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POLICY GAMES, DISTRIBUTIONAL CONFLICTS, AND THE OPTIMAL INFLATION

ALICE ALBONICO
University of Milan Bicocca

LORENZA ROSSI
University of Pavia

This paper shows that limited asset-market participation (LAMP) generates an extra inflation bias when the fiscal and the monetary authority play strategically. A fully redistributive fiscal policy eliminates the extra inflation bias, but at the cost of reducing Ricardians' welfare. A fiscal authority that redistributes income only partially reduces the inflation bias, but raises government spending. Although a fully conservative monetary policy is necessary to get price stability, it implies a reduction in liquidity-constrained consumers' welfare, in the absence of redistributive fiscal policies. Finally, under a crisis scenario, none of the policy regimes is able to avoid the fall in economic activity when the increase in the fraction of LAMP is coupled with a negative technology shock, whereas optimal policy can avoid recession when it responds to the increase in LAMP proportion alone.

Keywords: Limited Asset Market Participation, Optimal Monetary and Fiscal Policy, Strategic Interaction, Inflation Bias, Redistribution

1. INTRODUCTION

The recent financial crisis led monetary and fiscal authorities all over the world to reconsider their role and their behavior concerning both the structural equilibrium of the system and their stabilization policies in responding to shocks, in a context where the characteristics of the financial markets are changing. In particular, the empirical evidence shows that one of the consequences of the crisis was a

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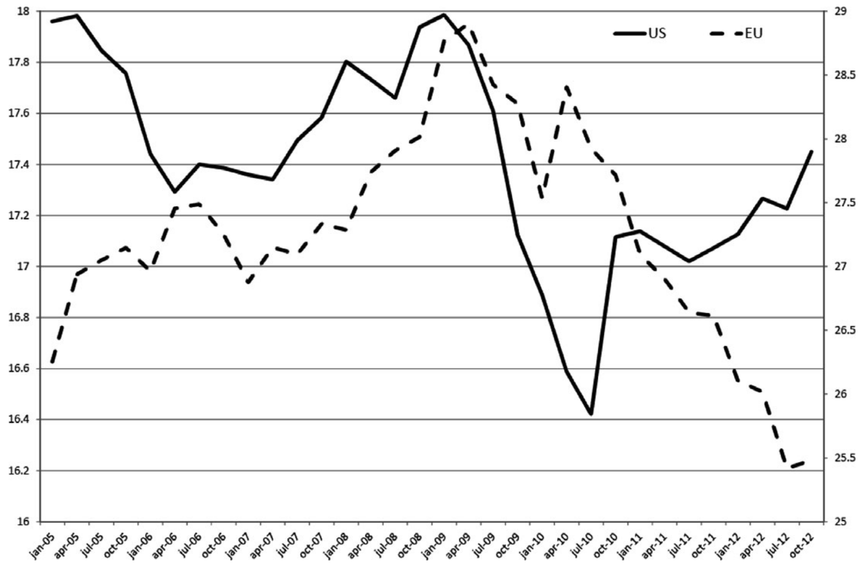

FIGURE 1. Consumer credit over GDP: United States (left) versus European Union (right).

significant worsening of the conditions of access to credit and financial markets for both households and firms. Questions regarding bank solvency have caused not only an interbank credit crunch but also a decline in credit availability. The main factors contributing to the decline in credit availability were bad expectations regarding general economic activity and housing market prospects, as well as cost of funds and balance sheet constraints for banks. Figure 1 shows the amount of consumer credit relative to GDP for the United States and the European Union.[1] This graph shows that credit availability dropped dramatically during the crisis. The dynamics of the United States leads the European Union fall in consumer credit. Precisely, consumer credit over GDP started decreasing in the first quarter of 2009 in the United States, whereas in the European Union the initial drop was registered in the second quarter of 2009.

In this paper, we study the strategic interactions between monetary and fiscal policy in an otherwise standard New Keynesian (NK) model characterized by distributional conflicts due to limited asset-market participation (LAMP henceforth) and we investigate the optimal policy responses, in particular with respect to optimal inflation. We model LAMP as is now standard in the literature [see Galí et al. (2004) and Bilbiie (2008), among others]. We assume that a fraction of households do not hold any assets, and thus are liquidity-constrained and in each period consume all their disposable labor income. The remaining households hold assets and smooth consumption. This heterogeneity between households breaks the Ricardian equivalence. For this reason, in the remainder of the paper we distinguish between non-Ricardian (or liquidity-constrained) and Ricardian consumers.

We focus our analysis on two policy games: (i) the Nash game; (ii) the fiscal leadership (FL henceforth) game with conservative monetary policy. In both these, games the fiscal and the monetary authority cannot commit; they make their policy decisions independently period by period and do not cooperate. We compare our results with those obtained in a standard Ricardian agent economy (RAE henceforth), which was first considered by Adam and Billi (2008). In the first part of the paper we analyze the steady state properties of each policy game and then we look at the dynamics of the model, showing the optimal impulse response functions in the face of positive technology shocks.

We find that the presence of liquidity-constrained consumers alters both the long-run and the short-run properties characterizing the policy games of a RAE. In particular, when the two policy authorities do not cooperate and cannot commit, an inflation bias arises, and it increases dramatically as the fraction of LAMP consumers increases. The central bank annualized inflation target approaches 9% even for a fraction of non-Ricardian agents close to 30%—50% higher than found by Adam and Billi (2008) in a RAE model.[2] The optimal steady state inflation seems to be dramatically high when compared with the rest of the papers in the literature studying optimal fiscal and monetary policy in the RAE model [see, for example, Schmitt-Grohé and Uribe (2004a, 2004b, 2007, 2010), among others]. In these papers indeed the optimal steady state inflation rate is often negative (i.e., the Friedman rule is always optimal) or approaches zero.[3] In our model the extra inflation bias arises because, as LAMP increases, per capita profits earned by Ricardians become higher and so does their consumption. The monopolistic distortion increases and the aggregate output lowers. Inflation acts as a tax on profits. Thus, by inflating the economy, the central bank is able to reduce the monopolistic distortion. Consequently, the higher the fraction of LAMP consumers, the greater is the need to inflate the economy.

Turning to the optimal dynamics, again we show that LAMP plays an important role in noncooperative games. In particular, we find that under discretionary policies, the optimal response of inflation to a positive technology shock is different from zero.

