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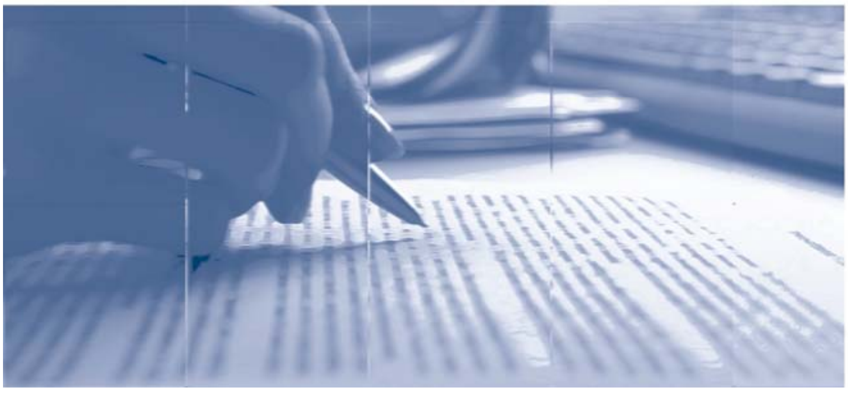

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# How Would Monetary Policy Look Like if John Rawls Had Been Hired as a Chairman of the Fed?

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**Abstract**

Using a textbook New Keynesian model extended with an inequality channel, we examine optimal monetary policy departing from the traditional utilitarian social welfare function, to consider alternative functions, including the Rawlsian approach of putting only weight to the agent with the lowest welfare level. Our main results show the optimal responses from a Rawlsian monetary authority are: (i) a less aggressive monetary tightening, but inducing a more pronounced drop in inflation after a monetary shock; (ii) a monetary policy easing after an increase in government spending and (iii) a more pronounced drop in the interest rate after a positive total factor productivity shock.

**Keywords:** Inequality, Optimal monetary policy, Interest rate variability

**JEL Classication:** E31, E32, E52

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# 1 Introduction

Central banks are key players in shaping economic policies. Indeed, they have an immense privilege: they are the only institutions allowed to create central bank money. This gives them the power to influence a central price in the economy: the interest rate. Interest rates are critical in many long term decisions by economic agents. Thus, by guiding these rates, central banks can significantly influence the economic choices made every day.

To help craft optimal monetary policy, central banks rely on economic models. In particular, they use models to determine the policy that would maximize social welfare. Presently, most models used by central banks, like dynamic stochastic general equilibrium (DSGE) models, rely on the assumption of a representative agent or household. In such a framework, the question of the maximization of social welfare is straightforward: since there is only one agent in the economy, maximizing social welfare is equivalent to maximizing individual welfare.

Recent economic research, though, abandons the representative agent hypothesis, because "many macro questions of great relevance simply cannot be addressed without allowing for at least some heterogeneity" (Heathcote, Storesletten, and Violante (2009)). A model with heterogeneous agents appears to be more aligned with reality.

However, moving to models with heterogeneous agents raises the question of which social welfare function to use, i.e., now that we have multiple agents, how do we aggregate their individual welfare levels into overall social welfare? The classic answer is to use a utilitarian social welfare function, in which social welfare is just the sum of individual welfare levels. This choice is rather arbitrary and several other social welfare functions could be used, ranging from a utilitarian function (same weight to all agents) to a Rawlsian function (weight to the agent with the lowest welfare level only), based on the philosophical work of John Rawls.

The objective of this paper is to identify and compare optimal monetary policy under different social welfare functions. We base our analysis on the research by Areosa and Areosa (2016). Their framework is similar to a textbook New Keynesian model with the addition of heterogeneous agents. Concretely, households are separated into two groups, which differ in three dimensions: productivities, wages and financial access. While one group has higher productivity, higher wages and better access to financial markets (henceforth, FI households), the other group has lower productivity, lower wages and no access to financial markets (FE households). The authors show that the fact that agents differ not only in whether they have access to the financial market, but also on the labor market creates an inequality channel.[1] This channel appears because the interest rate affects inflation through changes in the *distribution* of aggregate consumption. The ratio-

[1] Areosa and Areosa (2016) choose a consumption-based inequality index, moving beyond income as an indicator of well-being and being in line with Krueger and Perri (2006).

nale behind this effect is simple: since the interest rate affects the incentives for working and consuming differently, firms must change the way they organize their production to minimize costs. In this context, variations in the distribution of consumption capture variations in production costs, which appear in the Phillips curve. This is why models that do not consider heterogeneity in the labor market, like Bilbiie (2008) and Galí, López-Salido, and Vallés (2004), do not present the inequality channel.

Areosa and Areosa (2016) study the case of a utilitarian central bank and show that introducing heterogeneous agents with limited access to financial markets transforms the central bank's objective function. In addition to the output gap and inflation, as in the representative agent case, central banks now also include inequality in their objective function. 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. We extend their analysis to incorporate the fact that the central bank might not use a utilitarian welfare-based function, but put any other weights on the two groups of agents.

Our main results highlight how different weighting schemes affect the optimal response to monetary, fiscal and productivity shocks. The optimal response to a positive monetary shock does not depend significantly on how the central bank weights the welfare of each type of agent. In all cases, after a monetary shock, the interest rate rises, causing inflation and output gap to drop. Although this dynamic is observable for all weights, under a Rawlsian welfare-based function, the interest rate rises less and the output gap fall slightly less. In turn, inflation falls slightly more while inequality rises less. Even with less aggressive monetary policy, inflation drops more under a Rawlsian monetary policy. This finding is in line with the empirical evidence that points to inflation as a major concern for low-income people. In this context, an optimal monetary policy with focus on the low-income group would fight inflation insofar as it erodes real wages.

