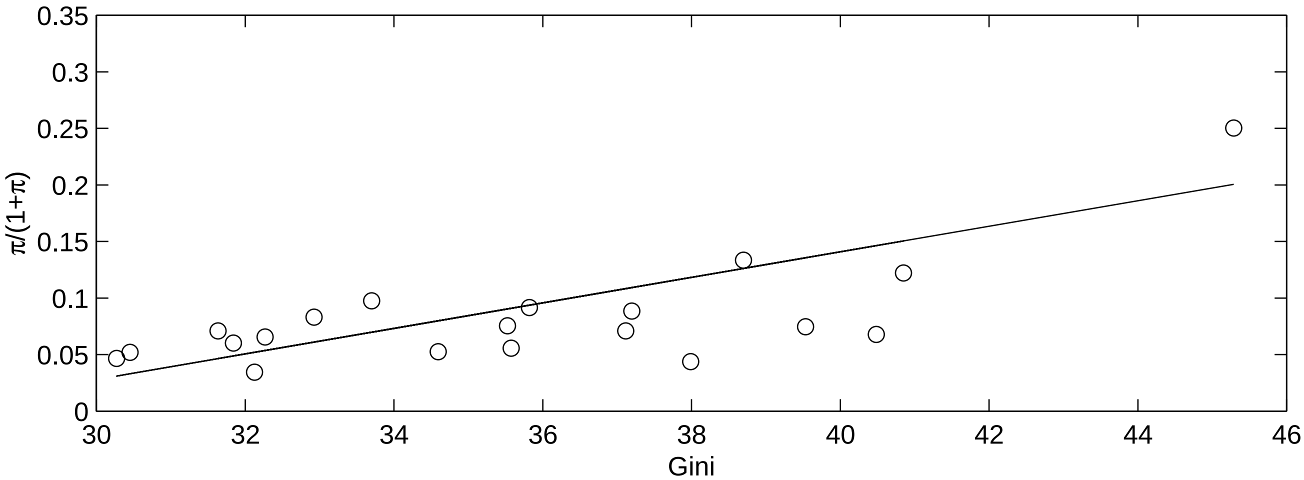


Figure 4: Inflation Tax and Inequality− Developing

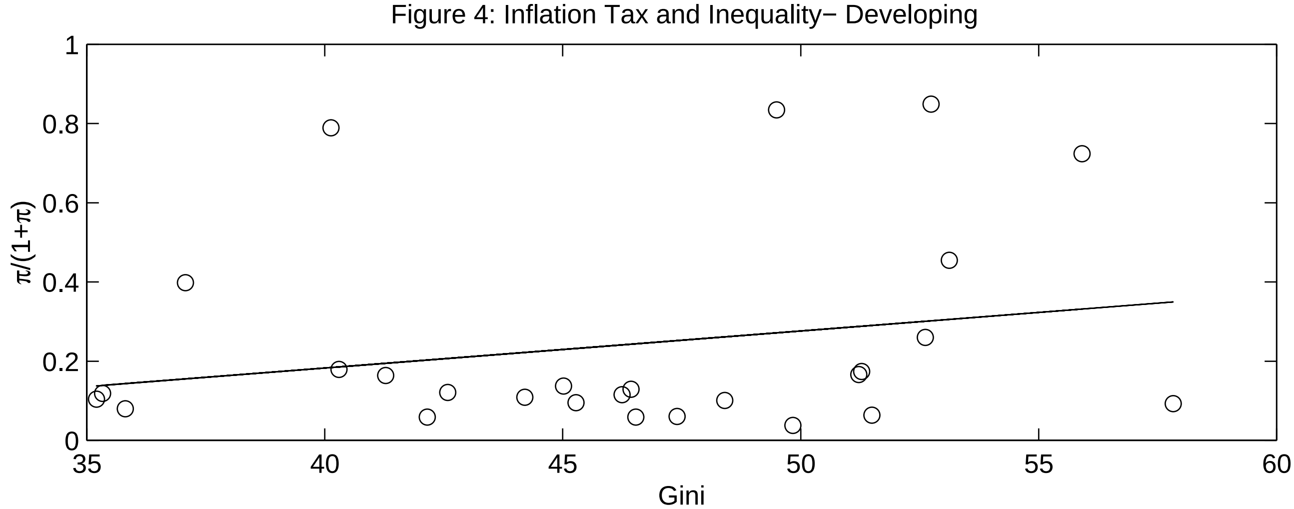


Figure 5: Correlation conditional on GDP per capita− Full sample

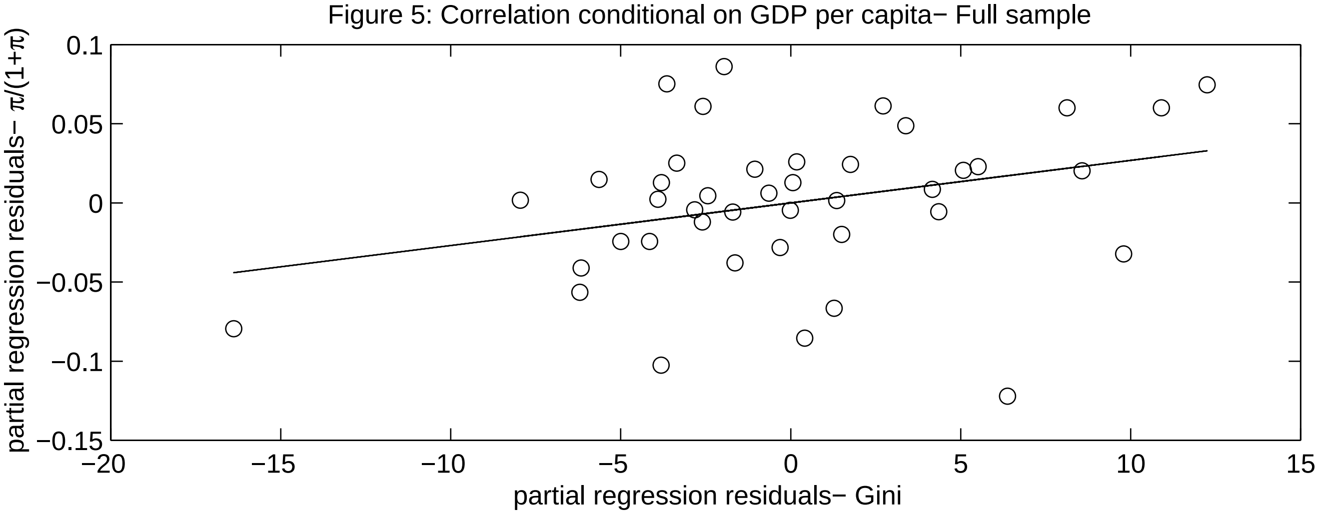


Figure 6: Correlation conditional on instab and CB indep− Full sample

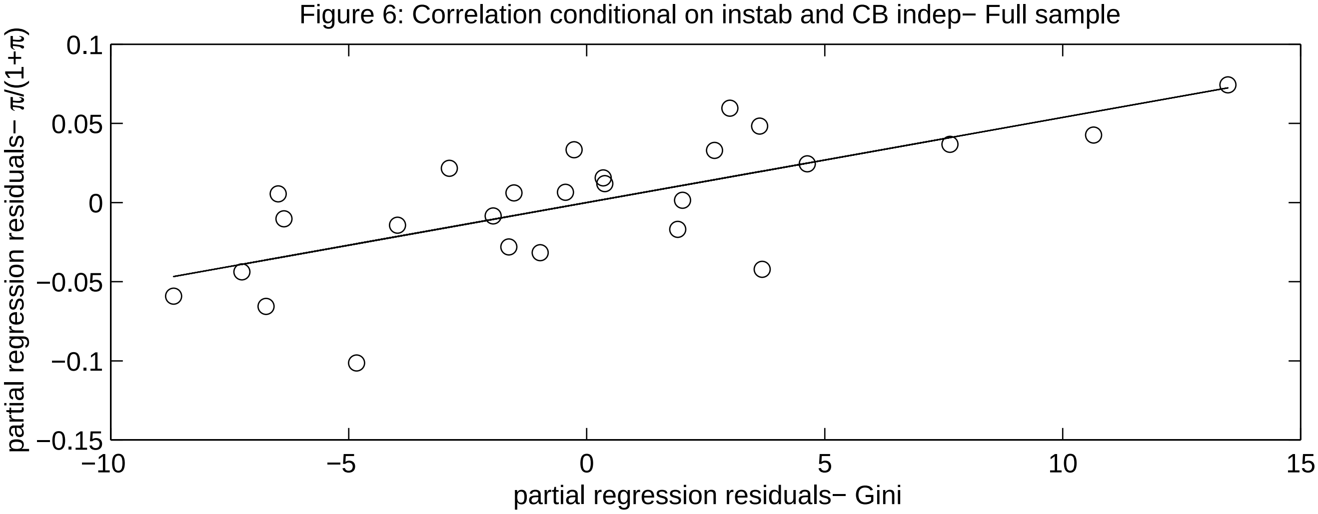


Figure 7: Correlation conditional on CB indep− OECD

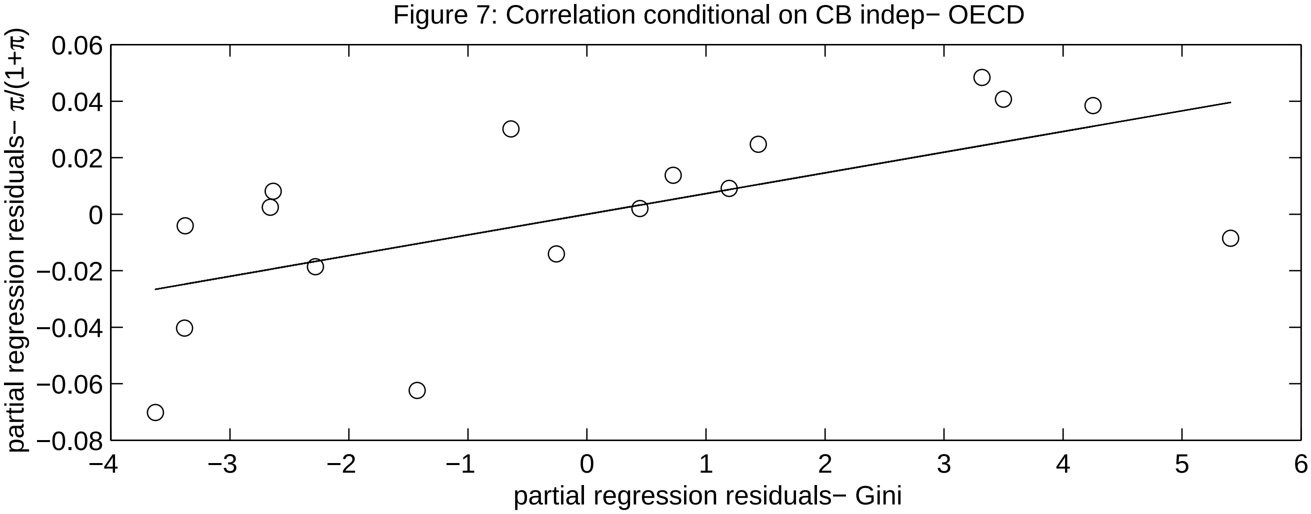


Figure 8: Correlation conditional on instab− Developing

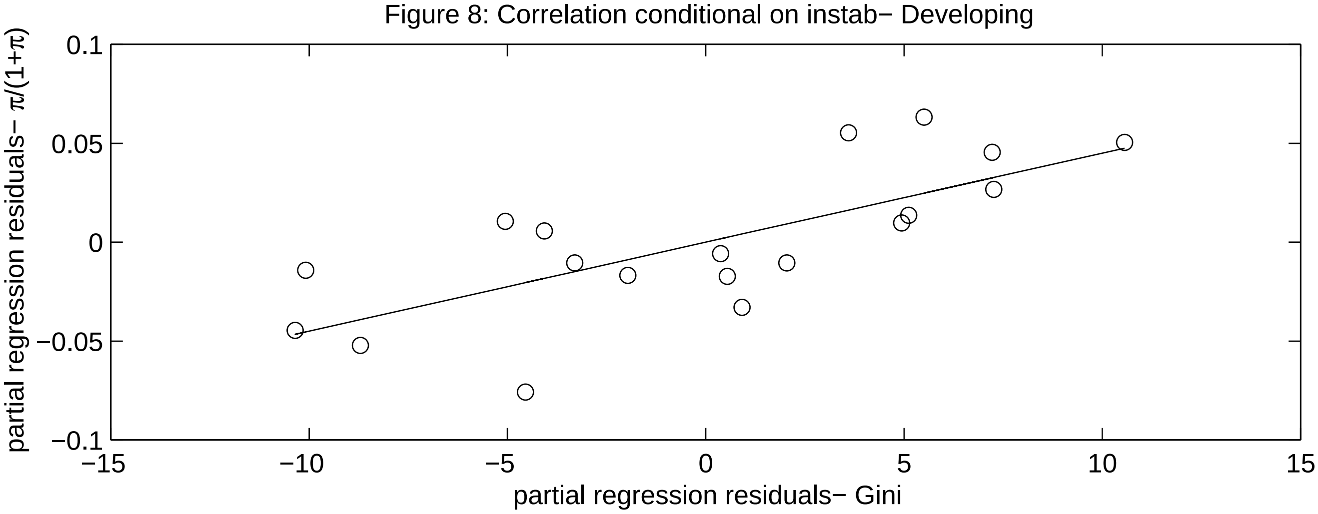