In a second part of the paper, we study the same policy games in the presence of redistributive fiscal policies to see whether and to what extent these policies affect the extra inflation bias that arises from LAMP. We consider two types of redistribution: (i) a fully redistributive fiscal policy, where the authority optimally decides the amount of taxes levied from each type of consumers, and (ii) a partially redistributive fiscal policy, where the authority chooses the amount of government spending and exogenously decides to tax less LAMP consumers. Analysis of the optimal steady state produces two main results. First, a fully redistributive fiscal policy eliminates the extra inflation bias originating from the distributional conflict. However, this is obtained at the cost of strongly reducing Ricardian households' welfare measured in terms of consumption equivalents, whereas LAMP consumers' welfare increases. In this respect, the fully redistributive fiscal policy is not Pareto superior. Second, a partially redistributive fiscal authority reduces the inflation bias, but generates a higher government spending bias.[4] Regarding the optimal dynamics under redistributive policies, we find that full redistribution restores the RAE equilibrium, so that inflation volatility is minimized. A partial redistributive policy also reduces inflation volatility by about 40%.

In the final part of the paper, we introduce a positive shock to the proportion of the LAMP consumers to simulate a reduction in credit availability. First, we compare the effects of such a shock in a competitive equilibrium with those implied by optimal policies. Second, we assume that this shock is followed by a fall in productivity to simulate a crisis scenario. We find that none of the policy regimes is able to avoid the fall in economic activity when the increase in the fraction of LAMP is coupled with a negative technology shock, whereas optimal policy can avoid recession when it responds to the increase in LAMP proportion alone.

In recent years, many authors have concentrated on the issue of consumer heterogeneity due to LAMP. They show that the presence of LAMP consumers alters the standard results on the dynamics of the NK model. For example, Galí et al. (2007) demonstrate that the presence of LAMP consumers can explain consumption crowding in, which follows an increase in government spending. Bilbiie (2008) shows that LAMP can lead to an inverted aggregate demand logic (the IS curve has a positive slope). Di Bartolomeo and Rossi (2007) show that the effectiveness of monetary policy increases as LAMP becomes more important. Galí et al. (2004) study the determinacy properties in a model with LAMP and capital accumulation under different Taylor rules. These authors show that the presence of liquidity-constrained consumers may alter the determinacy properties of a standard NK model. Finally, Colciago (2011) and Furlanetto (2011) extend the analysis in Galí et al. (2007) to the case of nominal wage stickiness.

In conclusion, the literature on LAMP neither analyzes the strategic interaction between monetary and fiscal policy, nor tackles redistributive issues. The only exception is Natvik (2012), which analyzes the effect of a government spending shock with and without redistribution and shows that steady state inequality matters in explaining the short-run dynamics.

Most of the literature that studies fiscal and monetary policy instead assumes that they are both driven by a unique authority [Schmitt-Grohé and Uribe (2004a, 2004b, 2007), among others]. This is clearly not the case now and in particular in the EU context, where the creation of the currency area led to a structure with a unique monetary authority and several independent fiscal authorities. In this context it is then relevant to investigate the strategic interactions between the central bank and the fiscal authorities, as was done by Beetsma and Jensen (2005), Adam and Billi (2008), and Gnocchi (2008), among others. Overall, these papers do not address the issue of LAMP. Therefore, to the best of our knowledge, we are the first to study different policy games in a model with LAMP, as well as to study the role played by redistributive fiscal policies.

The novelty of this study lies in the importance assigned to the presence of LAMP. In fact, as we will show in the next section, LAMP consumers have assumed an increasingly relevant role in the economy, because after the recent financial crisis the conditions of access to financial markets worsened. In this context, monetary and fiscal policies have to stabilize the economy in response to structural shocks. Therefore, the recent events fostered the theoretical study of the optimal monetary and fiscal policy mix in models characterized by LAMP. At the same time, the policy authorities have to take into account the distributional conflict arising when LAMP consumers and Ricardian consumers coexist.

The paper is organized as follows. The next section shows some evidence on the decline in households' asset market participation following the recent financial crisis. Section 3 introduces the model, and Section 4 presents the different policy regimes and analyzes the optimal steady state and optimal dynamics, also with redistributive fiscal policies. Section 5 presents the analysis in terms of welfare losses. Section 6 concludes.

2. THE MODEL

2.1. Households

The model economy consists of a continuum of infinitely lived households. Households are divided into a fraction $1-\lambda$ of "Ricardians" who smooth consumption and have access to assets markets remaining fraction λ of "liquidity-constrained" consumers who have no assets and spend all their current disposable labor income for consumption each period. Both types of households have the same preferences structure. The utility functions for Ricardians (o) and liquidity-constrained (r) are symmetric and can be written as

$$u(C_t^h, N_t^h, G_t) = \frac{{C_t^h}^{1-\sigma}}{1-\sigma} - \omega_n \frac{{N_t^h}^{1+\varphi}}{1+\varphi} + \omega_g \frac{{G_t}^{1-\sigma}}{1-\sigma}, \text{ with } h = o, r, \qquad (1)$$

where C_t^o, N_t^o are the Ricardian consumer's consumption and hours worked, C_t^r, N_t^r are the liquidity-constrained consumer's consumption and hours worked, and G_t is public expenditure. Utility weights ω_n and ω_g are positive parameters. As is standard in the literature for reasons of tractability, utility is separable in C, N, and G and $U_C > 0$, $U_{CC} < 0$, $U_N < 0$, $U_{NN} \leq 0$, $U_G > 0$, *and* $U_{GG} < 0$.[5]

The Ricardians' budget constraint is

$$P_t C_t^o + \frac{B_t}{1-\lambda} = R_{t-1}\frac{B_{t-1}}{1-\lambda} + P_t w_t N_t^o - P_t T_t^o + \frac{D_t}{1-\lambda}, \qquad (2)$$

where P_t is the nominal price index, R_t is the gross nominal interest rate, B_t represents the nominal value of the privately issued assets purchased by Ricardians at t and maturing at $t+1$, w_t is the real wage paid in a competitive labor market, T_t^o are lump-sum taxes, and D_t are profits of monopolistic firms.