A completely different situation arises after a fiscal shock, represented by an increase in government spending. While optimal monetary policy pushes the interest rate up when the central bank overlooks the financially excluded households, it comes down when the bank implements a Rawlsian monetary policy. This difference in the optimal policy appears in inflation: it drops in the former case and climbs in the latter. The idea that under a Rawlsian monetary policy, the central bank allows inflation to go up might seem puzzling. Nevertheless, despite a possible increase in inflation, a fiscal shock always benefits households with no access to the financial markets insofar as an increase in economic activity raises both real wages and working hours, increasing their consumption. An increase in the interest rate would partially offset this benefit. This dynamics suggests that when the central bank looks exclusively to the low-income group, it is prone to accept increases in the price index that are lower than the nominal wage growth.

Finally, our results suggest that a positive total factor productivity shock amplifies the difference in the production of the two groups of workers - skilled and unskilled. For this reason, the real wage grows more intensively for the qualified workers. When the central bank implements the monetary policy to benefit the less qualified workers, this difference diminishes, but does not disappear. The increase in real wages generates an increase in labor income, which in turn induces an increase in consumption. Compared to the unskilled workers, the skilled workers increase their consumption proportionally more. This difference in the response of the two groups appears as an increase in inequality, which becomes less intense when the central bank maximizes the welfare of the low-income group.

The next section briefly describes the literature that links monetary policy, inflation and inequality. We summarize the log-linear version of the model of Areosa and Areosa (2016) in Section 3. We then derive the optimal monetary policy in Section 4, calibrate the model to evaluate its quantitative implications in Section 5, and provide concluding remarks in Section 6. Details of all the derivations are available from us.

## 2 Brief literature review

**Empirical evidence**. Considering the empirical literature about the influence of inflation and monetary policy on inequality, Romer and Romer (1999) find a strong positive relationship between inflation and inequality while Easterly and Fischer (2001) find that direct measures of improvement in the well-being of the poor and inflation are negatively correlated. In opposition to these findings, Doepke and Schneider (2006) assess the effects of inflation through changes in the value of nominal assets to show that the main losers from inflation are rich, old households, the major bondholders in the economy. Recently, Coibion, Gorodnichenko, Kueng, and Silvia (2012) document that in the U.S. monetary policy contractions have substantial and persistent redistributive effects, increasing income and consumption inequality. Few empirical studies focus on the influence of inequality on inflation. For instance, Al-Marhubi (1997) finds that countries with greater inequality have higher mean inflation, even after accounting for the level of openness, political instability and central bank independence, while Dolmas, Huffman, and Wynne (2000) document a positive correlation between income inequality and inflation in democracies.

**Theoretical literature.** The analysis of monetary policy in much of the recent literature is based on a framework that assumes the existence of a representative household, which is clearly inadequate to evaluate inequality.[2] Recently, a growing literature incorporates heterogeneous agents into this framework in order to study the distributional

[2] See Goodfriend and King (1997), Clarida, Galí, and Gertler (1999) and Woodford (2003).

effects of monetary policy.[3] This article relies heavily on the works of Galí, López-Salido, and Vallés (2004) and Bilbiie (2008). Galí, López-Salido, and Vallés (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 (2008) and Natvik (2012) modify this framework to answer a different set of questions. While the former author neglects capital accumulation to study how the presence of non-asset holders alters the slope of the IS curve and the determinacy properties of interest rate rules, the latter shows that the ability to explain the positive consumption response as a consequence of rule-of-thumb behavior hinges on the arbitrary assumption that wealth is redistributed across households in steady state. Within this literature, Muscatelli, Tirelli, and Trecroci (2005) and Landon-Lane and Occhino (2005) use U.S. data to estimate models with liquidity-constrained consumers and find a significant role for rule-of-thumb consumer behavior, while Motta and Tirelli (2014) report that monetary contractions have redistributive effects in favor of asset holders, broadly confirming the findings in Coibion, Gorodnichenko, Kueng, and Silvia (2012).[4]

More recently, Ascari, Colciago, and Rossi (2011) and Ko (2015) introduce sticky wages into a model similar to Bilbiie (2008). While the former study neglects heterogeneous labor and concludes that the limited asset market participation is not relevant for monetary policy, the latter incorporates segmented labor markets and, similar to us, obtains that inequality poses a tradeoff with traditional monetary policy objectives. We, however, consider that our modeling choice, without sticky wages and simply considering different types of labor in the production function, keeps the most relevant insights of the relation between inflation, inequality and monetary policy with greater simplicity of exposition.

# 3 The model

We use the model presented in Areosa and Areosa (2016) to account for inequality effects while keeping the model as close as possible to the standard New Keynesian framework. There is a continuum of infinitely-lived households indexed in the unit interval and monopolistically competitive firms setting prices as in the sticky price model of Calvo (1983). There are, however, two main departures from the standard model: (i) an exogenous fraction $\lambda \in (0,1)$ of households - henceforth called *financially excluded* (FE) agents - offer unskilled labor, do not own any assets, and do not pay taxes, while the remaining fraction $1-\lambda$ of households - the *financially included* (FI) agents - offer skilled labor, pay taxes,

[3] For a broader view of the distributional consequences of monetary policy and inflation, see Doepke, Schneider, and Selezneva (2015), Auclert (2015), Brunnermeier and Sannikov (2012), Williamson (2008) and Albanesi (2007). Nakajima (2015) presents a recent overview.

