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Inflation and inequality ☆

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Abstract

Cross-country evidence on inflation and income inequality suggests that they are positively related. This article explores the hypothesis that this correlation is the outcome of a distributional conflict underlying the determination of government policies. A political economy model is presented 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.
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1. Introduction

Observations from a large sample of countries reveal a strong positive correlation between average inflation and measures of income inequality in the post-war period. This article explores the hypothesis that this correlation is the outcome of a distributional conflict underlying the determination of government policies. A political economy model is presented in which equilibrium inflation is positively related to income inequality due to the relative vulnerability to inflation of low income households.

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The centerpiece of the analysis is a monetary economy in which income inequality is an increasing function of permanent and exogenous differences in labor productivity.[1] The nature of the transaction technology implies that in equilibrium low income households hold more cash as a fraction of their total purchases. This is consistent with empirical evidence on transaction patterns and implies that low income households are more vulnerable to inflation. The political process for the determination of government policy is modelled as a bargaining game, following Bassetto (1999). The government must finance an exogenous level of government consumption by taxing labor income at a proportional rate or by increasing the supply of currency. Taxes cannot be raised and the government must resort to monetary financing if an agreement is not reached. Since currency is used for transactions, inflation is costly and there is an incentive to reach an agreement. However, since low income households hold more currency as a fraction of their total purchases, they stand to lose more than high income households if an agreement is not reached. This weakens their bargaining position and implies that the outcome of the political process will be biased against them. Higher inequality, arising from greater differences in labor productivity, increases the relative vulnerability to inflation of low income households and determines a further weakening of their bargaining position. These properties imply that equilibrium inflation is positively related to income inequality. For a plausibly parameterized version of the economy, 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.

The two critical elements in this framework are the higher vulnerability to inflation of low income households and the fact that the political process is modelled as a bargaining game. The cross-sectional distribution of currency holdings and transaction patterns by income level, as well as the survey evidence on the perceived costs of inflation, strongly suggest that low income households are more exposed to inflation. 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 income and wealth, and inversely related to the level of education. Attanasio et al. (2002) 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 (2001) present indirect evidence on the distributional consequences of inflation. Based on household polling data for 38 countries, they 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.[2]

The model assumes that there are two types of households who differ in labor productivity. Households supply labor and purchase consumption goods, and they make purchases with currency or by using a costly payment technology, as in Prescott (1987). Households trade-off the cost of transaction services against the foregone interest income

[1]Inequality in labor productivity is interpreted as resulting from socio-economic and institutional characteristics, such as access to public primary education. These characteristics change at a lower frequency than fiscal and monetary policy, as discussed by Sokoloff and Engerman (2000), and can be treated as exogenous for the purpose of this analysis.

[2]This data is described in more detail in Section 2.

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associated with holding currency, which is proportional to inflation. The presence of economies of scale in the alternative payment technology implies that low income households face a higher average cost of transaction services than those with high income.[3] Accordingly, they hold more currency as a fraction of their total purchases and are more vulnerable to inflation.

High inflation has often been explained as the outcome of "populist policies", broadly defined as policies that emphasize redistribution from the rich to the poor.[4] The presumption is that populist policies are favored by low income households, and more likely arise in countries with high income inequality. This view is inconsistent with the positive cross-country correlation between income inequality and inflation. Given the empirical evidence on the higher costs of inflation for low income groups, redistribution in favor of low income households should not be associated with high inflation.

This observations provides the motivation to model the process for the determination of government policy as a bargaining game. Standard majority voting models, which provide a natural alternative, would typically predict that higher inequality is associated with *lower* inflation, in an economy with realistic implications for the redistributional impact of inflation. A bargaining formulation of the political process implies that government decisions emerge from a consensus between different groups in the population. Thus, it captures an important feature of most political systems, that minorities are able to exert significant pressure on government policies. In the model presented here, the bargaining power of different types 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.[5] This property gives rise to the result that higher income inequality is associated with higher equilibrium 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. Section 4 describes the bargaining equilibrium in detail and characterizes the sufficient conditions for inflation to be positively correlated with inequality. Section 5 concludes.

2. The correlation between inflation and inequality

Fig. 1 is a scatter plot of the average inflation tax, defined as $\pi/(1+\pi)$ where π is the yearly inflation rate, and the Gini coefficient 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 Appendix. The top panel of Fig. 1 shows a strong positive correlation between inequality and inflation. The bottom panel of Fig. 1 is a scatter plot of inflation on an alternative measure of

[3]Descriptive evidence from the Federal Reserve Bulletin in Sprenkle (1993) supports the notion of substantial economies of scale in cash management.

[4]Dornbusch and Edwards (1989) provide a detailed discussion of populist policies in Latin America.

[5]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.

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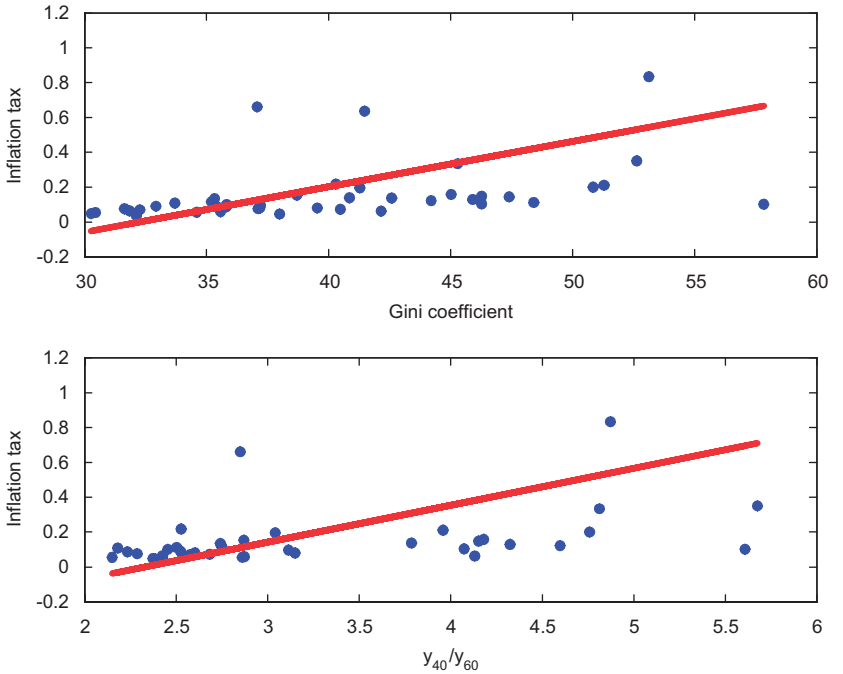

Fig. 1. The positive correlation between inflation and inequality.

inequality, denoted with $y40/y60$, 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. The same positive relation emerges.

Table 1 reports descriptive statistics on inflation and inequality. 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.[6] A group of four countries, Morocco, Tunisia, Malaysia and Honduras, stand out for having low inflation but very high inequality.[7] Excluding these countries from the sample increases the correlation between inflation and the Gini coefficient to 0.39.

Table 1 also reports OLS estimates of the relation between the inflation tax and inequality. The estimated slope coefficient is 0.4561 and is significant at the 1% level[8] 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 $2 \times (1+\pi)^2$. The inflation tax transformation reduces the extent to which extreme rates of inflation dominate the estimates and captures the

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

[7]The percentage inflation rate and the Gini coefficient are, respectively, 6.48% and 47.40% in Marocco, 6.29% and 49.15% in Tunisia, 3.96% and 49.84% in Malaysia, 6.83% and 51.50% in Honduras, and 10.21% and 57.83% in Guatemala.