The Ricardians' problem consists in choosing $\{C_t^o, N_t^o, B_t\}_{t=0}^{\infty}$ to maximize (1) for $h = o$, subject to (2), taking as given $\{P_t, w_t, R_t, G_t, T_t, D_t\}$.[6] From the first-order condition we get

$$w_t = \frac{\omega_n N_t^{o\varphi}}{C_t^{o-\sigma}} \tag{3}$$

and

$$\frac{C_t^{o-\sigma}}{R_t} = \beta E_t \frac{C_{t+1}^{o\ \ -\sigma}}{\pi_{t+1}}. \tag{4}$$

Liquidity-constrained consumers each period solve a static problem: they maximize the period utility of (1) for $h = r$, subject to the constraint that all their disposable income is consumed:

$$P_t C_t^r = P_t w_t N_t^r - P_t T_t^r. \tag{5}$$

From the first-order conditions we get

$$w_t = \frac{\omega_n N_t^{r\varphi}}{C_t^{r-\sigma}}. \tag{6}$$

Firms are indifferent with respect to the type of consumer to hire; therefore labor is homogenous and the two consumers get the same pay w_t, so that their marginal rate of substitution is also the same. This leads to the following condition:

$$\frac{\omega_n N_t^{o\varphi}}{C_t^{o-\sigma}} = \frac{\omega_n N_t^{r\varphi}}{C_t^{r-\sigma}} = \mathrm{MRS}_t, \tag{7}$$

which equates the ratios between the marginal utilities of Ricardian and liquidity-constrained consumers.

The aggregate consumption and hours worked are defined as follows:

$$C_t = \lambda C_t^r + (1-\lambda) C_t^o, \tag{8}$$

$$N_t = \lambda N_t^r + (1-\lambda) N_t^o. \tag{9}$$

2.2. Firms

There is a continuum of intermediate goods, indexed by $i \in [0, 1]$, and a sector of a final good that uses the technology $Y_t = [\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di]^{\frac{\epsilon}{\epsilon-1}}$. The sector of the final good operates in perfect competition. Profit maximization implies that $Y_t(i) = [P_t(i)/P_t]^{-\epsilon} Y_t$, where ϵ represents the elasticity of substitution across varieties. P_t is defined as $P_t = [\int_0^1 P_t(i)^{1-\epsilon} di]^{\frac{1}{1-\epsilon}}$. The intermediate-goods sector is characterized by firms producing each a differentiated good with a technology represented by a Cobb–Douglas production function with a unique factor of production (aggregate labor) and constant returns to scale:

$$Y_t(i) = Z_t N_t(i), \tag{10}$$

where $\log(Z_t/Z) = z_t$ is an aggregate productivity shock with an AR(1) process $z_t = \rho_z z_{t-1} + s_t^z$. Here $0 < \rho_z < 1$ and s_t^z is a normally distributed serially

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uncorrelated innovation with zero mean and standard deviation σ_z. In this context, each firm i has monopolistic power in the production of its own good, and therefore it sets the price. Prices are sticky à la Rotemberg (1982) so that firms face quadratic resource costs for adjusting nominal prices according to $\theta/2[P_t(i)/P_{t-1}(i)-1]^2$, where θ is the degree of price rigidity.

The problem of the firm is then to choose $\{P_t(i), N_t(i)\}_{t=0}^{\infty}$ to maximize the sum of expected discounted profits:

$$\max_{\{N_t(i),P_t(i)\}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{\gamma_t}{\gamma_0} \left\{ \frac{P_t(i)}{P_t} Y_t(i) - w_t N_t(i) - \frac{\theta}{2}\left[\frac{P_t(i)}{P_{t-1}(i)} - 1\right]^2 \right\}$$

$$\text{s.t. } Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\epsilon} Y_t = Z_t N_t(i)\,, \qquad (11)$$

where $Y_t = C_t + G_t$ and $\gamma_t = C_t^{o-\sigma}$.

At equilibrium all firms will charge the same price, so that we can assume symmetry. After defining mc_t as the real marginal cost, the FOCs are

$$w_t = \text{mc}_t Z_t \qquad (12)$$

$$0 = [1-(1-\text{mc}_t)\epsilon]Y_t - \theta(\pi_t - 1)\pi_t + \theta\beta E_t\left(\frac{C_{t+1}^{o\ -\sigma}}{C_t^{o-\sigma}}\right)(\pi_{t+1}-1)\pi_{t+1}. \qquad (13)$$

Equation (12) equals the marginal rate of substitution to the marginal rate of transformation, whereas (13) is the New Keynesian Phillips Curve when firms set prices à la Rotemberg. As in the standard NK model, it implies that current inflation depends positively on expected inflation and on current marginal costs. What is different from the full Ricardian case is that the discount factor depends only on Ricardian consumption.

Combining (12) with (3) and (6) yields such an expression for the real marginal cost:

$$\text{mc}_t = \frac{1}{Z_t}\left[\lambda\omega_n N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda)\omega_n N_t^{o\varphi} C_t^{o\sigma}\right] = \frac{\text{MRS}_t}{Z_t}. \qquad (14)$$

We combine it with (13) and get

$$C_t^{o-\sigma}(\pi_t - 1)\pi_t = [1-(1-\text{mc}_t)\,\epsilon]\,\frac{Z_t N_t C_t^{o-\sigma}}{\theta} + \beta E_t C_{t+1}^{o\ -\sigma}(\pi_{t+1}-1)\pi_{t+1}. \qquad (15)$$

Note that the flexible price solution leads to the following first-order condition (FOC) for firms:

$$\text{mc}_t = \frac{\epsilon - 1}{\epsilon}, \qquad (16)$$

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which implies that real marginal costs equal the inverse of the steady state gross markup in the flexible price economy, which is $\mu = 1 + \frac{1}{\varepsilon - 1}$.

2.3. Government

The government is composed of a monetary authority that sets the nominal interest rate R_t and a fiscal authority that determines the level of public expenditure G_t. The government runs a balanced budget, so in each period public consumption equals lump-sum taxes:[7]

$$P_t G_t = P_t T_t. \tag{17}$$

Defining aggregate lump-sum taxes as $T_t = \lambda T_t^r + (1-\lambda) T_t^o$, if the same amount of lump-sum taxes is withdrawn from each individual ($T_t^r = T_t^o$), we obtain $G_t = T_t = T_t^r = T_t^o$.

2.4. Equilibrium

To close the model, we consider also the goods-market-clearing condition:

$$Z_t[\lambda N_t^r + (1-\lambda) N_t^o] = \lambda C_t^r + (1-\lambda) C_t^o + G_t + \frac{\theta}{2}(\pi_t - 1)^2. \tag{18}$$

A rational expectations equilibrium for the private sector consists of a plan $\{C_t^r, C_t^o, N_t^r, N_t^o, P_t\}$ satisfying (4), (5), (7), (15), and (18), given the policies $\{G_t, T_t, R_t \geq 1\}$ and the exogenous process Z_t.