[4] Other studies modeling several types of market segmentation are Occhino (2004), Vissing-Jorgensen (2002), Alvarez, Atkeson, and Kehoe (2002) and Alvarez, Lucas, and Weber (2001).

and have access to financial markets and (ii) each firm uses a Cobb-Douglas technology to combine the two types of labor to produce a differentiated good.

With a slight abuse of terminology, we refer to financially included (FI) and financially excluded (FE) agents as "skilled" and "unskilled". This terminology comes from the fact that under the baseline calibration, FI agents are more productive and have a higher hourly wage and payroll than FE agents in steady state. The letters "$e$" and "$i$" refer to variables associated with FE and FI consumers.

The following equations summarize the log-linear version of the model, being $\hat{z}_t \equiv (z_t - \bar{z}) / \bar{z}$ the percent deviation of a given variable $z_t$ from its steady-state level $\bar{z}$, except for government spending $\hat{G}_t \equiv \left(G_t - \bar{G}\right) / \bar{Y}$, and the Gini index $\hat{g}_t \equiv \hat{g}_t - \bar{g}$. In order to make future references easier, we describe the structural parameters of the model in Table 1.

## 3.1 IS curve

The demand side of the model is represented by an intertemporal IS equation:

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

where $x_t$ is the output gap measure, $\pi_t$ is the inflation rate, and $\hat{\imath}_t$ is the nominal interest rate. The real interest rate that stabilizes the output gap, $r_t^f$, called the natural rate of interest, evolves according to:

$$r_t^f \equiv \vartheta^{-1} \left[\tilde{\nu} E_t \left\{\hat{G}_{t+1} - \hat{G}_t\right\} + (\tilde{q} - \tilde{\nu}) E_t \left\{\hat{A}_{t+1} - \hat{A}_t\right\}\right],$$

where $\hat{A}_t$ represents the productivity factor, $\hat{G}_t$ is government spending and where $\tilde{\nu} \equiv \frac{(1-\nu)\lambda\sigma - \nu q\omega}{q\omega + \lambda\sigma}$, $\tilde{q} \equiv \frac{q}{q\omega + \lambda\sigma}$ and $\nu \equiv \frac{1-q\sigma}{1-q\sigma-q(1+\omega)}$.

This equation combines two different behaviors: while FI agents use changes in the real interest rate to smooth their consumption in time, FE households do not react to those changes and simply consume their current labor income. As not all agents respond to interest rate changes, the slope of the IS curve $\vartheta \equiv \eta \left(\sigma \left(\frac{\lambda}{q}\right)\right)^{-1}$, being $\eta \equiv \frac{1-q\sigma-\lambda(1-\sigma)}{1-q\sigma-q(1+\omega)}$, is different from what is obtained in the standard New Keynesian model, which depends only on the intertemporal elasticity of substitution $\sigma > 0$. This result is in line with Bilbiie (2008), since both models assume the existence of *Limited Asset Market Participation* (LAMP) agents.

However, as Areosa and Areosa (2016) assume that the two types of agents offer different types of labor, the slope $\vartheta$ also depends on the elasticities associated with each type of labor, $q$ and $(1-q)$, on the inverse of elasticity of labor supply $\omega$ and on the fraction of FE agents.

## 3.2 Inequality evolution

Areosa and Areosa (2016) show how that it is possible to decompose the effect of each exogenous shock of the model into two different components: changes in the output gap, related to the *level* of aggregate consumption, and changes in the *distribution* of consumption, expressed through the Gini index, $\hat{g}_t$. This decomposition is expressed in the following equation:

$$\Phi_t = \left(\frac{\lambda}{q}(1-\sigma) - (1+\omega)\right) x_t - \left(\frac{1+\gamma}{\lambda}\right) \hat{g}_t, \tag{2}$$

where $\gamma \equiv \sigma\left(\frac{\lambda-q}{1-\lambda}\right)$, and $\Phi_t$ is a function of the fiscal and productivity shocks:

$$\Phi_t \equiv \frac{\frac{\lambda}{q}(\omega+\sigma)}{\omega+\sigma\left(\frac{\lambda}{q}\right)} \hat{G}_t - \frac{\left(\frac{\lambda}{q}-1\right)(1+\omega)}{\omega+\sigma\left(\frac{\lambda}{q}\right)} \hat{A}_t.$$

The evolution of the Gini index, obtained from substituting (2) in the IS curve, gives us an intuitive way of seeing how monetary policy affects inequality:

$$\hat{g}_t = E_t\{\hat{g}_{t+1}\} + \vartheta^\delta\left[\hat{\imath}_t - E_t\{\pi_{t+1}\} - r_t^\delta\right], \tag{3}$$

where $\vartheta^\delta \equiv \eta^\delta \sigma^{-1}$, $\eta^\delta \equiv (1-\lambda)(\eta-1)$, and $r_t^\delta$, the real interest rate that stabilizes $\hat{g}_t$, is defined as:

$$r_t^\delta \equiv \vartheta^{-1}\nu^\delta\left[E_t\left\{\hat{G}_{t+1} - \hat{G}_t\right\} - E_t\left\{\hat{A}_{t+1} - \hat{A}_t\right\}\right],$$

where $\nu^\delta \equiv \tilde{\nu} - \frac{\lambda(\omega+\sigma)\tilde{q}}{q(1+\omega)-\lambda(1-\sigma)}$.

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 based on the evolution of government spending and productivity.