[8]Standard errors are White-heteroskedasticity consistent. The full set of results, including t-statistics, are available in Albanesi (2002a).

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Table 1
The relation between inflation and inequality

	Summary statistics						Correlation with inflation			
	y40/y60[a]	(Country)	Gini	(Country)	Inflation	(Country)		All countries	OECD countries	Developing countries
Max	6.43	(Brazil)	57.83	(Brazil)	689.31	(Nicaragua)	Gini	0.21	0.70	0.22
Min	2.15	(Belgium)	30.27	(Belgium)	3.57	(Germany)	y40/y60[a]	0.34	0.85	0.23
Median	3.11	(Ireland)	38.70	(Portugal)	10.46	(Spain)		Excluding outliers[b]		Excluding outliers[b]
St. dev.	1.21		7.34		15.45**		Gini	0.39		0.27
USA	2.87		35.57		5.89		y40/y60[a]	0.41		0.30

Regression analysis
Dependent variable: inflation tax, white heteroskedasticity-consistent standard errors

	All countries						Developing countries			OECD countries			
Sample size	51	39	25	39	31	26	25	19	15	26	17	17	21
Intercept	0.73	0.8673	0.6775	0.6768	0.7143	0.6794	0.8657	0.7415	0.81	0.6391	0.6567	0.6901	0.6425
Gini	0.4561**	0.4267**	0.608**	0.5634**	0.5063**	0.5264**	0.1765	0.4501**	0.25	0.6784**	0.7207**	0.467**	0.6384**
Instability			0.0207	0.0325		0.0133		−0.0354				0.0548	0.0648
Legal indep.			−0.0718		−0.0674						−0.1139		
Turnover			0.0587		0.1011*	0.0826			0.07		0.0722	0.1044	
GDP per cap.		−0.0145											
R-squared	0.4251	0.56	0.6965	0.6415	0.61	0.6755	0.1043	0.5442	0.2235	0.3754	0.6382	0.5363	0.4649

* Significant at the 5% level, ** significant at the 1% level.
[a]Ratio of average income per capita in top 40% of population to bottom 60%.
[b]Outliers are Morocco, Tunisia, Malaysia, Honduras and Guatemala.

non-linearity of the relation between inflation and inequality. This non-linearity can also be captured by separately analyzing developing countries that have higher average inflation, and OECD countries,[9] using the inflation rate 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 developing countries and of 7.84 percentage points for OECD countries.[10]

Table 1 reports the conditional correlation between inflation and inequality, to account for potential joint endogeneity. The first conditioning variable considered is GDP per capita, which is an important indicator of the ability to collect revenues from direct taxation and is negatively correlated with average inflation across countries. The coefficient on inequality is positive and significant at the 1% level after conditioning on GDP per capita, as shown in Table 1. Institutional variables have been found to be important determinants of inflation. Edwards and Tabellini (1992) find a positive correlation between political instability and inflation and Cukierman (1992), among others, documents a negative correlation between inflation and central bank independence. The correlation between inequality and inflation is robust to conditioning on these institutional variables for the full sample and separately for OECD and developing countries. For developing countries, conditioning on institutional variables, strongly increases the estimated coefficient on inequality, as well as its statistical significance. This suggests that accounting for institutional differences across countries increases the strength and the statistical significance of the relation between inflation and 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. 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 (2001) 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 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".[11] 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. The likelihood of citing inflation as a concern is inversely related to educational attainment.

[9]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.

[10]The slope of the regression of percentage inflation on the Gini coefficient is 6.55, significant at the 1% level for the full sample. Results are similar with the alternative measure of income distribution. For OECD countries, the slope coefficient is 1.1285, significant at the 1% level. The full set of findings is available in Albanesi (2002a).

[11]Income categories are self-declared.

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3. A monetary economy with income inequality

The economy is populated by households, goods producing firms, financial firms and a government. Households consume a variety of differentiated goods and supply an endogenous quantity of labor to firms. Households have identical preferences but differ in labor productivity. Households can purchase consumption goods with previously accumulated currency or with a costly transactions technology, as in Prescott (1987).[12] The cost of the alternative transactions technology may depend on the type of good and on the size of the purchase. Households trade-off the cost of transactions 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. Since the average cost of transactions is non-increasing in the level of total purchases, low productivity households will make a greater fraction of their purchases with cash in equilibrium.

The government faces an exogenous and deterministic stream of spending, prints money and taxes labor income at a uniform proportional rate.[13] In each period fiscal and monetary policy are determined first. Households then choose their transaction pattern, and the goods and labor markets open. Finally, households receive labor income and pay for purchases made with the costly transaction technology and accumulate currency.

The problems faced by the agents in this economy are now described in more detail.

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:

$$\int_0^1 c(j)\,\mathrm{d}j \leqslant n,$$

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

$$P(j) = P = W, \quad j \in [0,1], \tag{3.1}$$

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 provide the alternative payment technology. The cost of purchasing good j without currency in efficiency units of labor is

$$\theta(j) = \theta_0 \left(\frac{j - \underline{z}}{\bar{z} - j}\right)^{\theta_1}, \tag{3.2}$$

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 $\bar{z} \in (0,1)$ can only be

[12]See also Cole and Stockman (1991), Dotsey and Ireland (1996), Lacker and Schreft (1996) and Freeman and Kydland (2001).

[13]For a version of the model with government debt, see Albanesi (2002a, b).

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purchased with cash. Perfect competition ensures:

$$q(j) = W\theta(j), \tag{3.3}$$

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 $0 < v_i < 1$, $i = 1, 2$, with $v_1 + v_2 = 1$. 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:

$$\sum_{t=0}^{\infty} \beta^t u^i(c_i, n_i), \quad u^i(c_i, n_i) = \frac{c_i^{1-\sigma} - 1}{1-\sigma} - \gamma n_i, \tag{3.4}$$

$$c_i = \left[\int_{j=0}^{1} c_i(j)^\rho \, \mathrm{d}j\right]^{1/\rho}, \quad \rho \in (0, 1), \quad \gamma > 0 \tag{3.5}$$

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. All households have identical preferences.

Households enter the period with M_{it} units of currency. They can purchase goods with currency or with the alternative payment technology. We will refer to these as cash and credit goods, respectively, following Lucas and Stokey (1983). Households pay a dollar amount equal to $q_t(j)$ for each credit good j. By (3.3), $q_t(j)$ is increasing in j. This implies that households optimally adopt a cut-off rule, so that goods $j \leqslant z_{it}$ are credit goods and the rest are cash goods. 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

$$c_{it} = [(1 - z_{it})c_{i1t}^\rho + z_{it}c_{i2t}^\rho]^{1/\rho}, \tag{3.6}$$

where c_{i1t} denotes the level of consumption of cash goods and c_{i2t} the level of consumption of credit goods, for $i = 1, 2$.[14]

Households face the constraint:

$$P_t c_{i1t}(1 - z_{it}) \leqslant M_{it}, \tag{3.7}$$

on the goods market. During the asset market session, households receive labor income net of taxes and clear consumption liabilities. Households face the following constraint on the asset market:

$$M_{it+1} \leqslant M_{it} - P_t(1 - z_{it})c_{i1t} - P_t z_{it} c_{i2t} - \int_0^{z_{it}} q_t(j)\,\mathrm{d}j + W_t(1 - \tau_t)\xi_i n_{it} \tag{3.8}$$

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

[14]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. 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.