Table 1.A

Statistics on Inflation and Inequality

	y40/y60	(Country)	Gini	(Country)	Inflation	(Country)
max	6.43	(Brazil)	57.83	(Brazil)	689.31	(Nicaragua)
min	2.15	(Belgium)	30.27	(Belgium)	3.57	(Germany)
median	3.11	(Ireland)	38.70	(Portugal)	10.46	(Spain)
st. dev.	1.21		7.34		15.45*	

	%CPI Inflation	Gini	y40/y60
USA	5.89	35.57	2.87

Outliers

	Morocco	Tunisia	Malaysia	Honduras	(Guatemala)
%CPI Inflation	6.48	6.29	3.96	6.83	10.21
Gini	47.40	49.15	49.84	51.50	57.83
y40/y60	3.83	4.14	4.60	6.33	5.61

Correlation with Inflation

	Full Sample	Excluding Outliers	Ex. Outliers and Hyperinflations
Gini	0.21	0.39	0.40
y40/y60	0.34	0.41	0.42

	OECD Countries	Developing Countries	Dev. Countries Ex. Outliers
Gini	0.70	0.22	0.27
y40/y60	0.85	0.23	0.30

Sample Size	51	**Correlation Between Gini and y40/y60**	0.62

y40/y60 Ratio of Average Income per Capita in Top 40% of Population to Bottom 60%.

* Excludes countries with per annum inflation above 100%

Table 1.B

The Relation between the Inflation Tax and Inequality*

White Heteroskedasticity-Consistent Standard Errors

	Full Sample		OECD Countries		Developing Countries	
	coeff	t-stat	coeff	t-stat	coeff	t-stat
Intercept	0.73	21.8914	0.6391	8.6298	0.8657	16.6387
Slope	0.4561	5.7042	0.6784	3.289	0.1765	1.5641
R-squared	0.4251		0.3754		0.1043	

The Relation between the Inflation Tax and the Distribution of Income

White Heteroskedasticity-Consistent Standard Errors

	Full Sample		OECD Countries		Developing Countries	
	coeff	t-stat	coeff	t-stat	coeff	t-stat
Intercept	0.8247	40.6735	0.7646	18.6738	0.9077	34.6076
Slope	0.0265	4.7356	0.0422	2.8427	0.0096	1.5344
R-squared	0.3592		0.3222		0.1008	