## 3.3 New Keynesian Phillips curve

The log-linear version of an aggregate supply relation takes the form:

$$\pi_t = \xi \widehat{MC}_t + \beta E_t\{\pi_{t+1}\}, \tag{4}$$

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

$$\widehat{MC}_t = \left(\omega + \sigma\left(\frac{\lambda}{q}\right)\right) x_t + \frac{\gamma}{\lambda}\hat{g}_t.$$

The first component of marginal cost is standard, but now has a different interpretation. Marginal costs are proportional to the output gap that *would* occur if consumption of both agents was equal. The second term corrects this measure through the inequality effect. We can use this equation and (4) to obtain our New Keynesian Phillips curve (NKPC):

$$\pi_t = \kappa x_t + \beta E_t \{\pi_{t+1}\} + \kappa^\delta \hat{g}_t, \tag{5}$$

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

From (2) and (5), the NKPC can be written in a more familiar format

$$\pi_t = \kappa^* x_t + \beta E_t \{\pi_{t+1}\} + u_t, \tag{6}$$

where the slope of the NKPC is

$$\kappa^* \equiv \left(\frac{1}{1+\gamma}\right) \left[\kappa + \kappa^\delta \lambda \left(\frac{\lambda}{q} - 1\right)\right].$$

and the shock $u_t$ is

$$u_t \equiv -\xi \left(\frac{\gamma}{1+\gamma}\right) \Phi_t,$$

where $\Phi_t$ is the same as in (2).

# 4 Optimal monetary policy

Areosa and Areosa (2016) assume that, following Erceg, Henderson, and Levin (2000) and Woodford (2003), the policymaker maximizes the average expected utility of households by taking a second-order approximation of the aggregate utility of all agents. We depart from this approach by assuming the monetary authority may put different weights $s$ on agents' utility functions. In this context, the central bank maximizes

$$W_0^s = sU_0^e + (1-s)\, U_0^i.$$

When $s = \lambda$, we have again the utilitarian case. When $s = 1$, the central bank implements a Rawlsian monetary policy, while when $s = 0$, the monetary authority simply overlooks the existence of FE agents.

In a technical appendix, available on request, we show that the second-order approximation of the utility function for a type-$k \in \{e, i\}$ agent results in:

$$W_0^k = -\frac{1}{2} Y (C)^{-\sigma} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left\{ \lambda_x^k \left(x_t - x_t^k\right)^2 + \lambda_g^k \left(\hat{g}_t - \hat{g}_t^k\right)^2 + \lambda_\pi^k \pi_t^2 \right\} \right\} + tip \tag{7}$$

where $\lambda_x^k$, $\lambda_g^k$ and $\lambda_\pi^k$ are constants that depend on the structural parameters of the model, while $x_t^k$ and $\hat{g}_t^k$ are variables that depend on the shocks.

From this expression, it becomes clear that for both FE and FI households: (i) it is not optimal to maintain zero inflation and a zero output gap in the face of inequality variations, (ii) the output gap the central bank should pursue is different from the standard New Keynesian gap measure, and (iii) there is an inequality gap.

The maximization of (7) subject to the constraints represented by the NKPC in (5) and equation (2), relating $x_t$ and $\hat{g}_t$, generates the following criterion under commitment:

$$\pi_t = -\frac{1}{\kappa^*\theta}\left[\kappa\left(x_t - x_{t-1}\right) - \Psi\left(\frac{\vartheta^\delta}{\vartheta}\right)\left(\hat{g}_t - \hat{g}_{t-1}\right)\right]. \quad (8)$$

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 for inequality variations over the same period.

To implement the target rule, we obtain an optimal instrument rule by substituting equations (1), (3), and (5) in the optimal criterion (8):

$$\hat{\imath}_t = \phi_\pi^s E_t\left\{\pi_{t+1}\right\} + \phi_x^s E_t\left\{x_{t+1}\right\} + \phi_\delta^s E_t\left\{\hat{g}_{t+1}\right\} + \phi_{x-1}^s x_{t-1} + \phi_{\delta-1}^s \hat{g}_{t-1} + \epsilon_t^s, \quad (9)$$

where the $\phi_j' s$ are functions of the structural parameters of the model and of the weight $s$ while composite shock $\epsilon_t^s$ depends on the natural rate of interest, on the real interest rate that stabilizes $\hat{g}_t$, and on both the output gap and the inequality gap.[5]

We call equation (9) our *expectations-based reaction function*, following Evans and Honkapohja (2006). If the monetary authority commits itself to setting interest rates in accordance with this reaction function at all times, then the rational-expectations equilibrium is necessarily determinate.

# 5 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 (1), (3), (5), and (9) and solve it numerically.

## 5.1 Calibration

We use the same calibration stated in Areosa and Areosa (2016).The baseline values of the parameters, described in Table 1, are standard and based on Giannoni and Woodford

[5] See the appendix for details.

Table 1: Baseline calibration

| Parameter | Description | Value |
|---|---|---|
| $\alpha$ | Fraction of firms that leave their prices unchanged | 0.66 |
| $\beta$ | Time discount factor | 0.99 |
| $\theta$ | Elasticity of substitution among differentiated goods | 11 |
| $\lambda$ | Proportion of unskilled agents with no access to the financial system | 0.4 |
| $\sigma$ | Risk aversion parameter | 0.90 |
| $\omega$ | Inverse of elasticity of labor supply | 0.33 |
| $q$ | Elasticity associated with unskilled labor | 0.10 |
| $\phi_g$ ($\phi_a$) | Fiscal (productivity) shock inertia | 0.90 |

(2005).

## 5.2 Optimal response to policy disturbances

### 5.2.1 Monetary shocks

Figure 1 shows the impulse responses of the four endogenous variables to a monetary shock. The different lines are indexed by $s$.