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well defined:

$$R_{t+1}M_{i,t+1}\Phi_{t+1} + \sum_{s=1}^{\infty} \Phi_{t+s} W_{t+s}(1-\tau_{t+s})\xi_i \geqslant 0, \tag{3.9}$$

where $\Phi_t = \prod_{t'=0}^{t-1} R_{t+1'}^{-1}$, $\Phi_0 = 1$, is the discount factor.

3.3. Government

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

$$M_{t+1} + W_t n_t \tau_t = P_t g_t + M_t, \tag{3.10}$$

where n_t is aggregate labor supply in efficiency units given by

$$n_t = \sum_{i=1,2} v_i \xi_i n_{i,t}.$$

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 given by $M_{i,t}$.
2. Households choose the fraction of credit goods, $z_{i,t}$.
3. Households, firms and the government trade in the goods and labor markets. Household consumption purchases are subject to (3.7). Equilibrium on the goods market requires:

$$\sum_{i=1,2} v_i[(1-z_{i,t})c_{i1,t} + z_{i,t}c_{i2,t} + C(z_{i,t}) - \xi_i n_{i,t}] + g_t = 0, \tag{3.11}$$

   where $C(z) = \int_0^z \theta(j)\,\mathrm{d}j$.
4. Wages are disbursed and credit goods purchases are settled. Households accumulate currency to take into the following period subject to constraint (3.8). The government is subject to (3.10).

Definition 3.1. A private sector equilibrium is given by a sequence of government consumption $\{g_t\}_{t\geqslant 0}$, a government policy $\{\tau_t, M_{t+1}\}_{t\geqslant 0}$, a price system $\{P_t, W_t, R_t, q_t(j)\}_{t\geqslant 0, j\in[0,1]}$ and an allocation $\{c_{i1,t}, c_{i2,t}, n_{i,t}, z_{i,t}, M_{i,t+1}\}_{i=1,2,t\geqslant 0}$ such that:

1. given the policy and the price system households and firms optimize;
2. government policy satisfies (3.10); and
3. markets clear.

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

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Proposition 3.2. *For $t \geqslant 0$, a government consumption $\{g_t\}_{t\geqslant 0}$ and policy $\{\tau_s, M_{s+1}\}_{s\geqslant t}$, an allocation $\{c_{i1,s}, c_{i2,s}, n_{i,s}, z_{i,s}, M_{i,s+1}\}_{i=1,2,s\geqslant t}$, with $n_{is} > 0$ for $i = 1, 2$, and a price system $\{P_s, W_s, R_s, q_s(j)\}_{s\geqslant t, j\in[0,1]}$ constitute a private sector equilibrium, if and only if conditions* (3.10), (3.7), (3.11), (3.3), (3.1) *and*

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

$$\sum_{i=1,2} v_i M_{i,s+1} = M_{s+1}, \tag{3.13}$$

$$\left(\frac{c_{i1,s+1}}{c_{i2,s+1}}\right)^{\rho-1} = R_{s+1} \geqslant 1, \tag{3.14}$$

$$\frac{\xi_i u_{i2,s}}{z_{i,s}} = \frac{\gamma}{(1-\tau_s)} \quad \text{for } s \geqslant t, \tag{3.15}$$

$$(R_{s+1} - 1)(P_{s+1} c_{i1,s+1}(1 - z_{i,s+1}) - M_{i,s+1}) = 0, \tag{3.16}$$

$$\left[\left(\frac{1}{\rho} - 1\right)(1 - R_s^{\rho/\rho-1}) c_{i2,s} - \theta(z_{i,s})\right] \begin{cases} \leqslant 0 & \text{for } z_{i,s} = \underline{z}, \\ = 0 & \text{for } z_{i,s} \in (\underline{z}, \bar{z}), \\ \geqslant 0 & \text{for } z_{i,s} = \bar{z}, \end{cases} \tag{3.17}$$

hold for $s \geqslant t$, and

$$c_{i1,t} = \min\left\{c_{i2t}, \frac{M_{i,t}}{P_t(1 - z_{i,t})}\right\}, \tag{3.18}$$

$$\sum_{s=t}^{\infty} \beta^{s-t} \left[u_{i1,s} c_{i1,s} + u_{i2,s} c_{i2,s} + u_{i2,s} \frac{C(z_{i,s})}{z_{i,s}} - \gamma n_{i,s}\right] = \frac{u_{i1,t}}{(1 - z_{i,t})} \frac{M_{i,t}}{P_t}, \tag{3.19}$$

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

The proof of this proposition is in Appendix A. Eq. (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 households' transversality condition.

3.5. Distributional impact of inflation

Households choose the optimal payment structure by balancing the opportunity cost of holding currency, given by the nominal interest rate R_t, and the cost of the alternative payment technology. This trade-off is captured by Eq. (3.17). The benefit from acquiring transaction services for the marginal cash good is given by the corresponding reduction in the foregone interest income. This benefit is proportional to the level of consumption and increasing in the nominal interest rate. The cost of the alternative payment technology for the marginal cash good, $\theta(z_{is})$, does not depend on the level of consumption. Since high productivity households have higher consumption, their benefit of adopting transaction

services is greater and they will make a greater fraction of their purchases with the alternative payment technology.[15]

To understand the resulting distributional implications, it is useful to define a household specific consumption price index, $\tilde{P}_t^i$ for $i = 1, 2$. $\tilde{P}_t^i$ is the total cost in efficiency units of labor of one unit of the consumption aggregator c_i, given by

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

$$P_t^i = [(1 - z_{i,t})(R_t)^{\rho/\rho-1} + z_{i,t}]^{\rho-1/\rho}, \tag{3.21}$$

where z_{it} solves (3.17).[16]

For a given value of R_t, $P_t^1 > P_t^2$, since $z_{2,t} > z_{1,t}$ by (3.17). Household optimization implies $\tilde{P}_t^i \leqslant R_t$ and $\tilde{P}_t^1 \geqslant \tilde{P}_t^2$, since high productivity households always have the option of choosing the same structure that is optimal for low income households. This implies that the effective net real wage in efficiency units is higher for high productivity households:

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

Hence, monetary growth rates that correspond to a positive equilibrium nominal interest rate imply a higher effective net real wage in efficiency units for high productivity households relative to low productivity households, since the latter make a greater fraction of their purchases with the alternative payment technology.

4. The political equilibrium

This section describes the political process for the determination of government policies. Government consumption is exogenous. Monetary growth and the tax rate on labor are the outcome of a 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 directly. The government budget constraint pins down the required growth in money supply and the corresponding nominal

[15] 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.

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

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

where w is an exogeous endowment of real wealth. Let

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

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

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

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interest rate is determined in equilibrium.[17] If an agreement cannot be reached, a relatively low default tax rate on labor income is applied and the government must resort to monetary growth to finance spending. This choice of threat point reflects the idea that an increase in the money supply is easy to implement, since it does not require parliamentary approval and it is always feasible, if the government can costlessly run the printing press. Since government policy is determined before private agents make their choices, representatives trade-off labor income taxes and the equilibrium consequences of expected money growth in their negotiations.