3. POLICY REGIMES

In this section we introduce the structure of the different policy games analyzed in the paper. First, we will introduce the Ramsey problem, which allows policy commitment at time zero and full cooperation between monetary and fiscal policy authorities. Then two different games structures will be presented: (1) the Nash game; (2) the FL game. In both cases, the two authorities cannot commit, but make their decisions separately and period by period. The equations for the solution of the Ramsey equilibrium and those of the different game structures are presented in a Technical Appendix.[8]

3.1. Ramsey Policy

In this case the policy authorities fully cooperate and can commit, which means that policy makers determine state-contingent future policies at time zero. Differently from the standard social planner problem, the Ramsey allocation takes into account the distortions characterizing the model economy, i.e., sticky prices and monopolistic distortions. Therefore, the Ramsey solution corresponds to a second-best allocation solving the following problem:

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$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t)\right\}$$
$$\text{s.t. (4), (5), (7), (15), (17), (18) for all } t, \tag{19}$$

where constraints (4), (5), (7), (15), (17), and (18) represent the equilibrium of the competitive economy.

Before the structures of the policy games are introduced, it is worth noticing that the competitive equilibrium of our model does not include any endogenous state variable. This happens because, as in Adam and Billi (2008), we assume (i) a cashless economy; (ii) a government running a balanced budget; (iii) labor as the only input in the production function. As a consequence, the endogenous variables, that is consumption, output, and inflation, are pure forward-looking variables. Because the only state variable is the exogenous shock, the equilibrium outcomes of our games are completely forward-looking and can be solved without making use of Markov-perfect equilibrium technicalities. This modeling choice gives us the opportunity to directly compare our results with those obtained by Adam and Billi (2008), by easily disentangling the role played by LAMP consumers.

In what follows we present the structure of the policy games.

3.2. Nash Game

In this case, policy makers do not cooperate and cannot commit, but decide their policy simultaneously and period by period, by taking as given the current policy choice of the other authority, all future policies, and future private-sector choices.

The problem of the fiscal authority is therefore

$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, G_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t)\right\}$$
$$\text{s.t. (4), (5), (7), (15), (17), (18) for all } t$$
$$\{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j-1} \geq 1, G_{t+j}\} \text{ given for } j \geq 1\,. \tag{20}$$

The set of first-order conditions define the behavior of the fiscal policy maker and thus its fiscal reaction function (FRF henceforth). Analogously, the monetary authority solves the following problem:

$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t)\right\}$$
$$\text{s.t. (4), (5), (7), (15), (17), (18) for all } t$$
$$\{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j-1}\} \text{ given for } j \geq 1\,. \tag{21}$$

As for the fiscal authority, the set of first-order conditions define the behavior of the monetary policy maker and thus its monetary reaction function (MRF henceforth). Thus, the following definition is justified:

DEFINITION. *The Nash equilibrium with sequential monetary and fiscal policy consists of the following time-invariant policy functions:* $C^r\{Z_t\}$, $C^o\{Z_t\}$, $N^r\{Z_t\}$, $N^o\{Z_t\}$, $\pi\{Z_t\}$, $R\{Z_t\}$, $G\{Z_t\}$, *solving equations* (4), (5), (7), (15), (17), (18)*, the FRF, and the MRF.*

3.3. Fiscal Leadership Game

As for the Nash game, policy makers cannot commit, but decide about policies period by period. Unlike the Nash game, however, the fiscal policy is determined before the monetary policy. Therefore, in this context, the fiscal authority behaves as the Stackelberg leader, whereas the monetary authority is the Stackelberg follower.[9]

The Stackelberg structure becomes relevant only when the utility functions of the monetary and the fiscal authority are different.[10] Thus, we assume that the monetary authority is more inflation-adverse than society, following Rogoff (1985) and Adam and Billi (2008). The idea is that a conservative monetary authority is closer to the ECB's mandate of maintaining price stability. The objective function of the monetary policy maker is a weighted sum of agents' utility and a cost of inflation, so that the monetary authority now solves the following:

$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} E_t \sum_{t=0}^{\infty} \beta^t$$
$$\times \left\{(1-\alpha)[\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda)u(C_t^o, N_t^o, G_t)] - \alpha \frac{(\pi_t - 1)^2}{2}\right\}$$
$$\text{s.t. (4), (5), (7), (15), (17), (18) for all } t$$
$$\left\{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j-1}\right\} \text{ given for } j \geq 1\,, \qquad \textbf{(22)}$$

where $\alpha \in [0, 1]$ is a measure of monetary conservatism. Notice that $0 < \alpha < 1$ means that the monetary authority dislikes inflation more than society and the central bank is defined as *partially conservative*. When $\alpha = 1$ the policy maker only cares about inflation and is defined as *fully conservative*.

Given that the fiscal authority is the Stackelberg leader, fiscal policy is determined before monetary policy and it takes into account the conservative monetary policy reaction function, which consists of the first-order conditions of (22). The fiscal policy problem at time t is thus given by

$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda)u(C_t^o, N_t^o, G_t)\right\}$$
$$\text{s.t. (4), (5), (7), (15), (17), (18), FOCs of (22) for all } t$$
$$\left\{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j}\right\} \text{ given for } j \geq 1\,. \qquad \textbf{(23)}$$

TABLE 1. Calibration

Parameter	Value	Source
β	0.9913	Adam and Billi (2008)
θ	17.5	Adam and Billi (2008) and Schmitt-Grohé and Uribe (2004b)
σ	1	in line with Adam and Billi (2008) log utility function
φ	1	Adam and Billi (2008)
ω_n	26.042	Adam and Billi (2008)
ω_g	0.227	Adam and Billi (2008)
ϵ	6	Adam and Billi (2008) and Galí et al. (2004)
Z	1	Adam and Billi (2008)
λ (SS)	[0,0.3,0.5]	Muscatelli et al. (2004), Forni et al. (2009), Di Bartolomeo et al. (2010), Campbell and Mankiw (1989) and Galí et al. (2004)
λ (dynamics)	0.5	Campbell and Mankiw (1989) and Galí et al. (2004)
ρ_z	0.9	
σ_z	0.01	
ρ_λ	0.9	
σ_λ	0.01	

3.4. The Optimal Steady State

Ramsey steady state. From the first-order conditions we derive that the value of π_t in steady state is 1, which implies price stability. Then, from the Euler equation, we find that $R = 1/\beta$. Combining these results with (15), we get

$$w = \left[\lambda \frac{\omega_n N^{r\varphi}}{C^{r-\sigma}} + (1-\lambda)\frac{\omega_n N^{o\varphi}}{C^{o-\sigma}}\right] = \frac{\epsilon - 1}{\epsilon}, \tag{24}$$

which implies that the steady state real wage does not depend on the fraction of LAMP. Equation (24) resembles the equilibrium result under flexible prices, where steady state real marginal costs equal the inverse of the desired markup.