Clearly the optimal response to a monetary shock does not depend significantly on how the central bank weights the welfare of each type of agent. In all cases, after a monetary shock the interest rate rises, causing inflation and output gap to drop. Figure 2 shows the impulse responses of consumption, real wages and hours worked of each group to a monetary shock. Because FE households cannot smooth their consumption in time, under a contraction their consumption falls more than FI's (between 1% and 1.5% after less than 1%), leading to an increase in inequality. Although this dynamic is observable for all weights, when $s$ is closer to one, the interest rate rises less, the output gap fall slightly less and inflation falls slightly more, while inequality rises less.

The difference in the intensity of the responses suggests that when the central bank is more concerned with not hurting the low-income group, it becomes less aggressive in implementing the monetary policy, avoiding output from falling more steeply. For both groups, a smaller drop in economic activity makes consumption, real wages and working hours fall less. Nevertheless, there is a substantial difference between the two groups of agents: in comparison to FE agents, the working hours drop about three times more than for FI agents (0.3% after 0.1%). This difference comes from the fact that FE agents are less willing to diminish their working hours, since they depend exclusively on their labor income to consume.

Even with a less aggressive monetary policy, inflation drops more under a Rawlsian

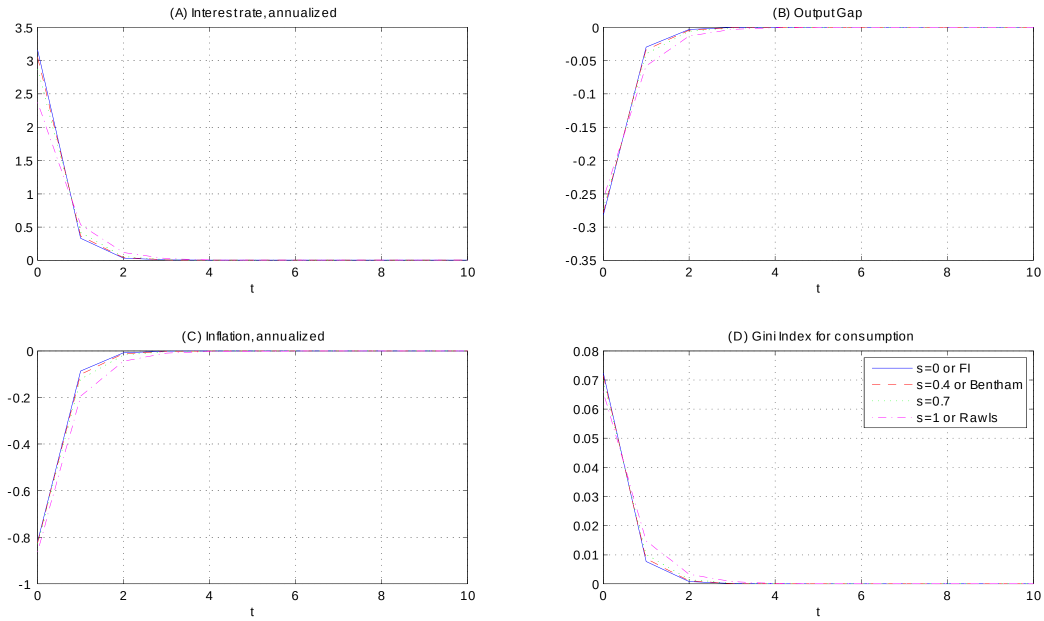


Figure 1: Impulse responses to a monetary shock under optimal commitment under alternative values of $s$ - aggregate variables

monetary policy. This finding is in line with the empirical evidence that points to inflation as a major concern for low-income people. In this context, an optimal monetary policy with focus on the low-income group would fight inflation insofar as it erodes real wages.

### 5.2.2 Fiscal shocks

According to Figure 3, the impulse responses of the endogenous variables after a fiscal shock depend greatly on the weight the central bank puts on agents' welfare function. While optimal monetary policy pushes interest rate up when the central bank overlooks the FE households, it comes down when the bank implements a Rawlsian monetary policy. This difference in the optimal policy appears in inflation: it drops when $s = 0$ and rises when $s = 1$.

The idea that under a Rawlsian monetary policy, the central bank allows inflation to go up might seem puzzling. Nevertheless, despite a possible increase in inflation, a fiscal shock always benefits households with no access to the financial markets insofar as an increase in economic activity raises both real wages and working hours, increasing their consumption, as shown in Figure 4. An increase in the interest rate would partially offset this benefit. This dynamics suggests that when the central bank looks exclusively at the low-income group, it is prone to accept increases in the price index that are lower than the nominal wage growth.

In contrast to the low-income group, FI households decrease their consumption for all policies the central bank may implement, including an interest rate cut. The rationale