To build intuition, the next section presents a one period version of the model for which it is possible to derive the key properties of the bargaining equilibrium analytically. The stationary sequential bargaining equilibrium for the infinite horizon economy is analyzed in Section 4.2.

4.1. One-period example

Consider the following one period version of the economy. Government policy is given by $\{\tau, R\}$, with $R \geqslant 1$. The household problem is

$$U^i(\{\tau, R\}) = \max_{c_{i1}, c_{i2}, z_i, n_i} \log c_i - \gamma n_i, \tag{4.1}$$

subject to

$$(1-\tau)\xi_i n_i = R c_{i1}(1-z_i) + c_{i2} z_i + \int_0^{z_i} \theta \, \mathrm{d}j, \tag{4.2}$$

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 (4.1). In addition, the resource constraint must be satisfied at $\{\tau, R\}$:

$$\sum_{i=1,2} v_i [c_{i1}(1-z_i) + c_{i2} z_i + \int_0^{z_i} \theta \, \mathrm{d}j - \xi_i n_i] + \bar{g} = 0. \tag{4.3}$$

Eq. (4.3) implicitly defines the function $R = R(\tau, \bar{g})$.[18]

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

The equilibrium policy solves the following problem:

$$\begin{aligned} &\mathscr{N}(p, \bar{g}) = \arg\max_{\{\tau, R\}} \mathscr{V}_1^p \mathscr{V}_2 \quad \text{subject to} \\ &\tau \geqslant \tau^{\mathrm{T}}, \\ &R^{\mathrm{T}} = \mathscr{R}(\tau^{\mathrm{T}}, \bar{g}) \geqslant 1, \\ &R = \mathscr{R}(\tau, \bar{g}) \geqslant 1. \end{aligned} \tag{4.4}$$

[17] 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.

[18] The government budget constraint holds if (4.2) and (4.3) are satisfied.

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Here,

$$\mathscr{V}_i \equiv \max\{0, U^i(\{\tau, R\}) - U^i(\{\tau^{\mathrm{T}}, R^{\mathrm{T}}\})\}$$

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

Definition 4.1. A 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 $\{\tau^*, R^*\} = \mathscr{N}(p, \bar{g})$ 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.

Proposition 4.2. *Assume that* $\partial R/\partial\tau \leqslant 0$. Let $\{\tau, R\} = \mathscr{N}(p, \bar{g})$ and $\{\hat{\tau}, \hat{R}\} = \mathscr{N}(p, \widehat{\bar{g}})$ *for* $\hat{\xi}_2 > \xi_2$, $\hat{\xi}_1 = \xi_1$ *and* $\widehat{\bar{g}}$ *satisfying*

$$\mathscr{R}(\tau^{\mathrm{T}}, \widehat{\bar{g}})|_{\hat{\xi}_2} = R^{\mathrm{T}}, \tag{4.5}$$

Then, if

$$\frac{\mathrm{d}U^1(\{\tau, R\})}{\mathrm{d}\tau} \geqslant 0, \tag{4.6}$$

$\hat{\tau} \leqslant \tau$ *and* $\hat{R} \geqslant R$.

The proof is in Appendix A.

Assumption $\partial R/\partial\tau(\tau, \bar{g}) \leqslant 0$ 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 $\partial R/\partial\tau \leqslant 0$, 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. By (4.5), government consumption is adjusted so that the threat point policy is the same in the two economies. Condition (4.6) states that households of different type have conflicting views over fiscal policy. Low productivity households would prefer an increase in the tax rate from the current level, while the converse is true for high productivity households.

The result in Proposition 4.2, falls from the first order condition for the bargaining problem, given by

$$p\left[\frac{\mathscr{V}_2}{\mathscr{V}_1}\right]\frac{\mathrm{d}U^1(\{\tau, R\})}{\mathrm{d}\tau} + \frac{\mathrm{d}U^2(\{\tau, R\})}{\mathrm{d}\tau} = 0. \tag{4.7}$$

Here, $\mathrm{d}U^i/\mathrm{d}\tau$ is the total derivative of U^i with respect to τ, i.e. $\mathrm{d}U^i/\mathrm{d}\tau = \partial U^i/\partial\tau + (\partial U^i/\partial R)(\partial R/\partial\tau)$. If policy were chosen to maximize type i's utility only, the term $\mathrm{d}U^i/d\tau$, which can be taken to represent type i's preferences over policy, would be set to 0. A higher weight on $\mathrm{d}U^1/\mathrm{d}\tau$ 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.

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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 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 (4.4) 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 (4.6) 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]

4.2. Stationary sequential bargaining equilibrium

In the infinitely horizon economy, representatives of each type of household 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. These bargaining equilibria are stationary, in the sense that the threat point policy is constant and equilibrium policy is time independent.

Let government policy in each period be given by $\{\tau, R\}$.[20] 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 $\{\tau^{\mathrm{T}}, R^{\mathrm{T}}\}$.
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 units of currency, $i = 1, 2$.

It is useful to describe certain properties of private sector equilibria for given government policy before providing a formal definition of the bargaining equilibrium. Proposition A.1 in Appendix A formally states and proves these properties.

[19]The same results would follow in an model in which the households bargaining 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.

[20]By (3.13), (3.16) and (3.14), a government policy $\{\tau_t, M_{t+1}\}_{s \geqslant t}$, can equivalently be characterized as $\{\tau_t, R_t\}_{s \geqslant t}$ in equilibrium. For given $\{\tau_t, R_t\}_{s \geqslant t}$, the corresponding money supply process can be determined from the money market clearing condition.

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Let $X_t = [\{\tau_s, R_s\}]_{s \geqslant t}$ denote a continuation government policy from period t onwards, for any $t \geqslant 0$. First, in any period $s > t$, $\{c_{i1,s}, c_{i2,s}, z_{i,s}\}$ for $i = 1, 2$ only depend on government policy at time s. Second, the end-of-period distribution of currency only depends on government policy for next period $\{\tau_{s+1}, R_{s+1}\}$. These properties are a consequence of the linear-in-labor utility specification, which implies no wealth effects on the level and composition of consumption, and consequently on money demand. Third, for given X_t, the equilibrium value of $c_{ij,t}$ depends on $M_{i,t}$ and P_t, which determine the shadow price of cash goods relative to credit goods. $M_{i,t}$ 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 $z_{i,t}$. Moreover, the nominal interest rate at any future date depends on the tax rate at that date and on the tax rate and nominal interest rate in the subsequent period only, so that we can write $R_t = \mathscr{R}(\tau_t; \{\tau_{t+1}, R_{t+1}\}, \bar{g})$. The function $\mathscr{R}(\cdot)$ is implicitly defined by the resource constraint and is formally defined in Eq. (A.15) in Appendix A.

The Markov sequential bargaining equilibrium can be characterized by analyzing one period deviations from a candidate equilibrium policy. I restrict attention to 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-labor preference specification has an important simplifying role. Since it implies that the distribution of currency across households at the end of the period only depends on government policy in the next period, the 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, and policy will be constant in all periods in a stationary bargaining equilibrium.

