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The Inequality Channel of Monetary Transmission*

Marta Areosa† **Waldyr Areosa**‡

Abstract

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We study optimal monetary policy when inequality is present by introducing agents with different productivities, wages, and financial market accesses into a general equilibrium model with sticky prices. Our main results are: (i) There is a channel from interest rate to inflation throughout inequality; (ii) The welfare-based objective of monetary policy includes inequality stabilization; (iii) Higher levels of financial exclusion are associated to bigger welfare losses and to smaller interest rate variability, providing an alternative explanation to why observed interest rate paths are much less volatile than optimal policies implied by most theoretical models of the monetary transmission mechanism.

JEL Classification: E31; E32; E52

Keywords: Inequality; Optimal monetary policy; Interest rate variability

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1 Introduction

Does inequality cause inflation? Is inflation bad for inequality? What are the links between inflation, inequality, and monetary policy? This paper offers a model for the joint determination of output, interest rate, inflation, and inequality that weaves together these classical questions studied by the empirical literature.[1]

We incorporate inequality by introducing two types of agents with different productivities, wages, and financial market accesses. While some households can hold assets and smooth consumption over time, others cannot hold assets and thus cannot react to interest rate changes. In this context, inequality, evaluated through an index built on the consumption of the two types of agents, becomes a straightforward channel between monetary policy and inflation. In choosing a consumption based inequality index, we move beyond income as an indicator of well-being, in line with Krueger and Perri (2006).[2]

Our model contrasts with the current theoretical literature for explicitly incorporating inequality in the structural equations of an otherwise standard New Keynesian framework. Besides a slope-modified intertemporal IS curve we derive both an intertemporal inequality curve and an "inequality augmented" Phillips curve. Inequality is also present in the welfare-based loss function of the monetary authority. Under this "inequality expanded" objective, an optimal monetary policy can no longer simultaneously stabilize the output gap and inflation since it has to take the effects of inequality into consideration, even when inequality has no impact on inflation.

We also calibrate the model with standard parameters values to show that the optimal policy implies that the variance of interest rate decreases with financial exclusion, although the welfare loss increases. This is a new explanation to why observed interest rate paths are much less volatile than optimal policies implied by most existing macroeconomic frameworks, as pointed out by Clarida et al. (1999).

Finally, we explore the effects of policy shocks on the economy under an optimal

[1] Next section briefly presents the empirical literature.

[2] The authors argue that current income may not be the appropriate measure of lifetime resources available to agents since a significant fraction of variations of income are due to variations in its transitory component.

commitment policy for different degrees of financial exclusion. After a monetary shock, higher levels of financial exclusion are associated to higher inequality and lower output gap, inflation, and the interest rate. After a fiscal shock, inflation and inequality drop with financial exclusion, while the output gap and interest rate increase.

The next section briefly describes the literature that links monetary policy, inflation and inequality. Section 3 introduces the model while section 4 presents its log-linear version. Section 5 deals with analyzes of the optimal monetary policy. Section 6 provides concluding remarks.

2 Brief literature review

2.1 Empirical evidence

On the one hand, there is extensive empirical literature about the influence of inflation and monetary policy on inequality. For example, both Romer and Romer (1999) and Easterly and Fischer (2001) point out that inflation hurts the poor. While the former finds a strong positive relation between inflation and inequality, the latter finds 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, using household level polling data for 38 countries, that the poor rather than the rich are more likely to mention inflation as a top national concern.

On the other hand, few empirical studies focus on the influence of inequality on inflation. For instance, Al-Marhubi (1997) performs OLS regressions of mean inflation on income inequality and finds that countries with greater inequality have higher mean inflation, even after accounting for the level of openness, political instability, and central bank independence. Dolmas et al. (2000) also run OLS regressions and document a positive correlation between income inequality and inflation in democracies, in contrast to what occurs in non-democracies.

2.2 New Keynesian literature

On the theoretical side, most of the work on monetary policy is based on a framework that assumes the existence of a representative household, which is clearly inadequate to evaluate inequality.[3] Some authors incorporate heterogeneous agents in this framework. Galí et al. (2004) introduce rule-of-thumb consumers in a conventional New Keynesian model with investment to show how their presence can dramatically change the properties of widely used interest rate rules. Bilbiie (2005) uses a similar framework, but in contrast to Galí et al. (2004) he abstracts from capital accumulation and focuses on a different set of questions, specifically how the presence of non-asset holders alters the slope of the IS curve, the determinacy properties of interest rate rules, optimal monetary policy and the response of the model to shocks. Muscatelli et al. (2005) and Landon-Lane and Occhino (2005) use US data to estimate models with liquidity constrained consumers and find a significant role for rule-of-thumb consumer behavior.

In the next section we explicitly incorporate inequality in the structural equations of the New Keynesian textbook model in order to provide unified treatment for the mutual influence between inflation and inequality presented by the empirical literature. Our model contrasts with the current theoretical literature for incorporating different productivities and wages as two other sources of inequality between consumers apart from financial market access. This modification affects the structural equations of the model, the monetary policy objective and introduces a dynamic inequality curve.

3 The model

The economy consists of households, firms, and the government. We use a modified version of the model presented in Galí et al. (2004) to analyze the effects of inequality on monetary policy. We read their rule-of-thumb consumers as agents excluded from the financial market. On the one hand, we simplify their model by ignoring investment, as in Bilbiie (2005). On the other hand, we incorporate different productivities and wages as two other sources of inequality between consumers apart from financial market access. We intend to account for inequality effects while keeping the model as close as possible to the standard New Keynesian framework.

We explicitly assume that money only plays the role of a unit of account. Money does not appear in either the budget constraint or utility function. Throughout, we

[3] See Clarida et al. (1999), Goodfriend and King (1997), and Woodford (2003b).

specify monetary policy in terms of an interest rate rule; hence, we do not need to introduce money explicitly in the model.

3.1 Households

We assume a continuum of infinitely-lived households indexed in the unit interval. An exogenous fraction $\lambda \in (0,1)$ of households - so forth called *financially excluded* (FE) agents - do not own any assets. The remaining fraction $1-\lambda$ of households - the *financially included* (FI) agents - has access to financial markets. We use letters "e" and "i" to index variables associated to FE and FI consumers.