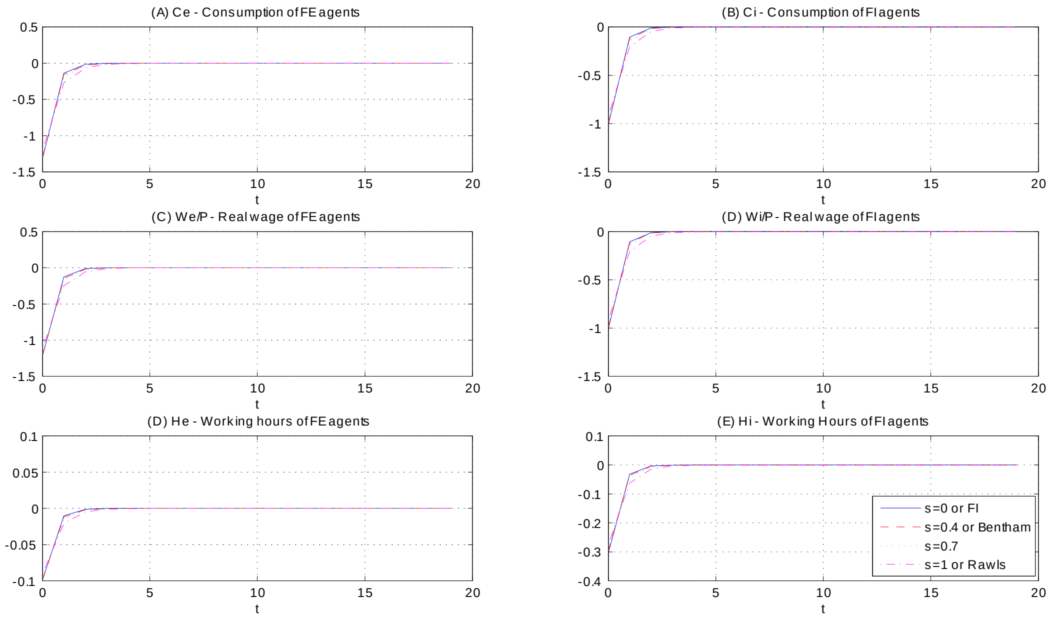


Figure 2: Impulse responses to a monetary shock under optimal commitment under alternative values of $s$ - FE versus FI agents

for this behavior is simple: although the FI households also benefit from the increase in real wages and working hours, their consumption does not depend exclusively on their labor income. When the central bank hikes the interest rate, they have an incentive to postpone their consumption. Moreover, as the only group to pay taxes, FI agents carry the burden of an increase in governmental spending. When the central bank cuts the interest rate to accommodate the demand shock, those agents face an increase in their labor income. But this increase is insufficient to offset the decrease in their income that comes from taxes. These opposite movements in the consumption of the two types of agents cause inequality to drop.

Clearly, the responses of real wages and working hours differ hugely between the two groups of agents. While working hours rise between 0.05% and 0.15% for FE households, they rise about 10 times more for FI households. This result is not surprising, considering that there is a major difference in the output elasticity associated with each type of agent. In this context, an increase in production depends greatly on the work supplied by FI agents. Concerning real wages, the opposite occurs: while it varies from -0.2 to 0.4 for FI agents, it increases between 0.5% and 1.5% for FE agents. This result suggests that when the central bank overlooks the FE households, the burden created by an increase in taxes makes FI agents prone to accept a decrease in real wages, even with an increase in working hours.

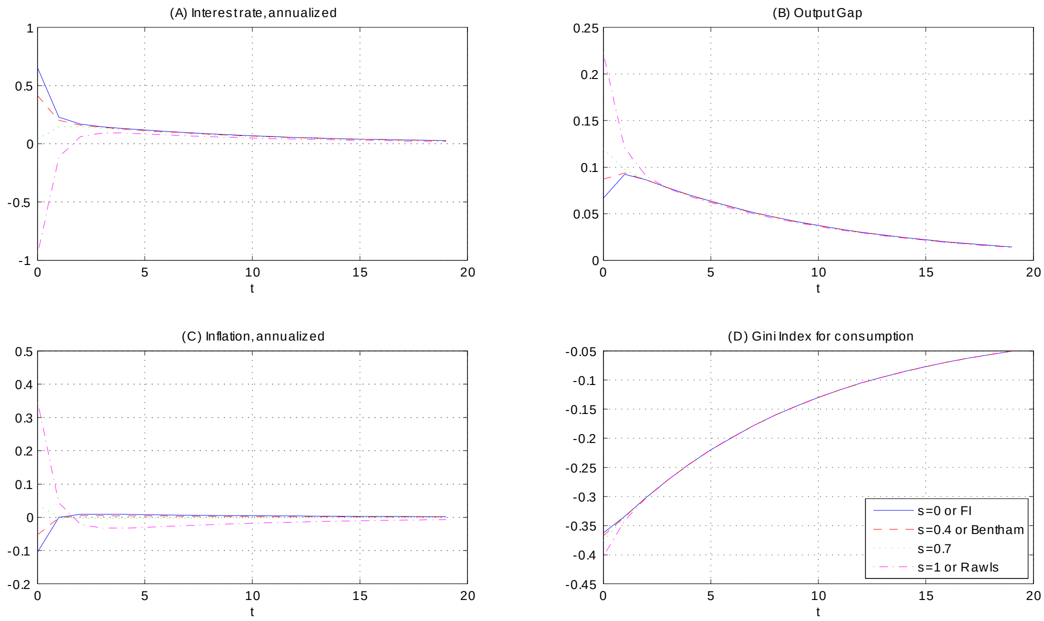


Figure 3: Impulse responses to a fiscal shock under optimal commitment under alternative values of $s$ - aggregate variables

### 5.2.3 Productivity shocks

There is no consensus about what would be a typical response after a positive technological shock. Galí (1999) addresses this important question considering both the influence of nominal rigidities and of real explanations. The author shows that the stylized facts presented by the empirical literature depend on the identifying assumptions relating structural shocks. Despite some empirical evidence pointing in the same direction, there are multiple ways to explain these stylized facts that depend on the structure of the model and on the parameters.

As can be seen in Figure 5, our results show that after a total factor productivity shock, output increases. From the demand side, this increase in economic activity becomes evident through the consumption growth of both agents, presented in Figure 6. Nevertheless, the output gap becomes negative, as potential output increases more than actual output. Monetary policy responds to this situation by pushing interest rate down. It is clear that when the central bank focuses on maximizing the welfare of the low-income group, it eases monetary policy more intensively (cutting approximately $-0.5\%$ when $s = 0$ after $-1.5\%$ when $s = 1$), making the output gap less negative and allowing inflation to climb (almost $0.3\%$, when $s = 1$, after no significant impact, when $s = 0$).