To define and characterize a bargaining equilibrium, consider one period deviations from a candidate equilibrium policy (τ, R), that results in a continuation policy $X' \equiv [\{\tau, R\}, \{\tau', R'\}, \{\tau, R\}, \{\tau, R\} \ldots]$. For a given candidate equilibrium policy $\{\tau, R\}$, the distribution of currency at the beginning of the period is determined is a function of (τ, R) only, as discussed above. It follows that the present discounted value of household utility in a private sector equilibrium for continuation policy X', can be expressed as a function of X' only. This value is denoted with $\hat{U}^i(X')$, where $\hat{U}^i(\cdot)$ satisfies (A.23) in Appendix A.

Definition 4.3. A stationary sequential bargaining equilibrium is a government policy $\{\tau, R\}$, a threat-point policy $\{\tau^{\mathrm{T}}, R^{\mathrm{T}}\}$, and a collection of functions $\{\hat{U}^i(X^*)\}_{i=1,2}$ and $\mathscr{R}(\cdot)$, defined by (A.23) and (A.15), respectively, such that, if $X^* = [\{\tau, R\}, \{\tau^*, R^*\}, \{\tau, R\} \ldots]$ and $X^{\mathrm{T}} = [\{\tau, R\}, \{\tau^{\mathrm{T}}, R^{\mathrm{T}}\}, \{\tau, R\} \ldots]$, with $R = \mathscr{R}(\tau; \{\tau, R\}, \bar{g})$ and $R^{\mathrm{T}} = \mathscr{R}(\tau^{\mathrm{T}}; \{\tau, R\}, \bar{g})$:

(i) $\{\tau^*, R^*\} = \mathscr{N}(\{\tau, R\}; p, \bar{g})$, where

$$\mathscr{N}(\{\tau, R\}; p, \bar{g}) = \arg \max_{\{\tau', R'\}} \mathscr{V}_1^p \mathscr{V}_2,$$

subject to

$$R' = \mathscr{R}(\tau'; \{\tau, R\}, \bar{g}), \tag{4.8}$$

where $\mathscr{V}^i = \max\{0, \hat{U}^i(X') - \hat{U}^i(X^{\mathrm{T}})\}$ for $i = 1, 2$; and

(ii) $\{\tau, R\} = \{\tau^*, R^*\}$.

Since $\hat{U}^i(\cdot)$ is the value of households' utility in a competitive equilibrium as a function of the continuation policy and $\mathscr{R}(\cdot)$ is the private sector equilibrium interest rate, condition (i) ensures that the objective and the feasible candidate policies for the bargaining problem are consistent with the private sector equilibrium restrictions. Condition (ii) is a rational expectations restriction on the bargaining equilibrium.

4.2.1. Quantitative experiments

This section studies the outcome of this bargaining equilibrium for a version of the economy calibrated to match income inequality and features of money demand for the US in the post-war period. The calibrated parameter values are displayed in Table 2A. To calibrate inequality, the parameters ξ_1 and v are set to 1 and 0.60, respectively, and ξ_2 is chosen to match the range of $y40/y60$ in the data, at $\tau = 0.30$ and $R = 1.06$. For ξ_2 ranging between 1.7 and 3.2, $y40/y60$ varies between 2.12 and 5.27 in the model. The parameters ρ, θ_0 and θ_1 are set to match the estimates of the interest elasticity of M1 and the ratio of the M1 to output in the US economy for the period 1959–1991 reported by Dotsey and Ireland (1996). The average nominal interest rate is 6% for this period, average $M1$ velocity is 5.4 and the interest elasticity of money demand is 5.95%. The substitutability between consumption goods allows an extra degree of freedom in the calibration, since ρ also needs to be pinned down. The calibration of ρ is based on Aiyagari et al. (1998). 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 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 $\rho = 0.5349$. This value can be taken as an upper bound because their estimate uses $M0$ inverse velocity while $M1$ is used for the rest of the calibration.[21] Since 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 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 approximately 33%.

To evaluate the effects of higher inequality on inflation in the model, the bargaining equilibrium is computed for increasing values of ξ_2/ξ_1 with $\xi_1 = 1$. Government spending is set to equal approximately 25% of total output in private sector equilibrium with $\tau = 0.25$. The threat-point tax rate, τ^{T}, corresponds to 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 parameterization are presented in Table 2A. Larger differences in labor productivity across types of households give rise to higher inflation in the bargaining equilibrium. The equilibrium nominal interest rate increases from 2%

[21] The estimate of the overall interest elasticity of money demand in Aiyagari et al. (1998) is equal to 10.02, close to double the one found by Dotsey and Ireland (1996) for $M1$.

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Table 2

(A) *Benchmark parameters*			
σ	γ	β	
0.7	3	0.97	
ρ	θ_0	θ_1	
0.05	0.021	0.3232	
Statistics at $R = 1.06$, $\tau = 0.3$ and $\xi_2 = 1.7$			
Semi-elasticity	$z1$	$z2$	M/GDP
−5.774	0.074	0.453	0.698
ξ_2	1.8	3.6	5.5
g	0.085	0.150	0.218
Threat point			
τ	0.25	0.22	0.21
% Inflation	10.26	37.85	15.11
R	1.13	1.42	1.19
Equilibrium			
τ	0.278	0.239	0.219
y40/y60	2.3	2.9	7.2
% Inflation	0.00	3.84	9.10
R	1.02	1.07	1.12
V_2/V_1	0.33	0.13	0.01
g/GDP	0.25	0.24	0.23
(B) *High fixed cost*			
σ	γ	β	
0.7	3	0.97	
ρ	θ_0	θ_1	
0.05	0.0421	0.3232	
Statistics at $R = 1.06$, $\tau = 0.30$ and $\xi_2 = 2.1$			
Semi-elasticity	$z1$	$z2$	M/GDP
−4.550	0.007	0.162	0.720
ξ_2	2.1	4	4.8
g	0.085	0.169	0.211
Threat point			
τ	0.2	0.23	0.23
% Inflation	17.59	18.29	38.90
R	1.18	1.19	1.40
Equilibrium			
τ	0.244	0.255	0.253
y40/y60	2.3	2.1	7.2
% Inflation	0.49	4.76	8.64
R	1.04	1.08	1.12
V_2/V_1	0.31	0.10	0.04
g/GDP	0.27	0.26	0.26

to 7% if ξ_2 varies from 1.8 to 3.6. It increases further to 12% if $\xi_2 = 5.5$. 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

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equilibrium, $\mathscr{V}_2/\mathscr{V}_1$. For low human capital households it is approximately three times greater than for high human capital households at $\xi_2 = 1.8$, and becomes approximately 10 and 100 times greater for ξ_2 equal to 3.6 and 5.5, respectively.

Table 2B reports results for the same parameterization with $\theta_0 = 0.042$, double the value in the previous exercise. A higher value of θ_0 corresponds to a higher fixed component of 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 increases 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. As shown in Table 2B, the equilibrium inflation rate is more responsive to an increase in ξ_2/ξ_1 relative to the benchmark parameters, 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 for the values of θ_0 shows that the effect of a smaller value of threat point inflation dominates for low levels of inequality, giving rise to lower equilibrium inflation rates.

The correlation between inequality and inflation predicted by the model is quantitatively significant. For the benchmark parameterization, the slope of the relation between equilibrium inflation and $y40/y60$ is 1.85. For the parameterization with higher transaction costs, the slope is 1.65. 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 41% of the correlation between inequality and inflation for countries with average inflation below 60% per annum. Fig. 2 displays the linear relation[22] predicted by the bargaining equilibrium for both parameterizations, against a scatter the data for countries with average yearly inflation below 60%.