The preference at period 0 of the type k representative household is represented by:

$$U_0^k \equiv E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t^k\right)^{1-\sigma}}{1-\sigma} - \frac{\left(H_t^k\right)^{1+\omega}}{1+\omega} \right] \right\}, \qquad k \in \{e, i\}, \tag{1}$$

where $0 < \beta < 1$ denotes the discount factor, C_t^k is an index of consumption goods and H_t^k is the number of hours worked at period t.[4]

Type k households offer labor in a perfectly competitive market with fully flexible wages. They also purchase differentiated goods in a retail market and combine them into a composite good using a Dixit and Stiglitz (1977) aggregator:

$$C_t^k \equiv \left[\int_0^1 C_t^k(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}, \qquad \theta > 1, \tag{2}$$

where $C_t^k(z)$ is the demand for differentiated goods of type z. Type k household minimizes the total cost of obtaining differentiated goods indexed by a unit interval $[0,1]$, taking as given their nominal prices $P_t(z)$. Cost-minimization then gives a demand curve of the form:

$$C_t^k(z) = C_t^k \left(\frac{P_t(z)}{P_t} \right)^{-\theta}, \tag{3}$$

where the aggregate price level P_t is defined to be

[4]For ease of reference, we group all primitive parameter definitions and baseline values in table 1.

$$P_t \equiv \left[\int_0^1 P_t(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}}.$$

3.1.1 Financially included consumer

In each period $t = 0, 1, 2, \ldots$, the FI household chooses decision rules for consumption C_t^i, labor H_t^i, and nominal bonds portfolio B_{t+1} to maximize (1) subject to a sequence of period budget constraints that must hold with equality in equilibrium:

$$E_t \{Q_{t,t+1} B_{t+1}\} \leq B_t + W_t^i H_t^i + \Pi_t^i - P_t C_t^i - T_t^i,$$

where $Q_{t,t+1}$ is the stochastic discount factor for computing the nominal value at period t of one unit of consumption goods at period $t+1$, W_t^i is the nominal wage rate for FI households, Π_t^i denotes nominal dividend income, and T_t^i represents the nominal value of (net) lump-sum taxes.

The following first order conditions must hold in equilibrium with a positive risk-free nominal rate of interest at period t, i_t:

$$1 + i_t = \left[\beta E_t \left\{ \left(\frac{C_{t+1}^i}{C_t^i} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \right\} \right]^{-1}, \tag{4}$$

$$\left(C_t^i\right)^{\sigma} \left(H_t^i\right)^{\omega} = \frac{W_t^i}{P_t}, \tag{5}$$

regarding the fact that $E_t \{Q_{t,t+1}\} = (1 + i_t)^{-1}$.

3.1.2 Financially excluded consumer

Households from this group are excluded from financial markets and consequently cannot hold assets. Thereafter, FE consumer maximizes (1) subject to the budget constraint:

$$P_t C_t^e \leq W_t^e H_t^e, \tag{6}$$

where W_t^e is the nominal wage rate for FE households. People excluded from the financial system are also unable to buy stocks and receive differentiated treatment from the government. As a result, only FI consumers receive dividends and pay lump-sum taxes.

As equation (6) holds with equality in equilibrium, FE agents just consume their current labor income. The associated first order condition is analogous to (5):

$$\left(C_t^e\right)^{\sigma}\left(H_t^e\right)^{\omega}=\frac{W_t^e}{P_t}, \tag{7}$$

which combined with (6) yields

$$\left(C_t^e\right)^{1-\sigma}=\left(H_t^e\right)^{1+\omega}. \tag{8}$$

3.2 Firms

Monopolistically competitive firms indexed in the unit interval characterize the goods market. Each firm z produces a differentiated good z using Cobb-Douglas technology:

$$Y_t\left(z\right)=A_t\left[H_t^e\left(z\right)\right]^q\left[H_t^i\left(z\right)\right]^{1-q}, \tag{9}$$

where $Y_t\left(z\right)$ denotes the level of output at period t of firm z while $H_t^e\left(z\right)$ and $H_t^i\left(z\right)$ are the total number of working hours hired from each type of agent by this firm. The variable $A_t>0$ is an exogenous technology factor while $q\in(0,1)$ and $1-q$ are the productivity factors associated with each type of agent.

Market clearing imposes $Y_t\left(z\right)=\lambda C_t^e\left(z\right)+\left(1-\lambda\right)C_t^i\left(z\right)+G_t\left(z\right)$, where $G_t\left(z\right)$ represents governmental demand for the good produced by firm z. We assume that government purchases an aggregate G_t of form (2) of all goods in the economy, and thus the government's demand for each good z is given by a demand curve analogous to (3). Thereafter, we obtain the following demand curve for each good z:

$$Y_t\left(z\right)=Y_t\left(\frac{P_t\left(z\right)}{P_t}\right)^{-\theta}, \tag{10}$$

where $Y_t\equiv C_t+G_t\equiv\lambda C_t^e+\left(1-\lambda\right)C_t^i+G_t$ is a composite index analogous to those specified in (2) that denotes aggregate demand.

Since the minimum cost criterion is given by $W_t^eH_t^e\left(z\right)/q=W_t^iH_t^i\left(z\right)/\left(1-q\right)$, we use equations (9) and (10) to derive the number of working hours for each type of agent:

$$H_t^k \equiv \frac{1}{\lambda_k} \int_0^1 H_t^k(z)\, dz = \frac{1}{\lambda_k} \left(\frac{1-q}{q}\right)^{q_k} \left(\frac{W_t^e}{W_t^i}\right)^{q_k} \frac{Y_t Z_t}{A_t}, \qquad k \in \{i, e\}, \tag{11}$$

where $(\lambda_i, q_i) = (1-\lambda, q)$, $(\lambda_e, q_e) = (\lambda, q-1)$, and $Z_t \equiv \int_0^1 \left(\frac{P_t(z)}{P_t}\right)^{-\theta} dz$ is a dispersion measure for prices.