Adding Conditioning Variables - Dependent Variable: Inflation Tax

White Heteroskedasticity-Consistent Standard Errors

Full Sample

Sample Size	39		25		39		31		26	
	coeff	t-stat	coeff	t-stat	coeff	t-stat	coeff	t-stat	coeff	t-stat
Intercept	0.8673	7.1874	0.6775	15.6812	0.6768	22.77	0.7143	17.2376	0.6794	16.8875
Gini*	0.4267	3.9192	0.608	4.5892	0.5634	7.97	0.5063	4.2972	0.5264	4.5204
Instability			0.0207	0.5015	0.0325	1.03			0.0133	0.3219
Legal Indep.			-0.0718	-1.37			-0.0674	-1.2349		
Turnover			0.0587	0.7075			0.1011	2.6615	0.0826	1.0261
GDP per capita	-0.0145	-1.4599								
R-squared	0.56		0.6965		0.6415		0.61		0.6755	

Developing Countries

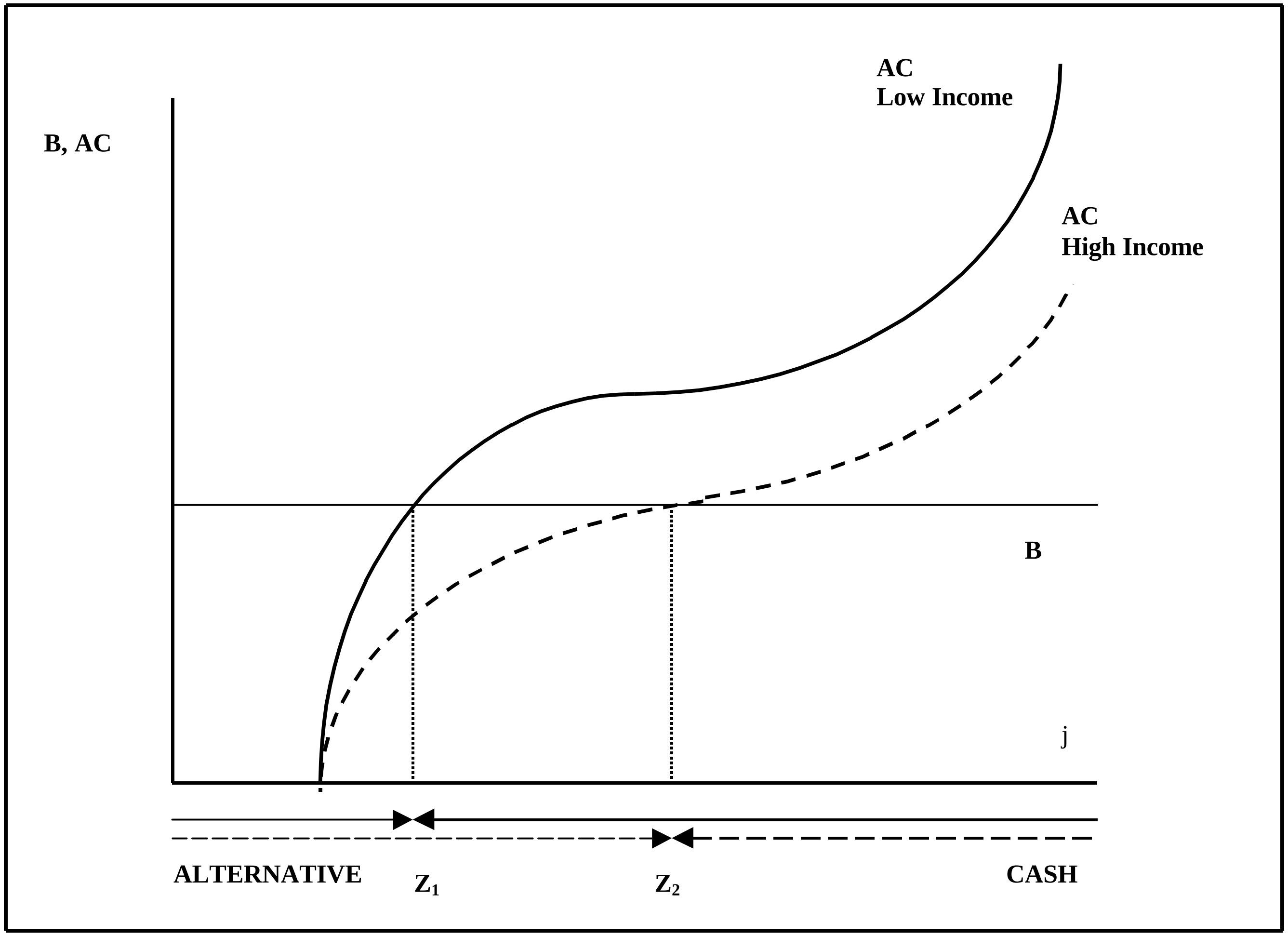
Sample Size	19		15	
	coeff	t-stat	coeff	t-stat
Intercept	0.7415	15.5363	0.81	9.3394
Gini*	0.4501	4.3462	0.25	1.3708
Instability	-0.0354	-0.8238		
Legal Indep.				
Turnover			0.07	1.4735
R-squared	0.5442		0.2235	