5. Concluding remarks

This paper proposes 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 is based on a monetary model in which in equilibrium low income households hold more cash as a fraction of total purchases, consistent with empirical evidence. The political process for the determination of fiscal and monetary policy is modelled as a bargaining game. A low labor income tax and a relatively high inflation rate prevail in case of no agreement. Since low income households are more vulnerable to inflation, their bargaining position is weak. This implies that inflation is positive in equilibrium and larger inequality corresponds to higher equilibrium inflation.

A number of assumptions are made to simplify the analysis. First, the distributional impact of inflation is exclusively a function of the equilibrium differences in transaction patterns across household with different income. This limits the redistributional impact of

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

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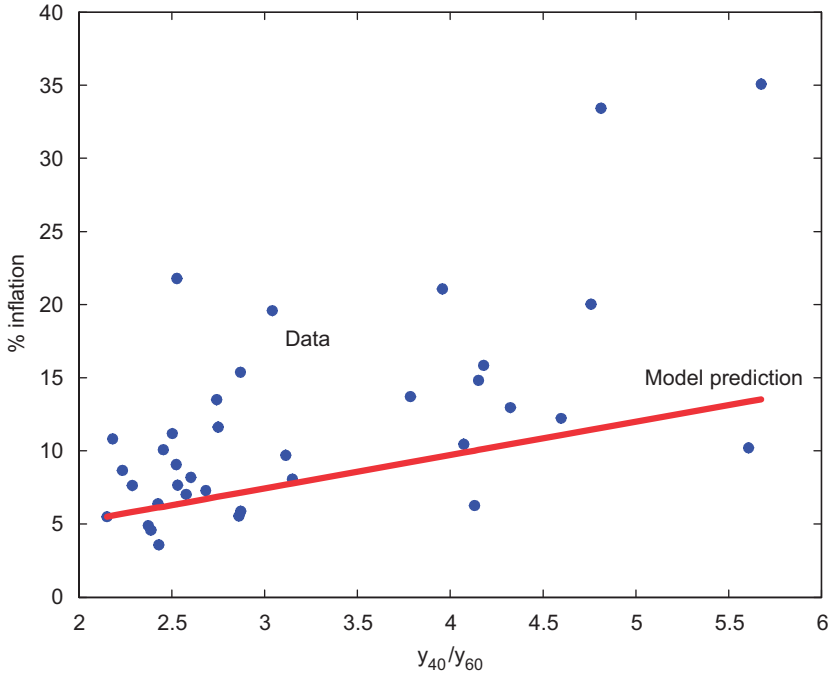

Fig. 2. The relation between iflation and inequality in the model and in the data.

inflation and weakens the correlation between inequality and inflation predicted by the model. Second, the amount of redistribution achievable with fiscal policy is limited, since the labor income tax is proportional. If the progressivity of the labor income tax could be adjusted, the predicted correlation between inequality and inflation would likely be smaller. Albanesi (2002b) analyzes Ramsey policies in a similar model allowing for progressive labor income taxes, and finds that departures from the Friedman rule are optimal if the Pareto weight on low income households is low enough. This result suggests that, even with weaker restrictions on the structure of labor income taxes, a positive correlation between inequality and equilibrium inflation might arise.

Alternative strategies have been used to formalize a distributional conflict resulting in high inflation. Alesina and Drazen (1991) study a war of a attrition between political groups over the timing of fiscal reform. In the interim, public expenditures are financed with seigniorage. The distribution of the burden of the reform is exogenous and asymmetric information on the costs of inflation delays the reform. By contrast in this paper the allocation of the fiscal burden is determined endogenously and equilibrium inflation is positive even with perfect information on the costs of inflation. Mondino et al. (1996) consider a model in which identical pressure groups set government transfers financed with seigniorage. This approach is better suited to describe conflict over policies that target narrow segments of the population. More recently, Dolmas et al. (2000) and Bhattacharya et al. (2001) describe overlapping generations economies with majority voting on taxes and seigniorage, in which larger inequality gives rise to higher equilibrium inflation. In Dolmas, Huffman and Wynne's model the correlation is driven by the fact

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that inflation is a "progressive" tax since high income households hold more currency in their model. 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 forces driving the correlation between inequality and inflation in these models do not appear to be consistent with direct and indirect evidence on the redistributional impact of inflation.

Appendix A

A.1. Private sector equilibrium

Proof of Proposition 3.2. Assume that an allocation $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, M_{it+1}\}_{i=1,2,t\geqslant 0}$, with $n_{it} > 0$ for $i = 1, 2$ and $t \geqslant 0$, and a price system $\{P_t, W_t, q_t(j)\}_{t\geqslant 0, j\in[0,1]}$ constitute a private sector equilibrium for a given policy $\{\bar{g}_t, \tau_t, M_{t+1}\}_{t\geqslant 0}$. Then, condition (3.1) and (3.3) correspond to optimality in firm behavior, condition (3.11) 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

$$L = \sum_{t=0}^{\infty} \beta^t \Big\{ u^i(c_{it}, n_{it}) - \mu_{it}(P_t c_{i1t}(1 - z_{it}) - M_{it}) \\ -\lambda_{it}\Big[M_{it+1} - M_{it} - W_t(1-\tau_t)\xi_i n_{it} + P_t c_{i1t}(1 - z_{it}) + P_t c_{i2t} z_{it} + \int_0^{z_{it}} q_t(j)\,\mathrm{d}j\Big]\Big\},$$

where c_{it} is defined in (3.6) 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

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

$$\mu_{it}(P_t c_{it}(1 - z_{it}) - M_{it}) = 0, \quad \mu_{it} \geqslant 0, \tag{A.2}$$

$$u_{i2t} = P_t \lambda_{it} z_{it}, \tag{A.3}$$

$$-u_{int} = W_t(1 - \tau_t)\xi_i \lambda_{it}, \tag{A.4}$$

$$P_t c_{i1t}(\mu_{it} + \lambda_{it}) - P_t c_{i2t}\lambda_{it} - q_t(z_{it})\lambda_{it} \begin{cases} <0 & \text{for } z_{it} = \underline{z}, \\ =0 & \text{for } z_{it} \in (\underline{z}, \bar{z}), \\ >0 & \text{for } z_{it} = \bar{z}, \end{cases} \tag{A.5}$$

$$\lambda_{it} = \beta(\lambda_{it+1} + \mu_{it+1}), \tag{A.6}$$

$$\lambda_{it} R_{t+1}^{-1} = \beta \lambda_{it+1}, \tag{A.7}$$

$$\lim_{T\to\infty} \beta^{\mathrm{T}} \lambda_{iT} M_{iT} = 0, \tag{A.8}$$

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as well as (3.7) and (3.8). To see that (A.8) is a necessary condition for household optimization, suppose it does not hold and

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

(The strictly smaller case is ruled out by (3.9).) 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 (A.1)–(A.3) yields (3.14), while (A.3) and (A.4) determine (3.15). The expression in (A.7) follows from (A.4) and $u_{int} = \gamma$, and (A.6), while (3.18) follows from (A.1) to (A.3) at $t = 0$. To derive (3.19), multiply (3.8) by λ_{it} and apply (A.2) and (A.6). This yields:

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

Now use (A.1), (A.3)–(A.5), multiply by β^t and sum over t from 0 to T. Let T go to infinity and apply (A.8). Now assume that an allocation $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}, M_{it+1}\}_{i=1,2,t\geqslant 0}$, with $n_{it} > 0$ for $i = 1, 2$ and $t \geqslant 0$, and a price system $\{P_t, W_t, R_t, q_t(j)\}_{t\geqslant 0, j\in[0,1]}$ satisfy (3.12)–(3.19) and (3.11) for a given policy $\{\bar{g}_t, \tau_t, M_{t+1}\}_{t\geqslant 0}$ for which (3.10) holds. Then, by (3.3) industrial and credit services firms optimize. To see that household optimization conditions are satisfied consider an alternative candidate plan $\{c'_{i1t}, c'_{i2t}, n'_{it}, z'_{it}\}_{i=1,2,t\geqslant 0}$ which satisfies the intertemporal budget constraint for the price system $\{P_t, W_t, R_t, q_t(j)\}_{t\geqslant 0, j\in[0,1]}$. This implies that

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

using (3.12) and the fact that $\{c_{i1t}, c_{i2t}, n_{it}, z_{it}\}_{i=1,2,t\geqslant 0}$ satisfies (3.14)–(3.19) and that the intertemporal budget constraint holds as a weak inequality using (3.9) and (3.8) for the price system $\{P_t, W_t, R_t, q_t(j)\}_{t\geqslant 0, j\in[0,1]}$. By concavity of u^i:

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

where c'_{it} is defined by (3.6). This establishes the result since (3.13) and (3.11) guarantee market clearing. □

Proposition A.1. *In a private sector equilibrium with continuation government policy $X_t = \{\tau_s, R_s\}_{s\geqslant t}$ and initial distribution of currency $M_{i,t}$ for $i = 1, 2$ at $t \geqslant 0$, the allocation satisfies*

$$c_{ij,t} = \bar{\mathfrak{c}}_{ij}(M_{i,t}, P_t; \tau_t, R_t), \tag{A.9}$$

$$c_{ji,s} = \mathfrak{c}_{ij}(\tau_s, R_s) \quad \textit{for } s > t, \tag{A.10}$$

$$z_{i,s} = \mathfrak{z}_i(\tau_s, R_s) \quad \textit{for } s \geqslant t, \tag{A.11}$$

$$n_{i,t} = \mathfrak{n}_i\left(\tau_t, \left(\frac{c_{i1t}}{c_{i2t}}\right)^{\rho-1}; \tau_{t+1}, R_{t+1} \right), \tag{A.12}$$

$$n_{i,s} = \mathfrak{n}_i(\tau, R; \tau', R') \quad \textit{for } s > t, \tag{A.13}$$

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$$M_{i,s+1} = \mathfrak{M}_i(\tau_{s+1}, R_{s+1}) \quad for\ s \geqslant t. \tag{A.14}$$

for $i,j = 1,2$. Furthermore,

$$R_s = \mathscr{R}(\tau_s; \{\tau_{s+1}, R_{s+1}\}, \bar{g}), \tag{A.15}$$

$$P_s = \beta R_s P_{s-1} \frac{(1-\tau_{s-1})}{(1-\tau_s)} \tag{A.16}$$

for $s > t$, and

$$P_t = \mathfrak{P}(M_{1,t}, M_{2,t}; \{\tau_t, R_t\}, \{\tau_{t+1}, R_{t+1}\}, \bar{g}). \tag{A.17}$$

Proof of Proposition A.1. Eqs. (3.14), (3.15) and (3.17) determine (A.10)–(A.11). The function $\bar{c}_{ij}(\cdot)$ in (A.9) is implicitly defined by (3.18) and (3.15). The function $\mathfrak{n}_i(\cdot)$ is defined by

$$\mathfrak{n}_i(\tau, R; \tau', R') = \frac{\beta}{\gamma} u'_{i1} c'_{i1} + \frac{u_{i2}}{\gamma}\left(c_{i2} + \frac{C(z_i)}{z_i}\right). \tag{A.18}$$

Eqs. (3.12) and (3.16), together with (A.9)–(A.11) imply (A.14). A policy and a price sequence $\{P_s\}_{s \geqslant t}$ consistent with a private sector equilibrium must also satisfy the resource constraint and clearing on the money market. Then, if a policy X_t is part of a private sector equilibrium, $R_s = \mathscr{R}(\tau_s; \{\tau_{s+1}, R_{s+1}\}, \bar{g})$ for all $s > t$, where $\mathscr{R}(\tau; \{\tau', R'\}, \bar{g})$ is implicitly defined by the resource constraint:

$$\begin{aligned}&\sum_{i=1,2} \nu_i \xi_i \mathfrak{n}_i(\tau, R; \tau', R') \\ &\quad = \bar{g} + \sum_{i=1,2} \nu_i \left[\mathfrak{c}_{i1}(\tau, R)(1 - \mathfrak{z}_i(\tau, R)) + \mathfrak{c}_{i2}(\tau, R)\mathfrak{z}_i(\tau, R) + \int_0^{\mathfrak{z}_i(\tau,R)} \theta(j)\,\mathrm{d}j\right].\end{aligned} \tag{A.19}$$

Given that (3.19) holds under the assumptions of Proposition A.1, (A.19) implies that the government's dynamic and intertemporal budget constraints are also satisfied. The equilibrium price sequence $\{P_s\}_{s \geqslant t}$ can be determined as a function of the policy X_t and of initial distribution of currency as follows. Eq. (3.12) determines $\{P_s\}_{s>t}$, for given P_t, and guarantees money market claring for $s > t$. The equilibrium value of P_t satisfies $P_t = \mathfrak{P}(M_{1t}, M_{2t}; \{\tau_t, R_t\}, \{\tau_{t+1}, R_{t+1}\}, \bar{g})$, where $\mathfrak{P}(M_1, M_2; \{\tau, R\}, \{\tau', R'\}, \bar{g})$ is implicitly defined by

$$\begin{aligned}&\sum_{i=1,2} \nu_i \xi_i \mathfrak{n}_i\left(\tau, \left(\frac{c_{i1}}{c_{i2}}\right)^{\rho-1}; \tau', R'\right) \\ &\quad = \bar{g} + \sum_{i=1,2} \nu_i \left[c_{i1}(1 - \mathfrak{z}_i(\tau, R)) + c_{i2}\mathfrak{z}_i(\tau, R) + \int_0^{\mathfrak{z}_i(\tau,R)} \theta(j)\,\mathrm{d}j\right],\end{aligned} \tag{A.20}$$

and c_{ij} are determined according to (A.9). □

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The present discounted value of optimized household utility at time t under policy X_t, current price level P_t and initial distribution of currency $M_{i,t}$, $i = 1, 2$ can be written as

$$U^i(M_{i,t}; X_t, \{M_{1,t}, M_{2,t}\}) = \bar{\mathscr{P}}^i(M_{i,t}, P_t; \tau_t, R_t; \tau_{t+1}, R_{t+1}) + \sum_{s=t+1}^{\infty} \beta^{s-t} \mathscr{P}^i(\tau_s, R_s; \tau_{s+1}, R_{s+1}) \tag{A.21}$$

for all $t \geqslant 0$, where P_t satisfies (A.17). Here,

$$\bar{\mathscr{P}}^i(M_i, P; \tau, R; \tau', R') = \left[\frac{(c_i)^{1-\sigma} - 1}{1-\sigma} - \gamma \mathfrak{n}_i\left(\tau, \left(\frac{c_{i1}}{c_{i2}}\right)^{\rho-1}; \tau', R'\right)\right],$$

with c_{ji} determined from (A.9), and

$$\mathscr{P}^i(\tau, R; \tau', R') = \left[\frac{(c_i)^{1-\sigma} - 1}{1-\sigma} - \gamma \mathfrak{n}_i(\tau, R; \tau', R')\right], \tag{A.22}$$

with c_{ij} for $i, j = 1, 2$ given by (A.10)–(A.11). c_i is determined from (3.5) for $i = 1, 2$.