Under these assumptions, all firms face the same nominal marginal costs MC_t^n given by

$$MC_t^n = \frac{1}{A_t} \left(\frac{W_t^e}{q}\right)^q \left(\frac{W_t^i}{1-q}\right)^{1-q}. \tag{12}$$

The marginal cost does not depend on the output level of an individual firm, as long as its production function exhibits constant returns to scale and input prices are fully flexible in perfectly competitive markets.

3.2.1 Flexible-price equilibrium

Under flexible prices, the optimal pricing decision for any firm z takes the traditional form

$$P_t(z) = \frac{\mu}{1+\tau} MC_t^n, \tag{13}$$

where $\mu = \frac{\theta}{\theta-1} > 1$ is the desired markup of the firm. The subsidy for output $0 \leq \tau < 1$ offsets the effect on imperfect competition in the goods markets on the steady state level of output.[5] We combine (12) with (5) and (7) to write the following expression for the real marginal cost:

$$MC_t \equiv \frac{MC_t^n}{P_t} = \frac{1}{A_t} \left(\frac{Y_t Z_t}{A_t}\right)^{\omega} (Y_t - G_t)^{\sigma} \Delta(\delta_t), \tag{14}$$

where factor

$$\Delta(\delta_t) \equiv \left(\frac{\delta_t^{\sigma}}{q(\lambda)^{\sigma+\omega}}\right)^q \left(\frac{(1-\delta_t)^{\sigma}}{(1-q)(1-\lambda)^{\sigma+\omega}}\right)^{1-q}$$

[5] See Woodford (2003b) for details.

is a function of δ_t, defined as the FE agents' share of total consumption

$$\delta_t \equiv \frac{\lambda C_t^e}{C_t}. \tag{15}$$

Finally, we combine equations (13) and (14) to show that relative prices depend on the distribution of consumption characterized by δ_t:

$$\frac{P_t(z)}{P_t} = \frac{\mu}{1+\tau}\frac{1}{A_t}\left(\frac{Y_t Z_t}{A_t}\right)^{\omega}(Y_t - G_t)^{\sigma}\,\Delta(\delta_t)\,.$$

We use an alternative definition of potential output in order to make our work more directly comparable with the existing literature. Thereafter, potential output, Y_t^f, defined as the output that would prevail under flexible wages and prices and *under equal consumption*, i.e. $C_t^e = C_t^i$, given current real factors (tastes, technology, government purchases), must satisfy:

$$1 = \frac{\mu}{1+\tau}\frac{1}{A_t}\left(\frac{Y_t^f}{A_t}\right)^{\omega}\left(Y_t^f - G_t\right)^{\sigma}\Delta(\lambda)\,. \tag{16}$$

Inequality decreases the potential output Y_t^f since $\Delta(\lambda) > 1$. Furthermore, if there is an excess of unqualified people (hereafter $\lambda > q$), Y_t^f decreases with λ.

Condition $\lambda > q$ reflects that there are more unqualified people than firms are willing to hire, increasing their costs. In our model, it is not possible to change the percentage of FE consumers without changing the percentage of less qualified people. This explains why condition $\lambda > q$ links these two apparently distinct characteristics.

Denoting steady state values with an over bar, equation (16) reduces to

$$1 = \frac{\mu}{1+\tau}\left(\bar{Y}\right)^{\omega+\sigma}\Delta(\lambda)\,,$$

where $\bar{A} = 1$ and $\bar{C} = \bar{Y}$.[6] Expressed in terms of percentage deviations around the steady state, the equal consumption flexible-price equilibrium output level is given by

$$\hat{Y}_t^f = \frac{\sigma\hat{G}_t + (1+\omega)\,\hat{A}_t}{\omega+\sigma}, \tag{17}$$

[6] The choice of $\bar{G} = 0$ has been made just to simplify calculations. We would obtain similar dynamics for fiscal and monetary shocks if we had assumed $\bar{G} \neq 0$.

which is the same expression for the natural rate of output in the standard New Keynesian framework, being $\hat{z}_t \equiv (z_t - \bar{z})/\bar{z}$ for all variables z_t, except for $\hat{G}_t \equiv G_t/\bar{Y}$.

4 Dynamic equilibrium

We derive the log-linear version of the model around a steady state with zero inflation, equal consumption for all agents, and without government spending $\left(\bar{C}^e = \bar{C}^i = \bar{C} = \bar{Y}\right)$ to analyze the transition dynamics. In order to allow for real effects of monetary policy, firms set prices as in the sticky price model of Calvo (1983). Specifically, during each period a fraction α of firms are not allowed to change prices, whereas the other fraction, $1 - \alpha$, do change.

4.1 IS curve

The demand side of the model is represented by an intertemporal IS equation. The log-linear version of (4) is

$$\hat{C}_t^i = E_t\left\{\hat{C}_{t+1}^i\right\} - \sigma^{-1}\left[\hat{\imath}_t - E_t\left\{\pi_{t+1}\right\}\right], \tag{18}$$

where π_t is the inflation rate. Analogously, we use equations (8) and (11) to obtain:

$$\hat{C}_t^e = \left(\frac{1+\omega}{1-\sigma}\right)\left[\hat{Y}_t - \hat{A}_t - \left(\frac{1-q}{1-\lambda}\right)\left(\frac{\sigma}{1+\omega}\right)\hat{\delta}_t\right], \tag{19}$$

where we write W_t^e/W_t^i in terms of δ_t.[7]

Finally, the log-linearization of (15) yields:

$$\hat{\delta}_t = \hat{C}_t^e - \hat{C}_t. \tag{20}$$

Defining $x_t \equiv \hat{Y}_t - \hat{Y}_t^f$ as our output gap measure and using equations (18) to (20), we obtain the following IS curve:

$$x_t = E_t\left\{x_{t+1}\right\} - \varphi\left[\hat{\imath}_t - E_t\left\{\pi_{t+1}\right\} - r_t^f\right], \tag{21}$$

[7] From equations (5) and (7), we have $\left(C_t^e/C_t^i\right)^\sigma\left(H_t^e/H_t^i\right)^\omega = W_t^e/W_t^i$. We can obtain $\frac{W_t^e}{W_t^i} = \left(\frac{1-\lambda}{\lambda}\right)^{\frac{\omega+\sigma}{1+\omega}}\left(\frac{q}{1-q}\right)^{\frac{\omega}{1+\omega}}\left(\frac{\delta_t}{1-\delta_t}\right)^{\frac{\sigma}{1+\omega}}$ by using equations (15) and (11) to replace C_t^e/C_t^i and H_t^e/H_t^i.