Given the complexity of the model, the steady state values of the other variables are obtained through numerical methods, after parameters are calibrated. From now on, we will refer to the calibration shown in Table 1, which is in line with Adam and Billi (2008).

The left-hand panel of Table 2 resumes the steady state values under Ramsey.[11] We consider three alternative values for the fraction of LAMP consumers: $\lambda = (0; 0.3; 0.5)$. When $\lambda = 0$, our model nests the RAE model, which is used as a benchmark model. Empirical evidence on LAMP found values in between 0.3 and 0.5. In particular, Campbell and Mankiw (1989) and Muscatelli et al. (2004), among others, estimate a value of λ equal to 0.5. Forni et al. (2009) find a fraction of non-Ricardian agents close to 40%, whereas Di Bartolomeo et al. (2010) report an average fraction of non-Ricardian agents of about 26% for the G7 countries. As shown in Table 2, although the steady state inflation rate is always equal to 1, no matter the value of λ, public spending decreases with λ increasing, even if

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TABLE 2. Stochastic steady state under no redistribution

	Ramsey problem			Nash			FL, $\alpha = 0.5$			FL, $\alpha = 1$		
	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$
π	1.0000	1.0000	1.0000	1.0146	1.0222	1.0341	1.0144	1.022	1.0338	1.0000	1.0000	1.0000
R	1.0087	1.0087	1.0087	1.0234	1.0311	1.0431	1.0233	1.0309	1.0428	1.0087	1.0087	1.0087
G	0.0400	0.0398	0.0395	0.0402	0.0402	0.0403	0.0402	0.0402	0.0403	0.0400	0.0398	0.0395
Y	0.2001	0.2003	0.2007	0.2014	0.2032	0.2068	0.2014	0.2031	0.2067	0.2001	0.2003	0.2007
C^r		0.1446	0.1448		0.1450	0.1453		0.1450	0.1453		0.1446	0.1448
C^o	0.1600	0.1673	0.1776	0.1593	0.1645	0.1675	0.1593	0.1645	0.1676	0.1600	0.1673	0.1776
N^r		0.2213	0.2211		0.2215	0.2215		0.2215	0.2215		0.2213	0.2211
N^o	0.2000	0.1913	0.1802	0.2013	0.1952	0.1921	0.2013	0.1952	0.1919	0.2000	0.1913	0.1802
D^o	0.0333	0.0477	0.0669	0.0313	0.0414	0.0468	0.0314	0.0415	0.0471	0.0333	0.0477	0.0669
V	−354.5	−355.0	−355.6	−355.7	−357.6	−361.7	−355.7	−357.6	−361.6	−354.5	−355.0	−355.6
V^r		−379.7	−379.6		−379.2	−379.0		−379.2	−379.0		−379.7	−379.6
V^o	−354.5	−344.4	−331.6	−355.7	−348.4	−344.5	−355.7	−348.3	−344.2	−354.5	−344.4	−331.6

only marginally. Moreover, notice that consumption of Ricardian households, C^o, is an increasing function of λ. The reason is the following. As λ increases, the fraction of Ricardians decreases, so that per capita profits $D/(1-\lambda)$ rise, boosting per capita Ricardian consumption. LAMP consumption increases slightly as λ becomes greater than 0.3 because of a small reduction of G. In fact, the steady state of the government budget constraint implies that $G = T = T^o = T^r$, and therefore from (5) we obtain $C^r = wN^r - G$. It is easy to understand that the more than proportional decrease in G with respect to N^r causes C^r to rise, because the steady state value of the real wage is constant. Therefore, from the policy authority point of view, it is optimal to reduce public spending to maximize welfare when λ increases, because it raises C^r. However, overall, the effects of varying λ are only marginal under Ramsey.

Nash steady state. We find the steady state of the Nash game through numerical methods. The second panel of Table 2 shows the results.

As pointed out by Adam and Billi (2008), when the policy authorities play simultaneously and under discretion, there is an inflation bias with respect to the Ramsey steady state. Also, in our model the inflation bias increases dramatically as the fraction of liquidity-constrained households λ grows larger. The central bank annualized inflation target approaches 9% even for a small fraction of non-Ricardian agents close to 30%. This value is about 14% when the fraction of LAMP consumers is 0.5. The intuition is straightforward. The inflation bias arises because the monetary authority disregards private expectations on inflation. LAMP is an additional distortion in the economy with respect to the two usually faced by the central bank: (i) the monopolistic competition distortion; (ii) the sticky price distortion. The first decreases as the steady state inflation increases. This happens because the steady state inflation rate acts as an implicit tax on profits. In contrast, the sticky price distortion calls for price stability by reducing the price adjustment costs. When λ increases, per capita profits earned by Ricardians, i.e., $D/(1-\lambda)$, become higher and the monopolistic distortion increases. By increasing the steady state inflation rate, the central bank reduces the monopolistic distortion and increases the steady state output. Overall, the monopolistic distortion becomes more and more relevant as the fraction of LAMP consumers increases. Notice that higher inflation leading to lower markups is a result already found in Rotemberg and Woodford (1991) and Benabou (1992), but for some reason it was not exploited by the subsequent Woodfordian NK literature. Typically, this literature ignores complications associated with monopolistic distortion and studies optimal monetary policy around an efficient steady state [an exception is Benigno and Woodford (2005)]. In our model, as for example in Schmitt-Grohé and Uribe (2007), we depart from the widespread practice in the NK literature of evaluating welfare by considering models in which the deterministic steady state is efficient. This last approach introduces a battery of subsidies to production and employment aimed at eliminating the long-run distortions. This is usually done for purely computational reasons. However, as argued by many, this practice has

TABLE 3. Inflation bias under different degrees of price rigidity

	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$
$\psi = 0.25$ ($\theta = 2.22$)	1.0165	1.0256	1.0392
$\psi = 0.50$ ($\theta = 9.91$)	1.0154	1.0237	1.0365
$\psi = 0.75$ ($\theta = 58.47$)	1.0117	1.0174	1.026

two main shortcomings: (i) the policy instruments necessary to remove the steady state distortions are empirically implausible; (ii) a policy that is optimal for an economy with an efficient steady state will not necessary be so for an economy with a distorted steady state.