OECD Countries

Sample Size	17		17		21	
	coeff	t-stat	coeff	t-stat	coeff	t-stat
Intercept	0.6567	8.83	0.6901	1.4235	0.6425	8.7412
Gini*	0.7207	2.87	0.467	2.8702	0.6384	3.0137
Instability			0.0548	0.7929	0.0648	1.3079
Legal Indep.	-0.1139	-2.2158				
Turnover	0.0722	0.5849	0.1044	1.6716		
R-squared	0.6382		0.5363		0.4649	

*Gini coefficient devided by 100.

Figure 9: Optimal Choice of Transaction Services- Effect of Scale Economies



B= Benefit of purchasing good j with alternative payment technology per unit of consumption
AC= Cost of purchasing good j with alternative payment technology per unit of consumption

Table 2

Money Demand Calibration	
$v=PY/M^d$	elasticity=dln(v)/(dR)
From Dotsey and Ireland (1996)	
Data for the US for 1959-1991	
Average annualized nominal interest rate	
	6%
Interest elasticity of money demand- M1	
	5.95
Average M1 velocity	
	5.4
From Ayagari, Braun and Eckstein (1998)	
Short Run Elasticity of Money Demand-M0	
	1.15
Inequality Calibration	
Data for the US for 1965-1990	
y40/y60	2.87

Table 3

Benchmark Parameters				
σ	0.7			
θ_0	0.021			
θ_1	0.3232			
$\rho<=$	0.5349			
Statistics at R=1.06 and ξ_2=1.837				
ρ	**0.2**	**0.3**	**0.4**	**0.5**
v	2.11	*2.11*	2.12	2.14
z_1	0.11	*0.11*	0.12	0.12
z_2	0.33	*0.33*	0.33	0.33
elasticity	5.81	*5.90*	6.02	6.19
Income Inequality at R=1.05 and τ=0.30				
ξ_2/ξ_1	1.7	2.2	2.7	3.2
y40/y60	2.12	3.08	4.13	5.27

Table 4

Properties of the Ramsey Equilibrium

	η_1=0.40				ξ_2=1.837		
ξ_2	**1.84**	**3.67**	**5.51**	η_1	**0.40**	**0.50**	**0.70**
R	1.15	1.18	1.26	**R**	1.21	1.14	1.00
τ	0.22	0.20	0.17	τ	0.23	0.27	0.38
c_1	0.11	0.11	0.11	c_1	0.10	0.10	0.11
z_1	0.30	0.39	0.56	z_1	0.37	0.17	0.00
n_1	0.17	0.17	0.18	n_1	0.17	0.17	0.16
c_2	0.29	0.80	1.45	c_2	0.27	0.26	0.25
n_2	0.22	0.31	0.37	n_2	0.23	0.22	0.22
z_2	0.84	0.99	1.00	z_2	0.90	0.75	0.00
P_2/P_1	0.95	0.90	0.87	P_2/P_1	0.93	0.96	1.00
y40/y60	2.36	6.54	11.37	**y40/y60**	2.49	2.42	2.50