where $\varphi \equiv \eta\sigma^{-1}$ and $\eta \equiv 1 + \frac{\lambda(\omega+\sigma)}{1-q\sigma-\lambda(1+\omega)}$. The real interest rate that stabilizes the output gap, r_t^f, called the natural rate of interest, evolves according to:

$$r_t^f \equiv \varphi^{-1}\left[\left(\frac{1+\omega}{\omega+\sigma}\right)\eta E_t\left\{\hat{A}_{t+1}-\hat{A}_t\right\}+\left(\frac{1-(1+\omega)\eta}{\omega+\sigma}\right)E_t\left\{\hat{G}_{t+1}-\hat{G}_t\right\}\right].$$

As in Bilbiie (2005), our model predicts that when financial exclusion change from high to low the slope of the IS curve changes from positive ("non-Keynesian") to negative. Note, however, that η also varies with q. If $\eta > 1$, the impact of the interest rate on the output gap is more intense than in the standard New Keynesian model. We show in panel (A) of figure 1 that, considering only Keynesian values, η increases with λ.

4.2 Inequality evolution

We combine equations (19) and (20) to write $\hat{\delta}_t$ as a function of x_t:

$$\hat{\delta}_t = \left(\frac{1}{1+\gamma}\right)\left[(\sigma+\omega)x_t+\hat{G}_t\right], \tag{22}$$

where $\gamma \equiv \sigma\left(\frac{\lambda-q}{1-\lambda}\right)$. We choose the Gini index for consumption, given by $g_t = -\lambda\hat{\delta}_t$, as the inequality variable of our economy.[8]

The evolution of the Gini index, obtained from the substitution of (22) in the IS curve and the replacement of $\hat{\delta}_t$ for g_t, gives us an intuitive way of seeing how monetary policy affects inequality:

$$g_t = E_t\{g_{t+1}\} + \varphi^\delta\left[\hat{\imath}_t - E_t\{\pi_{t+1}\} - r_t^\delta\right], \tag{23}$$

where $\varphi^\delta \equiv \eta^\delta\sigma^{-1}$, $\eta^\delta \equiv (1-\lambda)(\eta-1)$ and r_t^δ, the real interest rate that stabilizes g_t, is defined as

$$r_t^\delta \equiv r_t^f - \frac{\varphi^{-1}}{\omega+\sigma}E_t\left\{\hat{G}_{t+1}-\hat{G}_t\right\}.$$

[8]Normalizing C_t to unity (or 100 percent of consumption) and imposing that $C_t^e < C_t^i$, we obtain $g_t = -\lambda\hat{\delta}_t$. If $C_t^e > C_t^i$, we find that $g_t = \lambda\hat{\delta}_t$. Thereafter, the Gini index is given by $\left|\lambda\hat{\delta}_t\right|$, which assumes only positive values as a measure. In this context, it does not matter for the Gini index that agent consumes more, but only how different their consumption is. In the present work, we will define $g_t = -\lambda\hat{\delta}_t$. Although this variable is not a measure, the sign helps to identify which agents are increasing their consumption. "Inequality increases" means that FE agents are reducing their consumption.

If $\eta > 1$, inequality rises with the interest rate. The difference between the real interest rates that stabilize the output gap and the Gini index is solely based on the evolution of government spending. Panel (A) of figure 1 shows that η^{δ} increases with λ, being always smaller than η.

4.3 New Keynesian Phillips curve

The Calvo (1983) model leads to an aggregate supply relation of the form:

$$\pi_t = \xi \widehat{MC}_t + \beta E_t \{\pi_{t+1}\}, \tag{24}$$

where $\xi \equiv (1-\alpha)(1-\alpha\beta)/\alpha > 0$ and $\widehat{MC}_t$ is the percent variation of real marginal costs.

Considering (17), a log-linearization of the real marginal costs expressed in (14) yields:

$$\widehat{MC}_t = (\omega + \sigma) x_t + \frac{\gamma}{\lambda} g_t.$$

The first component is standard but now with a different interpretation. Marginal costs are proportional to the output gap that *would* occur if consumption of both agents were equal. The second term corrects this measure by the inequality effect. We can use this equation and (24) to obtain our New Keynesian Phillips curve (NKPC)

$$\pi_t = \kappa x_t + \beta E_t \{\pi_{t+1}\} + \kappa^{\delta} g_t, \tag{25}$$

where $\kappa \equiv \xi(\omega + \sigma)$ and $\kappa^{\delta} \equiv \xi\gamma/\lambda$.

From (22) and (25) the NKPC can be written in a more familiar format

$$\pi_t = \kappa^* x_t + \beta E_t \{\pi_{t+1}\} + u_t, \tag{26}$$

where $\kappa^* \equiv \kappa \left(\frac{1}{1+\gamma}\right)$ and the shock u_t is given by

$$u_t \equiv -\xi \left(\frac{\gamma}{1+\gamma}\right) \hat{G}_t.$$

Equation (23), which shows how monetary policy affects inequality, together with equation (25), the inequality augmented NKPC, lead to our first result:

Conclusion 1 (Inequality channel) *There is a channel from interest rate to inflation throughout inequality when* $\lambda \neq q$. *If there is an excess of unqualified people* $(\lambda > q)$, *inflation rises with inequality* $\left(\kappa^{\delta} > 0\right)$. *Besides, the inequality-inflation trade-off* $\left(\kappa^{\delta}\right)$ *decreases with financial exclusion* (λ). *Alternatively, if* $\lambda > q$, *the output-inflation trade-off is higher than in the standard New Keynesian model* $(\kappa^{*} < \kappa)$. *In addition, a shock* u_t *arises as a function of the share of government spending that impacts the real interest rate that stabilizes inequality* $\left(r_t^{\delta}\right)$ *but not the natural rate of interest* $\left(r_t^{f}\right)$.