An increase in total factor productivity is usually associated with a decrease in working hours. This stylized fact is also present in the model, but just for FI agents (varying from slightly below $-0.8\%$, when $s = 0$, to slightly above $-0.8\%$, when $s = 1$). Concerning the FE agents, the model shows that, since they depend on their labor income to consume,

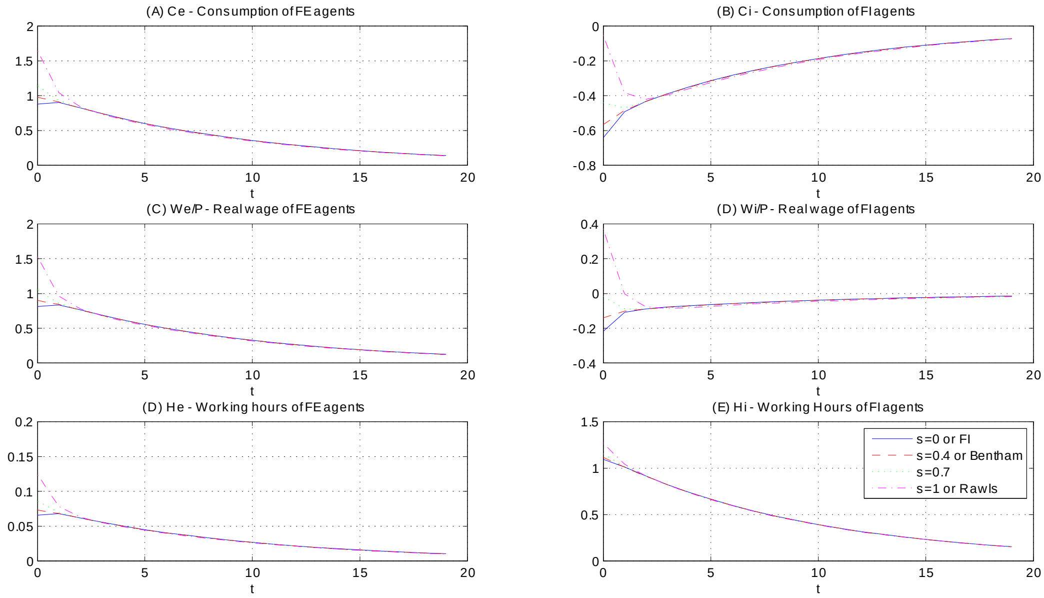


Figure 4: Impulse responses to a fiscal shock under optimal commitment under alternative values of $s$ - FE versus FI agents

they keep their working hours almost unchanged (with a small increase that ranges from near 0.02%, when $s = 0$, to barely 0.05%, when $s = 1$). As this slightly positive response is at least 15 times smaller than the drop of the FI agents' working hours, the aggregate impact is clearly negative.

The difference in intensity across the two types of agents is also present in two other variables - real wages and consumption. In both cases, variations occur in the same direction. Nevertheless, while FE agents' real wage increases between 0.2% (when $s = 0$) and 0.6% (when $s = 1$), FI agents' varies at least 2 times more (from near 1%, when $s = 0$, to about 1.5%, when $s = 1$). These figures suggest that a positive total factor productivity shock amplifies the difference in the production of the two groups of workers - skilled and unskilled. For this reason, the real wage grows more intensively for the qualified workers. When the central bank implements the monetary policy to benefit the less qualified workers, this difference diminishes, but does not disappear.

The increase in real wages generates an increase in labor income, which in turn induces an increase in consumption. Compared to the unskilled workers, the skilled workers increase proportionally more their consumption (near 0.2% after 1.5%, when $s = 0$, and, 0.6% after about 1.7%, when $s = 1$). The rationale behind this observation rests on the fact that this group is also benefited by a greater increase their real wages, since as already mentioned, a total factor productivity shock amplifies the difference in the production of the two groups of workers. This difference in the response of the two groups appears as an increase in inequality, which becomes less intense when the central bank maximizes the welfare of the low-income group (0.3%, when $s = 0$, after 0.27%, when $s = 1$).