Table 5

Sentitivity of Ramsey Equilibrium

Response of Ramsey Policy to θ_0

$\rho=0.30$, $\theta_1=0.3232$, $\sigma=0.7$, $\xi_2=1.837$, gbar/GDP=0.30, $\eta_1=0.40$

θ_0	**0.0105**	**0.021**	**0.0315**	**0.042**
R	1.6082	1.1523	1.068	1.0884
τ	0.1092	0.2165	0.2351	0.2205

Response of Ramsey Policy to ρ

$\theta_0=0.0421$, $\theta_1=0.3232$, $\sigma=0.8$, $\eta_1=0.40$

ρ	**0.15**	**0.35**	**0.55**	**0.75**
τ	0.1616	0.1974	0.2455	0.297
R	1.121	1.0855	1.0452	1

$\theta_0=0.021$, $\theta_1=0.3232$, $\sigma=0.7$, gbar/GDP=0.17, $\xi 2=3.6740$, $\eta_1=0.40$

ρ	**0.2**	**0.5**	**0.65**	**0.8**
R	1.5857	1.0005	1.0064	1.0468
τ	-0.0405	0.1965	0.1857	0.1493

Table 6

Parameters			
σ	γ	β	
0.7	3	0.97	
r	q_0	q_1	
0.05	0.021	0.3232	
Statistics at R=1.06, t=0.3 and x_2=1.7			
Semi-Elasticity	z1	z2	M/GDP
-5.774	0.074	0.453	0.698
x_2	**1.8**	**3.6**	**5.5**
gbar	0.085	0.150	0.218
Threat Point			
t	0.25	0.22	0.21
% inflation	10.26	37.85	15.11
R	1.13	1.42	1.19
Equilibrium			
t	0.278	0.239	0.219
% inflation	0.00	3.84	9.10
R	1.02	1.07	1.12
V_2/V_1	0.33	0.13	0.01
gbar/GDP	0.25	0.24	0.23

Table 7

Parameters			
σ	γ	β	
0.7	3	0.97	
r	q_0	q_1	
0.05	0.0421	0.3232	
Statistics at R=1.06, t=0.30 and x_2=2.1			
Semi-Elasticity	z1	z2	M/GDP
-4.550	0.007	0.162	0.720
x_2	**2.1**	**4**	**4.8**
gbar	0.085	0.169	0.211
Threat Point			
t	0.2	0.23	0.23
% inflation	17.59	18.29	38.90
R	1.18	1.19	1.40
Equilibrium			
t	0.244	0.255	0.253
% inflation	0.49	4.76	8.64
R	1.04	1.08	1.12
V_2/V_1	0.31	0.10	0.04
gbar/GDP	0.27	0.26	0.26

Table 8

Slope of the Relationship between Inflation and Inequality Predicted by the Model

	Ramsey Equilibrium			Stationary Nash Bargaining Equilibrium					
	From Table 4			From Table 6			From Table 7		
x_2/x_1	**1.8**	**2.1**	**4**	**1.8**	**2.1**	**4**	**1.8**	**2.1**	**4**
y40/y60	2.36	2.95	7.57	2.3	2.9	7.21	2.32	2.91	7.24
% inflation	18.79	18.94	24.45	0.00	0.54	5.22	-0.65	0.49	4.76
Slope	**1.13**			**1.07**			**1.06**		
Slope at low ξ_2	0.25			0.90			1.93		
Slope at high ξ_2	1.19			1.09			0.99		

Slope of the Relationship between Inflation and Inequality in the Data

	Gini Coefficient	**y40/y60**	
OECD	1.13	**2.56**	**
Full*	0.98	**4.46**	

*Excludes countries with average inflation surpassing 60% per annum.