To further investigate the role of steady state monopolistic distortion, we consider also a value of θ alternative to the baseline value considered by Adam and Billi (2008). We translate the cost of adjusting prices into an equivalent Calvo probability, $\theta = \frac{\varepsilon - 1}{\kappa}$, where $\kappa = (1 - \psi)(1 - \psi\beta)/\psi$ and ψ is the Calvo probability that firms do not adjust prices. This allows us to generate results for different degrees of price rigidity. In particular, we consider $\psi = [0.25; 0.50; 0.75]$ corresponding to an average duration of prices fixed for 1.33, 2, and 4 quarters, respectively. Table 3 shows that the more flexible prices are, the higher is the inflation bias. If prices are sticky for one year (more than what was implied in our benchmark calibration), the inflation bias is lower than in our benchmark case. However, the annualized inflation target is still highly positive (7% for a fraction of LAMP of 30%). The intuition behind this result is straightforward. As shown in Table 3, an increase in price flexibility implies lower adjustment costs. Thus, ceteris paribus, the central bank has an incentive to increase the steady state inflation rate, so that the distortion due to monopolistic competition decreases and output is pushed closer to its efficient level. Moreover, for the same reason, the inflation bias increases with the fraction of LAMP, thus leaving our result unchanged. Summing up, we can state that the optimal steady state inflation remains highly positive for empirically plausible values of the Rotemberg adjustment costs and increases as λ becomes higher.

Finally, we also find a government spending bias, as in the RAE. However, this bias is only marginally affected by LAMP consumers. This happens because the fiscal authority takes into account that an increase in public spending has two effects. First, government spending enters households' utility function directly. Therefore, an increase in spending increases welfare. Second, an increase in G, by implying higher taxes, reduces LAMP consumers' disposable income and thus their consumption and welfare. This second effect does not concern Ricardian agents, because they have an additional source of income represented by profits. Notice that differently from Ramsey, where zero steady state inflation implies a decrease in public spending as λ increases, under Nash government spending increases with λ. The intuition is the following. Under Nash, the monetary authority uses inflation to redistribute income from Ricardians to LAMP consumers, so that ceteris paribus Ricardian consumption is lower under Nash than under Ramsey, whereas that of LAMP consumers is higher under Nash. As the inflation bias and thus redistribution toward LAMP households increase with λ , the fiscal authority can increase public spending without weighting on LAMP consumption.

Fiscal leader steady state. The third panel of Table 2 shows that the optimal steady state values under the FL with a partially conservative monetary policy ($\alpha = 0.5$) change only marginally with respect to the Nash case.[12]

As in Adam and Billi (2008), when $\alpha = 1$, meaning that the monetary authority only cares about inflation, the FL leads to the Ramsey steady state. The fiscal authority takes into account that the monetary policy maker is determined to achieve price stability at all costs, so that if there is a fiscal expansion it will raise the interest rate to contain inflationary pressures. The fiscal policy maker benefits from the first move and therefore can internalize this effect, leading to the Ramsey steady state. This also implies that the welfare losses are minimized, as we will show in the next section.

We state the main finding of this section in Result 1.

Result 1. Under the Nash game and the FL game with a partially conservative central bank, the optimal monetary policy implies an inflation bias that strongly increases as the fraction of liquidity-constrained consumers, λ, increases.

3.5. The Optimal Steady State with Redistributive Fiscal Policies

In the policy regimes considered so far, the fiscal authority cannot redistribute among consumers, and withdraws the same amount of lump-sum taxes from each type of consumer, generating a great loss in terms of welfare for liquidity-constrained consumers. At the same time, this involves a consistent gain for Ricardian consumers (see Table 4). Also, the tax burden (measured by the share of taxes over total income) of liquidity-constrained consumers ($\mathrm{TB}^r = T^r/WN^r$) is greater than that of Ricardians ($\mathrm{TB}^o = T^o/WN^o + D^o$). It amounts to 21% of total income for liquidity-constrained consumers and to 18% for Ricardians, for $\lambda = 0.5$ (see Table 5).

This gives rise to a distributional conflict between the two types of consumers. To solve this problem, the fiscal authority may consider the possibility of choosing the amount of taxes for each type of consumer, instead of government spending, to redistribute income and thus welfare beteween the two types of households. For this reason, in what follows, we will consider redistributive fiscal policies. In particular, we will solve the policy games assuming that the fiscal authority alternatively adopts (i) a fully redistributive policy or (ii) a partially redistributive policy.

TABLE 4. Welfare losses in consumption equivalents (in percent)

	No redistribution			Full redistribution		Partial redistribution
	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$	$\lambda = 0.3$	$\lambda = 0.5$	$\lambda = 0.5, \delta = 0.3$
			Ramsey problem			
V	−0.86	−1.28	−1.82	−0.86	−0.86	−1.12
V^r		−20.37	−20.34	−0.86	−0.86	−11.22
V^o	−0.86	8.24	21.00	−0.86	−0.86	10.12
			Nash game			
V	−1.88	−3.55	−6.90	−1.89	−1.89	−3.77
V^r		−20.06	−19.89	0.34	0.33	−10.75
V^o	−1.88	4.54	8.19	−2.82	−4.06	3.76
			Fiscal leader with partially conservative monetary policy			
V	−1.86	−3.50	−6.82	−1.87	−1.88	−3.72
V^r		−20.06	−19.89	0.25	0.26	−10.75
V^o	−1.86	4.60	8.39	−2.77	−3.97	3.87
			Fiscal leader with fully conservative monetary policy			
V	−0.86	−1.28	−1.82	−0.86	−0.86	−1.12
V^r		−20.37	−20.34	−0.86	−0.86	−11.22
V^o	−0.86	8.24	21.00	−0.86	−0.86	10.12

Fully redistributive fiscal policy. The fully redistributive fiscal authority solves the policy problems analyzed so far by choosing the lump-sum taxes paid by Ricardian consumers, labeled as T_t^o, and those paid by LAMP consumers, labeled as T_t^r. Because the fiscal authority now has two different fiscal instruments, the policy problems can be solved by adding the following constraint:

$$T_t = \lambda T_t^r + (1 - \lambda)\, T_t^o. \tag{25}$$

The usual balanced budget condition, $T_t = G_t$, holds and thus public expenditure G_t becomes endogenous.[13] Table 5 presents the steady state values for all the policy games.