If $M_{i,t} = \mathfrak{M}_i(\tau_t, R_t)$, $c_{ij,t}$ is also satisfies (A.9) and the shadow price of cash goods relative to credit goods is exactly equal to R_t. Hence, in a one period deviation from a candidate equilibrium policy $\{\tau, R\}$, the initial distribution of currency will be given by $\{\mathfrak{M}_1(\tau, R), \mathfrak{M}_2(\tau, R)\}$, so that the present value of utility at the continuation X', can be expressed as

$$\hat{U}^i(X') \equiv U^i(\mathfrak{M}_i(\tau, R); X', \{\mathfrak{M}_1(\tau, R), \mathfrak{M}_2(\tau, R)\}), \tag{A.23}$$

for $i = 1, 2$.

A.2. 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 A.2. *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

$$c_i = w_i, \tag{A.24}$$

$$n_i = \frac{c_i}{w_i \gamma}\left[(RP^i)^{\rho/(\rho-1)} + \frac{\tilde{P}^i}{P^i}\right], \tag{A.25}$$

$$c_{i2} = c_i (P^i)^{1/(1-\rho)}, \tag{A.26}$$

$$\left(\frac{c_{i1}}{c_{i2}}\right)^{\rho-1} = R, \tag{A.27}$$

$$R = \mathscr{R}(\tau, \bar{g}),$$

where

$$P^i = [(1 - z_i)R^{\rho/(\rho-1)} + z_i]^{(\rho-1)/\rho}, \tag{A.28}$$

$$\tilde{P}^i = P^i + \frac{C(z_i)}{c_i}, \tag{A.29}$$

$$w_i = \frac{\xi_i(1-\tau)}{\gamma P^i} \tag{A.30}$$

for $i = 1, 2$, with $\mathscr{R}(\cdot)$ implicitly defined by (4.3).

Proof of Proposition A.2. The first order conditions for the household problem are given by

$$u_{i1} - R(1 - z_i)\lambda_i = 0, \tag{A.31}$$

$$u_{i2} - z_i\lambda_i = 0, \tag{A.32}$$

$$\gamma - (1-\tau)\xi_i\lambda_i = 0, \tag{A.33}$$

plus the analogous of (3.17) and (4.2), where λ_i is the Lagrange multiplier on (4.2). Eq. (A.24) follows from (A.32), (A.28) and (A.30), (A.27) follows from (A.31) to (A.32). Eq. (A.25) follows from (4.2) using (A.28)–(A.30). □

Proposition 4.2 characterizes sufficient conditions for increased inequality to correspond to higher equilibirum nominal interest rate in the bargaining equilibrium.

Proof of Proposition 4.2. The necessary condition for the bargaining problem is

$$p\left[\frac{\mathscr{V}_2}{\mathscr{V}_1}\right]\frac{\mathrm{d}U^1(\{\tau, R\})}{\mathrm{d}\tau} + \frac{\mathrm{d}U^2(\{\tau, R\})}{\mathrm{d}\tau} = 0. \tag{A.34}$$

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 (A.34) 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 (4.6), it is sufficient to show that $\mathscr{V}_2$ is decreasing in ξ_2 and that $\mathrm{d}U^i(\{\tau, R\})/\mathrm{d}\tau$ is non-increasing in ξ_i.

By Proposition A.2:

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

This simplifies to

$$U^i(\{\tau, R\}) = -\frac{\gamma}{\xi_i}\frac{C(z(\tau, R; \xi_i))}{1-\tau}, \tag{A.35}$$

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

$$\left(\frac{1}{\rho} - 1\right)(1 - R^{\rho/(\rho-1)})\left(\frac{\xi_i(1-\tau)}{\gamma}\right)(P^i)^{\rho/(1-\rho)} - \theta = 0, \tag{A.36}$$

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for z_i interior. Eq. (A.36) is the first order condition for z_i in the household problem. Differentiating (A.36) with respect to ξ_i obtains:

$$\frac{\partial z(\tau, R; \xi_i)}{\partial \xi_i} = \frac{1}{\xi_i} \frac{(1 - R^{\rho/(\rho-1)})z_i + 1}{(1 - R^{\rho/(\rho-1)})} \geqslant 0. \tag{A.37}$$

From (A.35):

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

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

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

by (A.37) and (4.5). Eq. (4.6) implies that $\mathrm{d}U^2(\{\tau, R\})/\mathrm{d}\tau \leqslant 0$. To show that $\mathrm{d}U^2(\{\tau, R\})/\mathrm{d}\tau$ is non-increasing in ξ_2 note that

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

and

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

$$\frac{\partial U^i}{\partial R} = \frac{-\gamma}{\xi_i(1-\tau)}\theta\frac{\partial z(\tau, R; \xi_i)}{\partial R}.$$

From

$$\frac{\partial z(\tau, R; \xi_i)}{\partial R} = \frac{\rho}{1-\rho}\frac{R^{1/(\rho-1)}z_i}{(1 - R^{\rho/(\rho-1)})},$$

$$\frac{\partial z(\tau, R; \xi_i)}{\partial \tau} = -\frac{(1 - R^{\rho/(\rho-1)})z_i + 1}{(1 - R^{\rho/(\rho-1)})(1-\tau)},$$

one can show that

$$\frac{\mathrm{d}(\partial U^i/\partial \tau)}{\mathrm{d}\xi_i} = \frac{-\gamma}{\xi_i^2(1-\tau)^2} \leqslant 0,$$

$$\frac{\mathrm{d}(\partial U^i/\partial R)}{\mathrm{d}\xi_i} = \frac{\gamma\theta}{\xi_i(1-\tau)}\frac{\partial z}{\partial R}\left(\frac{1}{\xi_i(1-\tau)} + \frac{\partial z_i}{\partial \xi_i}\frac{1}{z_i}\right) \geqslant 0.$$

Then, $(\mathrm{d}(\mathrm{d}U^i/\mathrm{d}\tau))/\mathrm{d}\xi_i \leqslant 0$ follows from $\partial R/\partial \tau \leqslant 0$. □

A.3. Data

The data on inflation from Easterly et al. (1994) and the data on income inequality is from the Deininger and Squire (1996) source file. The sample of countries included in the analysis is smaller than the "high quality" data sample. The criteria for inclusion in the

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sample are availability of before tax income inequality measures and quintile income distribution measures at least every five years.[23] Inequality measures for before tax income for Norway, Sweden, Finland and the UK are drawn from data from the Luxemburg Income Study. 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 frequency of power transfers 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. This measure 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 1980s. 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. The IMF International Financial Statistics are used for data on GDP per capita.

A list of countries and variables included in the sample is provided in Albanesi (2002a).

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[23]This significantly restricts the sample number of countries included relative to previous studies, such as Romer and Romer (1998). In addition, it addresses the concerns raised in Atkinson and Brandolini (2001) on using secondary datasets on inequality.

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