5 Optimal monetary policy

The policymaker maximizes the average expected utility of households. Following Erceg et al. (2000) and Woodford (2003b), we obtain our policy objective function by taking a second-order approximation to the aggregate utility of all agents given by:

$$W_0 = \lambda U_0^e + (1-\lambda) U_0^i,$$

where U_0^e and U_0^i are defined in (1).

This procedure yields

$$W_0 = -\Omega E_0 \left\{ \sum_{t=0}^{\infty} \beta^t L_t \right\} + tip, \tag{27}$$

where *tip* denotes terms independent of the actual policy such as constants and terms involving only exogenous variables while L_t is given by:

$$L_t \equiv \lambda_x x_t^2 + \lambda_\pi \hat{\pi}_t^2 + \lambda_\delta g_t^2, \tag{28}$$

where λ_x, λ_π and λ_δ are functions of the structural parameters of the model and $\lambda_x + \lambda_\pi + \lambda_\delta = 1$.[9] Thereafter, we have:

[9] Specifically, $\lambda_x \equiv \frac{\kappa}{\Gamma}$; $\lambda_\pi \equiv \frac{\theta}{\Gamma}$; $\lambda_\delta \equiv \frac{\Psi}{\Gamma}$; with $\Gamma \equiv \kappa + \theta + \Psi$ and $\Psi \equiv \xi \left[\frac{(1+\omega)\lambda(1-\lambda)+\sigma q(1-q)}{\lambda^2(1-\lambda)^2}\right] \frac{\sigma}{1+\omega} > 0$. Also $\Omega \equiv \frac{\left(\bar{Y}\right)^{1-\sigma}}{2}\left[\frac{\Gamma}{\xi}\right]$.

Conclusion 2 (Inequality objective) *The objective of a monetary policy consistent with welfare maximization includes inequality stabilization* (g_t^2)*, as well as inflation and output gap stabilization* $(\hat{\pi}_t^2$ *and* $x_t^2)$*. Furthermore, the relative importance of* g_t^2 *on loss function* L_t *decreases as* $\lambda \to 1/2$*, meaning that when the two groups are equally represented, central banks should pay relatively less attention to inequality variations and direct their policy concerns to the evolution of inflation and output gap.*

This result is in line with Fowler (2005) that finds empirical evidence that a Gini based monetary feedback rule is compatible with several features of the US economy.

The maximization of (27) subject to the constraints represented by the NKPC in (25) and the equation that governs the dynamics of g_t in (22) generates the following criterion under commitment:

$$\hat{\pi}_t = -\frac{1}{\kappa^*\theta}\left[\kappa\left(x_t - x_{t-1}\right) - \Psi\left(\frac{\eta^\delta}{\eta}\right)\left(g_t - g_{t-1}\right)\right]. \qquad (29)$$

This so-called *optimal target criterion* represents a policy rule that is optimal from a *timeless perspective* following Giannoni and Woodford (2005). Inflation should be accepted as long as it is negatively proportional to output gap variations corrected by inequality variations over the same period.

It is not optimal to maintain zero inflation and a zero output gap in the face of inequality variations. If $\lambda > q$, the coefficient on x_t in first order condition $\kappa\left(\kappa^*\theta\right)^{-1} = (1+\gamma)\,\theta^{-1}$ is greater than standard value θ^{-1}. In this context, optimal policy results in greater inflation variability for a given level of output gap variability when inequality is present.

Intuitively, stabilizing inflation has become more costly when $\lambda > q$. As $\hat{\imath}_t$ increases, x_t decreases, and this serves to reduce inflation, but the direct effect in g_t of the rise in the nominal interest rate partly offsets the deflationary impact of a tighter monetary policy. Because it is more costly (in terms of the output gap) to control inflation, equilibrium inflation variability will be higher.

In order to implement the target rule, we obtain an optimal instrument rule by substituting equations (21), (23), and (25) in the optimal criterion (29):

$$\hat{\imath}_t = \phi_\pi E_t\{\pi_{t+1}\} + \phi_x E_t\{x_{t+1}\} + \phi_\delta E_t\{g_{t+1}\} + \phi_{x-1}x_{t-1} + \phi_{\delta-1}g_{t-1} + \epsilon_t, \qquad (30)$$

where the $\phi_j's$ are functions of the structural parameters of the model while composite shock ϵ_t is defined according to

$$\epsilon_t \equiv \varphi\phi_x r_t^f - \varphi^\delta \phi_\delta r_t^\delta,$$

which is the weight average between the natural rate of interest and the real interest rate that stabilizes g_t.[10]

We call equation (30) our *expectations-based reaction function* following Evans and Honkapohja (2006). If the monetary authority commits itself to set interest rates in accordance with this reaction function at all times, then the rational-expectations equilibrium is necessarily determinate.[11]

6 Implications for welfare and transition dynamics

To illustrate not only the impact on welfare but also the response to monetary and fiscal shocks under optimal commitment, we calibrate the model represented by equations (21), (23), (25), and (30) and solve it numerically.

6.1 Calibration

The model's structural parameters are α, β, θ, σ, ω, q and λ. The baseline values we use, shown in table 1, are standard and based on Giannoni and Woodford (2005). Since we intend to keep the model as close as possible to the standard New Keynesian framework, we will not consider calibrations that generates "non-Keynesian" effects, e.g. a IS curve with a positive slope or a inverted Taylor principle.

We set $\sigma = 0.9$ in order to obtain in our baseline case ($\lambda = q$) the value of

[10] The coefficients are $\phi_\pi \equiv 1 + \frac{\beta\kappa^*\theta}{\Upsilon}$, $\phi_x \equiv \frac{\Upsilon_1}{\Upsilon}$, $\phi_{x-1} \equiv -\frac{\kappa}{\Upsilon}$, $\phi_\delta \equiv -\frac{\Upsilon_2}{\Upsilon}$, and $\phi_{\delta-1} \equiv \frac{\Psi}{\Upsilon}\left(\frac{\eta^\delta}{\eta}\right)$, being $\Upsilon \equiv \varphi\Upsilon_1 + \varphi^\delta\Upsilon_2$, $\Upsilon_1 \equiv \kappa(1+\kappa^*\theta)$, and $\Upsilon_2 \equiv \Psi\left(\frac{\eta^\delta}{\eta}\right) - \kappa^\delta\kappa^*\theta$. Once again $\Psi \equiv \xi\left[\frac{(1+\omega)\lambda(1-\lambda)+\sigma q(1-q)}{\lambda^2(1-\lambda)^2}\right]\frac{\sigma}{1+\omega} > 0$.