Notice that for all games, the fully redistributive fiscal policy makes it possible to control the insurgence of the inflation bias, which remains at its RAE level no matter the fraction of liquidity-constrained consumers. However, with respect to the economy with no redistribution, whereas LAMP consumers are better off, Ricardian consumers are worse off in terms of welfare. Total welfare remains at its RAE level. Thus, a strong reduction of the inflation bias is obtained at the cost of reducing Ricardian welfare. Indeed, for all cases considered, liquidity-constrained consumers pay a lower amount of taxes than that paid with no redistribution. Further, per capita taxes paid by these consumers remain constant no matter the value of λ. Differently, Ricardians are charged a larger amount of per capita taxes, which increases as the fraction of liquidity-constrained consumers increases. The reason is the following. Ricardians have an additional form of income with respect

TABLE 5. Stochastic steady state under different degrees of redistribution

	No redistribution			Full redistribution		Partial redistribution
	RAE, $\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$	$\lambda = 0.3$	$\lambda = 0.5$	$\lambda = 0.5, \delta = 0.3$
			Ramsey problem			
π	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
G	0.0400	0.0398	0.0395	0.0400	0.0400	0.0406
T^r	0.0400	0.0398	0.0395	0.0067	0.0067	0.0244
T^o	0.0400	0.0398	0.0395	0.0543	0.0734	0.0568
V	−354.5	−355.0	−355.6	−354.5	−354.5	−354.8
V^r		−379.7	−379.6	−354.5	−354.5	−367.2
V^o	−354.5	−344.4	−331.6	−354.5	−354.5	−342.4
TB^r		0.22	0.21	0.04	0.04	0.14
TB^o	0.20	0.19	0.18	0.25	0.31	0.25
			Nash game			
π	1.0146	1.0222	1.0341	1.0145	1.0145	1.0239
G	0.0402	0.0402	0.0403	0.0402	0.0402	0.0412
T^r	0.0402	0.0402	0.0403	0.0053	0.0053	0.0247
T^o	0.0402	0.0402	0.0403	0.0552	0.0751	0.0577
V	−355.7	−357.6	−361.7	−355.7	−355.7	−357.9
V^r		−379.2	−379.0	−353.1	−353.1	−366.6
V^o	−355.7	−348.4	−344.5	−356.8	−358.3	−349.3
TB^r		0.22	0.22	0.03	0.03	0.14
TB^o	0.20	0.20	0.19	0.26	0.32	0.26
		Fiscal leader with partially conservative monetary policy				
π	1.0144	1.0220	1.0338	1.0144	1.0145	1.0237
G	0.0402	0.0402	0.0403	0.0402	0.0402	0.0412
T^r	0.0402	0.0402	0.0403	0.0054	0.0054	0.0247
T^o	0.0402	0.0402	0.0403	0.0551	0.0750	0.0577
V	−355.7	−357.6	−361.6	−355.7	−355.7	−357.9
V^r		−379.2	−379.0	−353.2	−353.2	−366.6
V^o	−355.7	−348.3	−344.2	−356.7	−358.2	−349.1
TB^r		0.22	0.22	0.03	0.03	0.14
TB^o	0.20	0.20	0.19	0.26	0.32	0.26
		Fiscal leader with fully conservative monetary policy				
π	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
G	0.0400	0.0398	0.0395	0.0400	0.0400	0.0406
T^r	0.0400	0.0398	0.0395	0.0067	0.0067	0.0244
T^o	0.0400	0.0398	0.0395	0.0543	0.0734	0.0568
V	−354.5	−355.0	−355.6	−354.5	−354.5	−354.8
V^r		−379.7	−379.6	−354.5	−354.5	−367.2
V^o	−354.5	−344.4	−331.6	−354.5	−354.5	−342.4
TB^r		0.22	0.21	0.04	0.04	0.14
TB^o	0.20	0.19	0.18	0.25	0.31	0.25

to liquidity-constrained consumers, represented by profits. Because by lowering the inflation bias per capita profits increase, the fiscal authority tries to offset the increasing profits by increasing Ricardian taxes. Moreover, given that per capita profits increase as the fraction of LAMP increases, the fiscal authority charges Ricardians higher taxes in order to restore equity as λ gets higher. In particular, under Ramsey and the FL game with a fully conservative monetary policy (both cases characterized by full price stability), the larger amount of profits is exactly offset by the higher taxes paid by Ricardians. On the other hand, in the Nash game and the FL game with partially conservative MP, the reduction in the inflation bias is obtained by a greater increase in the amount of taxes paid by Ricardians, so that the increase in per capita profits is more than offset by higher taxes when λ increases.

Finally, under the fully redistributive policy, the government spending bias does not depend on the fraction of LAMP consumers, because for each policy problem it is always at its respective RAE level.

Partially redistributive fiscal policy. We now consider a fiscal policy that only partially redistributes income. The reason is twofold: (i) The fiscal authority may prefer to control the amount of spending instead of that of taxes; (ii) The fiscal authority may be ruled by policy makers who are reluctant, for example for electoral reasons, to redistribute income fully. In both cases the fiscal authority may be in favor of a partially redistributive scheme instead of a fully redistributive one. Following this idea, we assume that the fiscal authority controls spending and redistributes a smaller fraction of income from Ricardians to LAMP consumers than the one that would be optimal for a fully redistributive fiscal authority. We model partial redistribution by assuming that the fiscal authority optimally chooses the value of G_t that satisfies

$$T_t = \delta T_t + (1 - \delta) T_t = \lambda T_t^r + (1 - \lambda) T_t^o = G_t,$$

where δ is chosen exogenously so that

$$T_t^r = \frac{\delta T_t}{\lambda} \text{ and } T_t^o = \frac{(1 - \delta) T_t}{1 - \lambda}.$$

Notice that to the extent to which $\delta < \lambda$, the fiscal authority taxes LAMP consumers less than Ricardian, and thus its policy is redistributive in favor of LAMP consumers. Then, for a given value of λ, the lower δ, the more redistributive is the fiscal policy.

Overall, as shown in Table 3, we find that under discretionary regimes with a partially redistributive policy the inflation bias remains substantially high. Further, it increases with δ. In particular, as shown in Table 5, with $\delta = 0.3$ and $\lambda = 0.5$, the tax burden of the LAMP household in steady state is 14%, whereas that of Ricardian households is 26% under Nash.[14] The latter is a value very close to the tax burden of the U.S. middle class. In this case the steady state inflation is equal to 10% in annual terms. This still implies a very high inflation bias, even if lower

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than what we obtained without redistribution policies. Similar results hold for the FL regime with partially conservative monetary policy.