** Excludes Turkey

Figure 10: Features of the Bargaining Problem− Benchmark Parameterization, ξ2=1.8

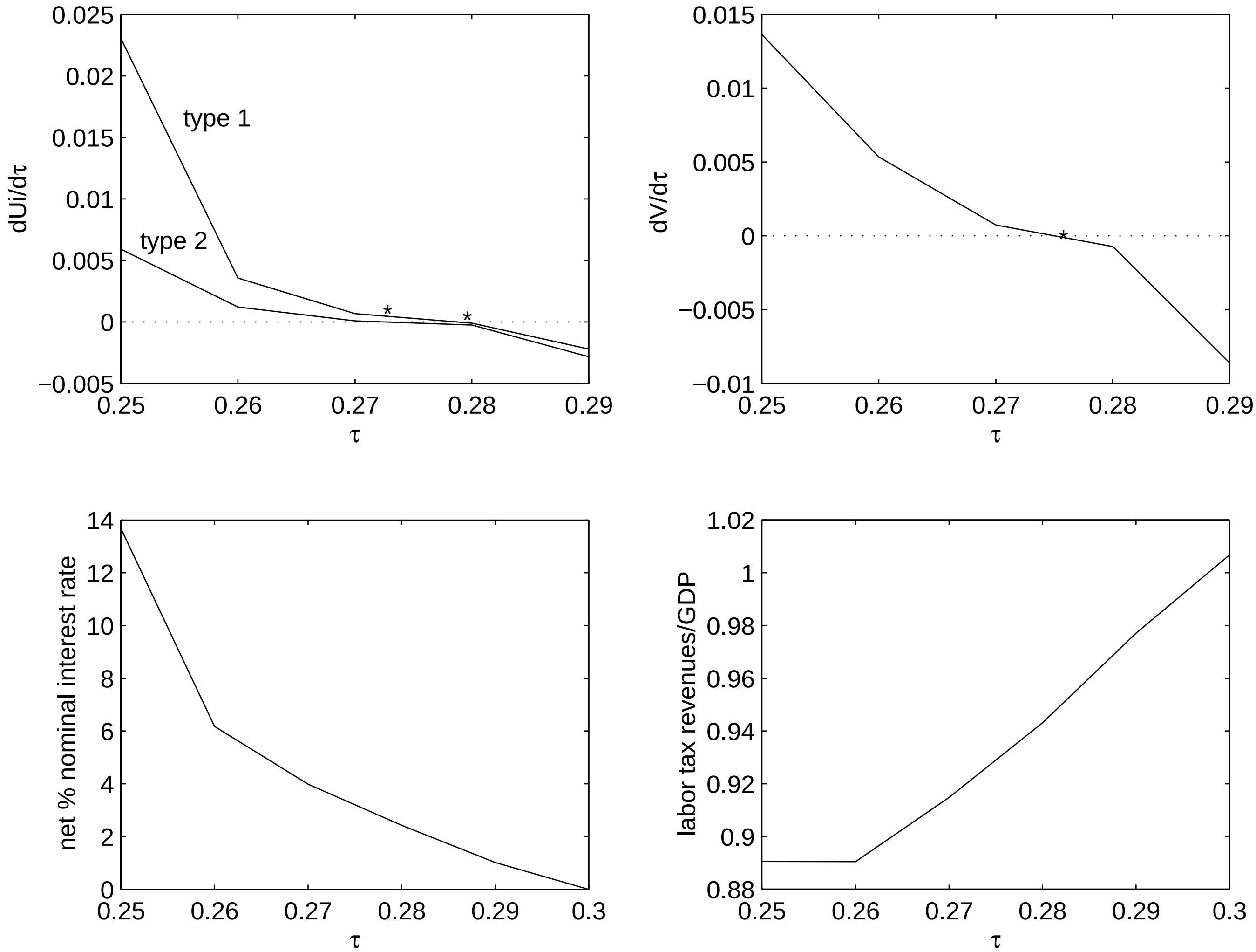


Figure 11: Predicted Relation Between Inequality and Inflation