[11] Note that we can substitute (22) in (30) to obtain a model similar to Woodford (2003b). When $\lambda > q$ and $\eta > 1$, the relevant signals of our model are analogous to the ones presented in Woodford (2003b, page 530), and so the result immediately applies.

$\varphi = 1.60$, which is very similar to the value obtained for Giannoni and Woodford (2005) for their equivalent parameter φ^{-1}. The discount factor β is set equal to 0.99, appropriate for interpreting the time interval as one quarter. The value of 0.66 for α is consistent with an average lifetime of price contracts of three quarters. A value of 11 for θ implies a steady state markup of 1.1. Because the focus of this article is on exploring the effects of inequality, results are reported for several values of λ. Based on surveyed evidence around the world, we restrict attention to the values of financial inclusion below 0.4.[12] The value of q just matter in comparison with λ ($q \gtrless \lambda$) but does not affect the results quantitatively. We set q to 0.1 in order to obtain $\lambda \geq q$ and, in turn, $\bar{W}^e \leq \bar{W}^i$ and $\kappa^\delta \geq 0$ (or equivalently, $\kappa^* < \kappa$).

Parameter	Description	Value
α	Fraction of firms that leave their prices unchanged	0.66
β	Time discount factor	0.99
θ	Elasticity of substitution among differentiated goods	11
λ	Level of financial exclusion	$(0, 0.4]$
σ	Risk aversion parameter	0.90
ω	Inverse of elasticity of labor supply	0.33
q	FE productivity	0.10
ϕ_g	fiscal shock inertia	0.90

Table 1: Baseline calibration

Figure 1 presents the evolution of the main composite parameters of the model.

6.2 Welfare analysis

Taking the unconditional expectation of (27) to abstract from initial conditions, we obtain the welfare as a function of weighted variances:

$$\hat{E}\left[L^0\right] \equiv \Lambda_x V\left[x_t\right] + \Lambda_\pi V\left[\hat{\pi}_t\right] + \Lambda_\delta V\left[g_t\right],$$

where, for any variable z_t, we have the weight $\Lambda_z \equiv \Gamma \lambda_z$, and where the measure of variability is defined by

[12] Aizcorbe et al. (2003) pointed out that 90.9 percent of US families had some type of transaction account in 2001. Accordingly to FSA (2000), 7 percent of households in Britain lack any financial products at all.

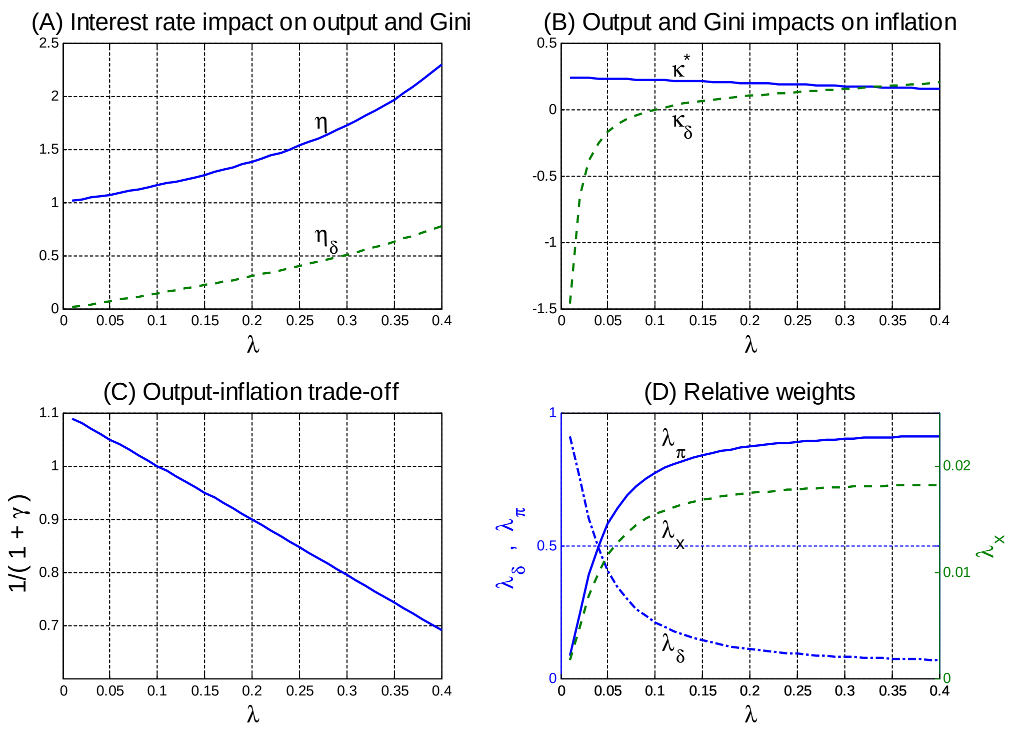

Figure 1: Financial exclusion and inequality effects under baseline calibration of table 1.

$$V\left[z_t\right] \equiv (1-\beta)\sum_{t=0}^{\infty}\beta^t E_0\left[z_t^2\right],$$

which, except for discounting, corresponds to the unconditional variance of z_t. We include Γ in the calculation of $\hat{E}\left[L^0\right]$ to analyze how welfare evolves with λ. It is important to remember that λ_x, λ_π and λ_δ have been normalized to sum one. Therefore, the graph in panel (D) of figure 1 describes how inflation becomes relatively more important as λ grows. Without this normalization, Λ_π, and Λ_x do not vary with λ, in contrast to Λ_δ that decreases.[13]

Under the optimal plan, higher levels of financial exclusion are associated to bigger welfare losses. The impact of the interest rate on inequality, η, and output gap, η^δ, increases with λ. See panel (A) of figure 1. At the same time, inflation stabilization becomes more costly, since nominal interest rate generates opposite impacts on g_t and x_t. As a result, the equilibrium variability of π_t, x_t, and g_t is

[13] Under our baseline calibration, $\Lambda_\pi = 11$ and $\Lambda_x = 0.2963$. The value of $\Lambda_\delta \sim 1$ when $\lambda = 0.4$ and $\Lambda_\delta \to \infty$ when $\lambda \to 0$.