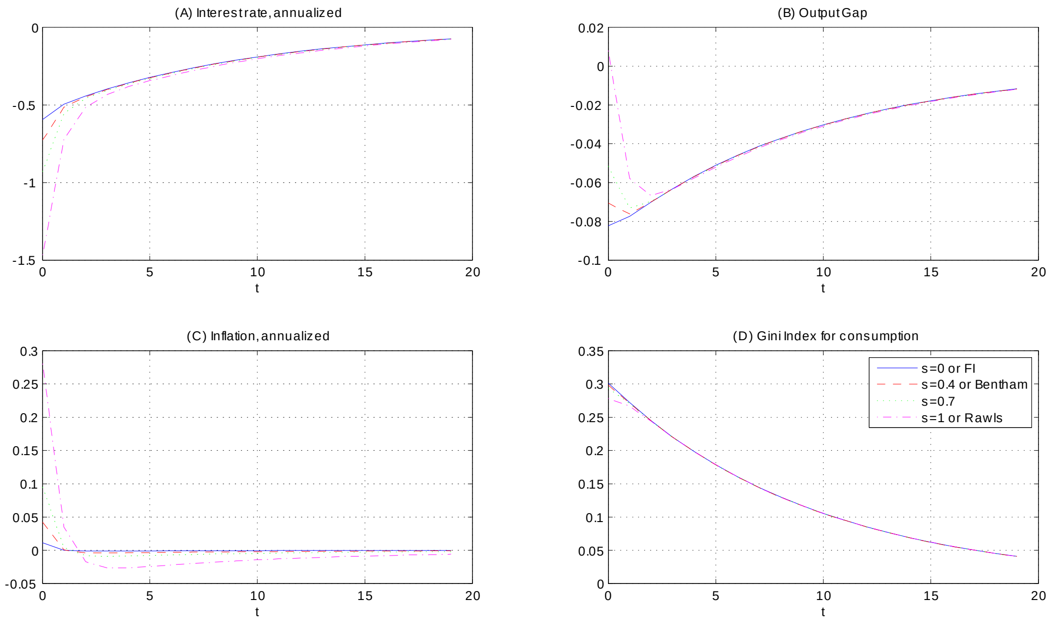


Figure 5: Impulse responses to a productivity shock under optimal commitment under alternative values of $s$ - aggregate variables

# 6 Conclusions

In this work, we identify and compare optimal monetary policy under different social welfare functions. We base our analysis on the research by Areosa and Areosa (2016), which examines optimal monetary policy in the presence of inequality by introducing unskilled agents with no access to the financial system into an otherwise textbook New Keynesian model. We extend their analysis to incorporate the fact that the central bank might not use a utilitarian welfare based function, but put any other weights on the two groups of agents.

The optimal response to a monetary shock does not depend significantly on how central bank weights the welfare of each type of agent. In all cases, after a monetary shock, the interest rate rises, causing inflation and output gap to drop. Although this dynamics is observable for all weights, when $s$ is closer to one, the interest rate rises less, the output gap fall slightly less, inflation falls slightly more, while inequality rises less. Even with a less aggressive monetary policy, inflation drops more under a Rawlsian monetary policy. This finding is in line with the empirical evidence that points to inflation as a major concern for low-income people. In this context, an optimal monetary policy with focus on the low-income group would fight inflation insofar as it erodes real wages.

A completely different situation arises after a fiscal shock. While optimal monetary policy pushes the interest rate up when the central bank overlooks the FE households, it comes down when central bank implements a Rawlsian monetary policy. This difference in the optimal policy appears in inflation: it drops in the former case and rises in the

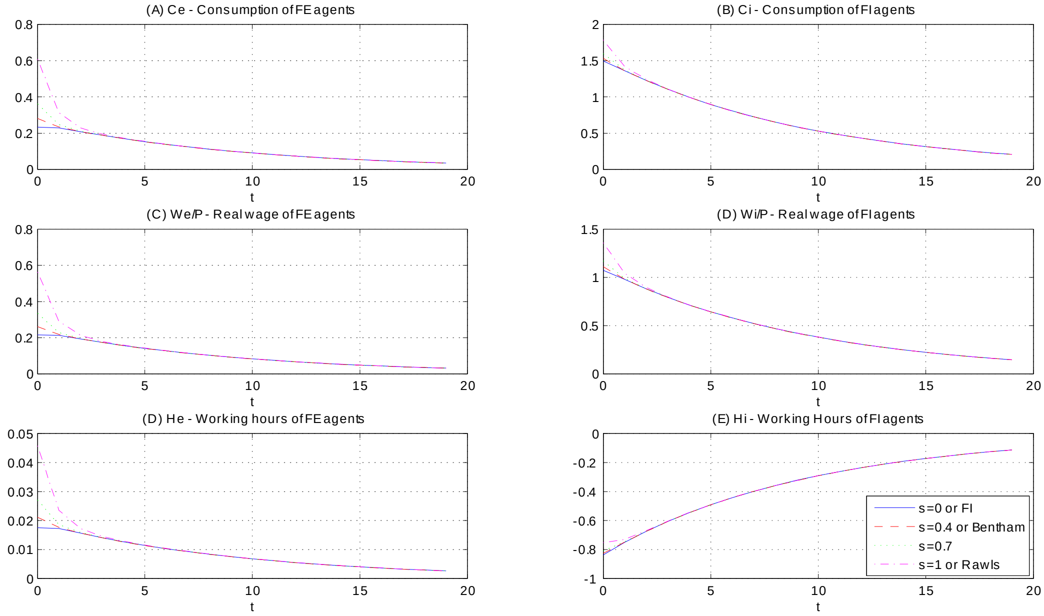


Figure 6: Impulse responses to a productivity shock under optimal commitment under alternative values of $s$ - FE versus FI agents

latter. The idea that, under a Rawlsian monetary policy, the central bank allows inflation to go up might seem puzzling. Nevertheless, despite a possible increase in inflation, a fiscal shock always benefits households with no access to the financial markets insofar as an increase in the economic activity raises both real wages and working hours, increasing their consumption. An increase in the interest rate would partially offset this benefit. This dynamics suggests that when the central bank looks exclusively to the low-income group, it is prone to accept increases in the price index that are lower than the nominal wage growth.

Our results also suggest that a positive total factor productivity shock amplifies the difference in the production of the two groups of workers - skilled and unskilled. For this reason, the real wage grows more intensively for the qualified workers. When the central bank implements the monetary policy to benefit the less qualified workers, this difference diminishes, but does not disappear. The increase in real wages generates an increase in the labor income, which in turn induces an increase in consumption. Compared to the unskilled workers, the skilled workers increase their consumption proportionally more. This difference in the response of the two groups appears as an increase in inequality, which becomes less intense when the central bank maximizes the welfare of the low income group.

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