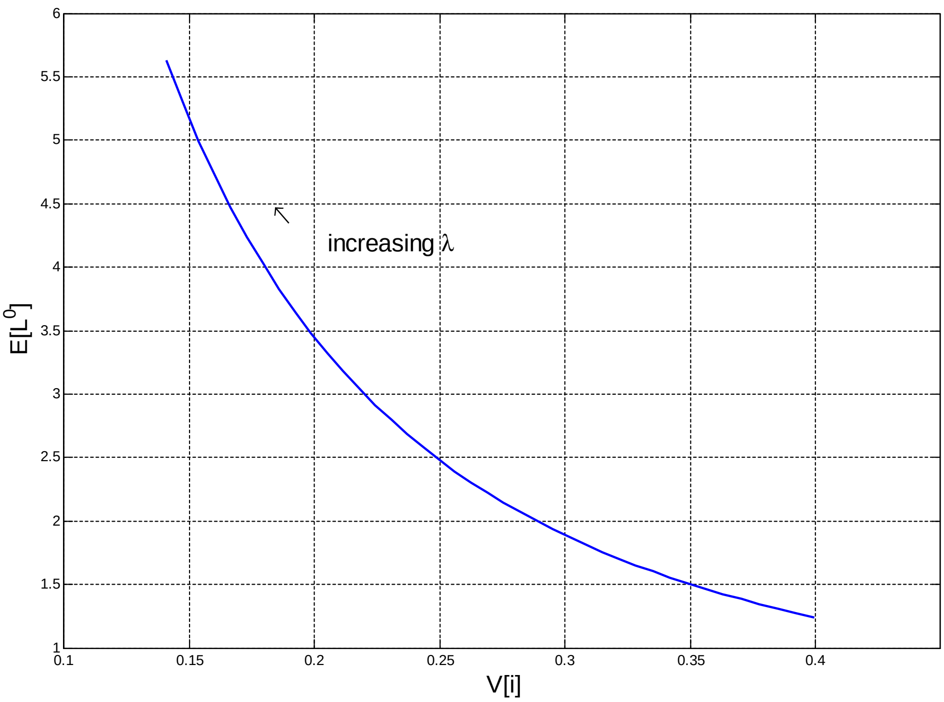

Figure 2: Welfare loss and interest rate variability.

higher.

Note, however, that interest rate variability decreases with financial exclusion. This leads to our final result:

Conclusion 3 (Efficient frontier) *An efficient frontier emerges from the fact that welfare loss and interest rate variability evolve in opposite ways with financial exclusion under the optimal plan.*

Figure 2 presents the efficient frontier.

In our model, interest rate volatility is avoided because of its direct impact on inequality, which increases with λ. This is a new explanation to why observed interest rate paths are much less volatile than optimal policies implied by most existing macroeconomic frameworks, as pointed out by Clarida et al. (1999). Some of the arguments that have been proposed to explain this behavior include uncertainty about the data (Orphanides (2001)), model uncertainty (Brainard (1967)), the zero bound on nominal interest rates non-binding (Woodford (2003a)), and the fear of disruption of financial markets.

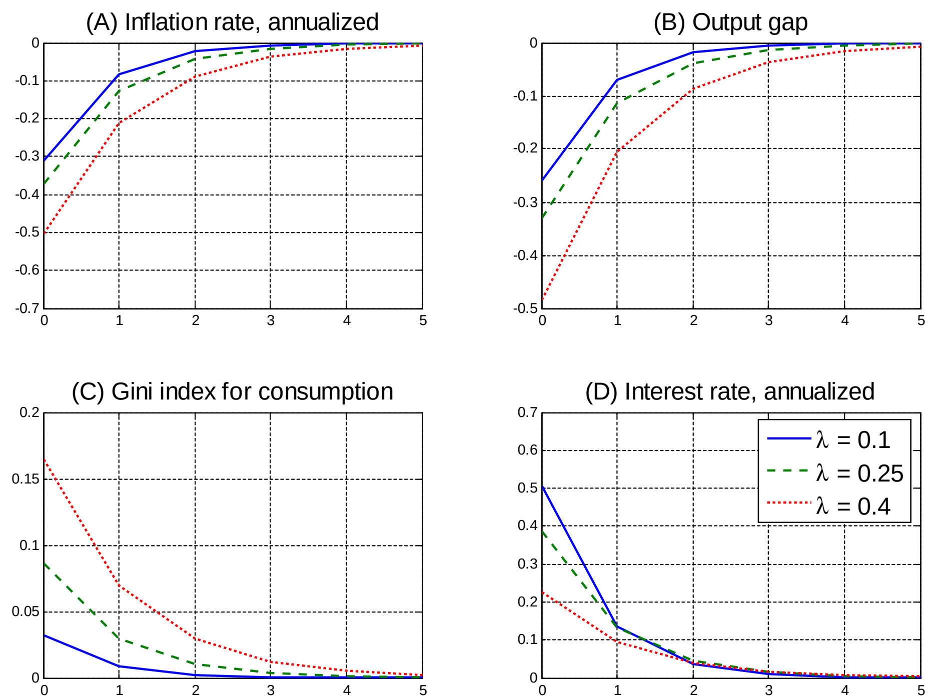

Figure 3: Impulse responses to a monetary shock under optimal commitment under alternative levels of financial exclusion - main variables.

6.3 Optimal response to policy disturbances

6.3.1 Monetary shocks

Figure 3 shows the impulse responses of the four endogenous variables to a monetary shock under an optimal commitment policy. The different lines are indexed by λ.

The introduction of an inequality channel does not affect the basic response pattern. For all values of λ, a monetary shock contracts the output gap and increases inequality, as measured by the Gini index $\left(-\lambda\hat{\delta}_t\right)$, since interest rates rise above both their natural rate r_t^f and the natural rate of inequality r_t^δ. These movements generate opposite impacts on inflation. Nevertheless, since persistently negative future output gaps compensate for inflationary pressure generated by the increase in inequality, inflation falls. As λ increases, all these dynamics are amplified, the initial responses of the output gap and inflation are lower, and the Gini response is higher. Since the optimal interest rule considers inequality, the nominal interest rate rises less under this policy.

From the point of view of the agents' decisions, FI agents postpone their con-

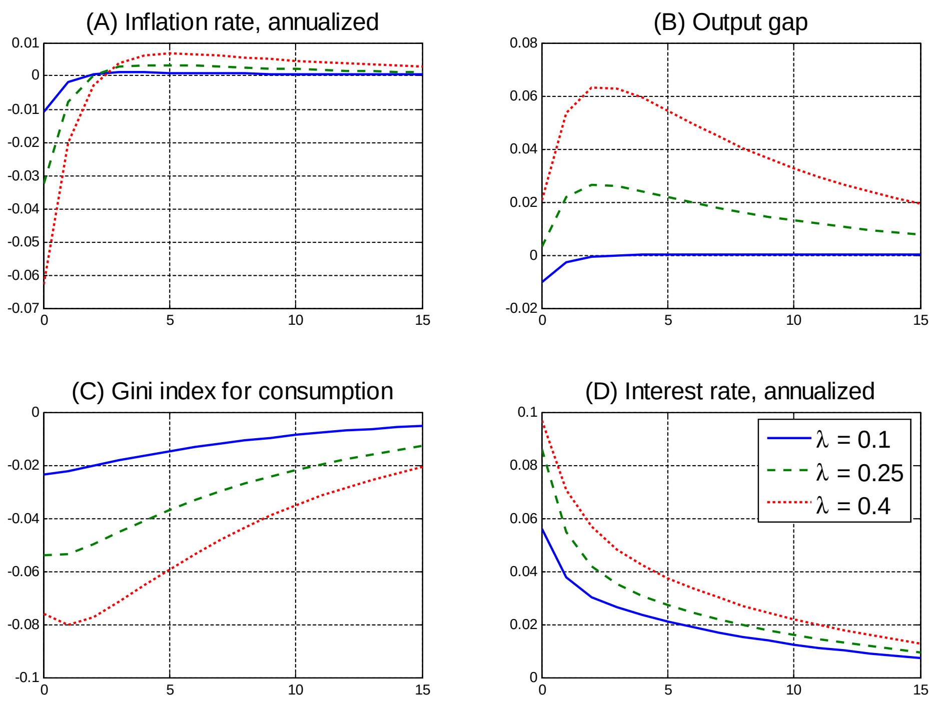

Figure 4: Impulse responses to a fiscal shock under optimal commitment under alternative levels of financial exclusion - main variables.

sumption in response to an interest rate increase induced by the monetary shock. Market clearing forces firms to reduce their production and, consequently, the demand for labor and wages paid for both agents. Since FE agents direct all their current labor income to consumption, any reduction in wages and working hours will drive them to reduce their consumption as well.

When $\eta > 1$, FE consumption and wages, expressed in terms of percentage deviations around the steady state, are more volatile than FI consumption and wages, while the opposite is true regarding hours. It happens because FE consumers are less susceptible to cuts in their wages since they only consume if they work.

6.3.2 Fiscal shocks

Figure 4 shows the impulse responses of the four endogenous variables to a fiscal shock under an optimal commitment policy. The different lines are indexed by λ.

Under a fiscal shock, $r_t^f \neq r_t^\delta$. As a result, the central bank becomes unable to stabilize inequality and output gap with just one instrument – the interest rate.

Since both variables impact inflation, maintaining a zero output gap is not enough to keep inflation at zero. Even when inequality has no influence on inflation ($\lambda = q$), the optimal policy that reduces fluctuations in welfare allows both inflation and the output gap to deviate from zero. When $\lambda > q$ the presence of the Gini index on the Phillips curve affects inflation similarly to the introduction of a cost channel as in Ravenna and Walsh (2006).

This dynamics contrasts with the one presented by the standard textbook New Keynesian model, when monetary authorities face no trade-off between stabilizing inflation and output gap, being able to perfectly offset the impact of a fiscal shock.

As figure 4 shows, the monetary authority responds to a fiscal shock with an increase in the interest rate. As the interest rate rises less than r_t^δ, inequality drops. The impact on the output gap depends on the value of λ. For bigger values of λ, the rise in r_t^f more than compensates for monetary tightening, increasing the output gap, while the opposite occurs for small values of λ. The inflation dynamics is initially dominated by the Gini index, while the influence of the output gap is noticeable on the overshooting that occurs.

After the fiscal shock, the resulting interest rate increase induces FI agents to postpone their consumption. However, government spending more than compensates for this decline in consumption, forcing firms to increase their production and, consequently, the demand for labor. Nevertheless, as FI agents are not so anxious for consumption, they are willing to accept smaller wages for the same amount of work. Thereafter, their real wages fall, even with an increase in working hours. On the other hand, FE agents do not respond to the resulting interest rate increase and thereby require higher real wages to work more. Since FE agents direct all their current labor income to consumption, any increase in wages and working hours will drive them to increase their consumption as well.

7 Conclusions

We have incorporated inequality into the standard New Keynesian framework by introducing two types of agents with different productivities, wages, and financial market accesses. In our model, inequality, evaluated through an index built on the consumption of the two types of agents, affects both structural equations and the monetary policy objective.

We show that monetary policy influences both output gap and inequality, which in turn affect inflation. Furthermore, we derive a welfare-based loss function for the monetary authority that encompasses not only inflation and output gap but also inequality variations.

We also show that welfare losses and interest rate variability under the optimal plan evolve in opposite directions with financial exclusion. Finally, we show how different levels of financial exclusion affect both welfare and the dynamic responses of the model after fiscal and monetary shocks.

As part of future research associated with the present paper, we plan to conduct a quantitative analysis of the joint evolution of nominal interest rates and inequality in several countries. Finally, it would also be relevant to explore how social plans, such as investments in education or minimum-wage policies, affect both inequality and the monetary policy. Nevertheless, additional investigation into this "social-macro dynamics" requires a unified theoretical framework that encompasses both social and economic policies. This model is just a first step in this direction.

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