Further, notice that differently from the case of a fully redistributive fiscal policy, a partially redistributive policy leads to a significant increase in government spending, under all cases considered. The reason is the following. Ceteris paribus, an increase in government expenditure does not imply a one-to-one reduction in LAMP disposable income, with a partial redistributive fiscal policy. Consequently, LAMP consumption is higher than that occurring under either a nonredistributive fiscal policy or a fully redistributive one. Thus, with partial redistribution, the fiscal authority has a stronger incentive to increase government spending. Adam and Billi (2008) already pointed out that the lack of fiscal commitment gives rise to a spending bias. In this respect, we find that this bias is even stronger under a partially redistributive fiscal policy. Thus, we can state that a partially redistributive fiscal policy, although reducing the inflation bias, generates an extra government spending bias under discretionary policies. In Table 3 of the Online Appendix we also show results for $\delta = 0.2$. This allows us to compare steady state results for $\lambda = 0.3$ and $\lambda = 0.5$. We find that both the inflation bias and the government spending bias increase as λ increases. The intuition behind the latter result is straightforward. With $\delta = 0.2$, the fiscal authority redistributes more toward LAMP consumers; thus it has more room to increase public spending.

Finally, as expected, Ricardians are always better off than under a fully redistributive policy, whereas they are worse off with respect to the welfare they can afford with nonredistributive fiscal policies. Total welfare is higher than that of the economy without redistribution.

We summarize the main findings of this section as follows.

Result 2. A fully redistributive fiscal policy cancels out the extra-inflation bias generated by LAMP. Although total welfare remains at its RAE level, LAMP consumers are better off and Ricardians experience a loss of welfare. A partially redistributive policy reduces the extra inflation bias, but causes a higher government spending bias.

3.6. The Optimal Dynamics

This section presents the impulse responses analysis when a positive technology shock hits the economy, without redistributive fiscal policies. These responses are intended to be interpreted as the optimal responses when the economic system is already under financial restraint. This makes it possible to compare our impulse response functions (IRFs henceforth) to those already presented in the literature in the RAE model.

Ramsey dynamics. We analyze the model dynamics in the case of the Ramsey optimum through IRFs. We look at the optimal dynamics in response to a positive technology shock.

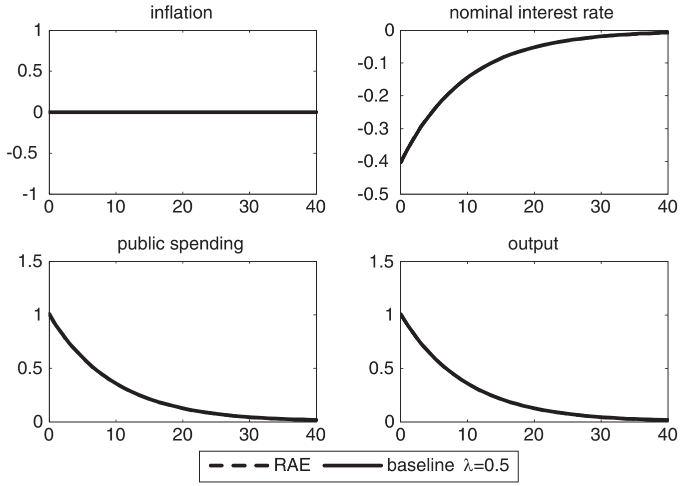

FIGURE 2. Ramsey IRFs to a 1% positive technology shock under the baseline model and the RAE model.

Figure 2 shows the effects of a 1% increase in technology on the main macroeconomic variables. We consider the fully Ricardian case ($\lambda = 0$, dashed lines) and the case in which the fraction of liquidity-constrained consumers is $\lambda = 0.5$ (solid lines). As expected, in both cases policy makers accommodate the shock to boost the economy by reducing nominal interest rates and raising public expenditure. The authorities commit so that they are completely credible; this is why the resulting optimal dynamics features price stability and a persistent increase of aggregate output, no matter the value of λ.

Moreover, as shown in Figure 3, we find that the optimal inflation volatility is always zero as λ varies.

Nash dynamics. Under Nash some differences emerge with respect to Ramsey dynamics. Figure 4 depicts the optimal deviations from the steady state of the main macroeconomic variables in response to a persistent technology shock, for $\lambda = 0$ (dashed lines) and $\lambda = 0.5$ (solid lines).

In response to a technology shock, the lack of commitment produces a rise in inflation and an increase in output. Remarkably, hours worked fall. The contraction in hours following a positive productivity shock is in line with the NK literature [see, for example, Galí and Rabanal (2004)]. The inflation bias increases as λ increases, whereas the reduction in labor hours becomes greater. The intuition for these results is as follows. The monetary policy is not forward-looking, but decides period by period and thus generates an inflation bias: the authority is tempted to stimulate demand by lowering interest rates, which increases Ricardian consumption. The aggregate demand is then stimulated by an increase in public

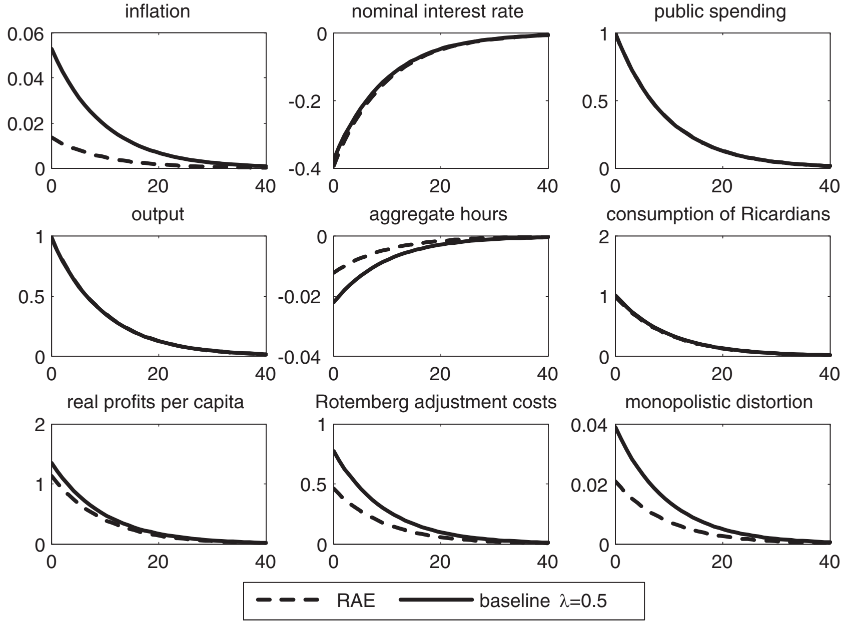

FIGURE 3. Nash IRFs in response to a 1% positive technology shock under the baseline model and the RAE model.

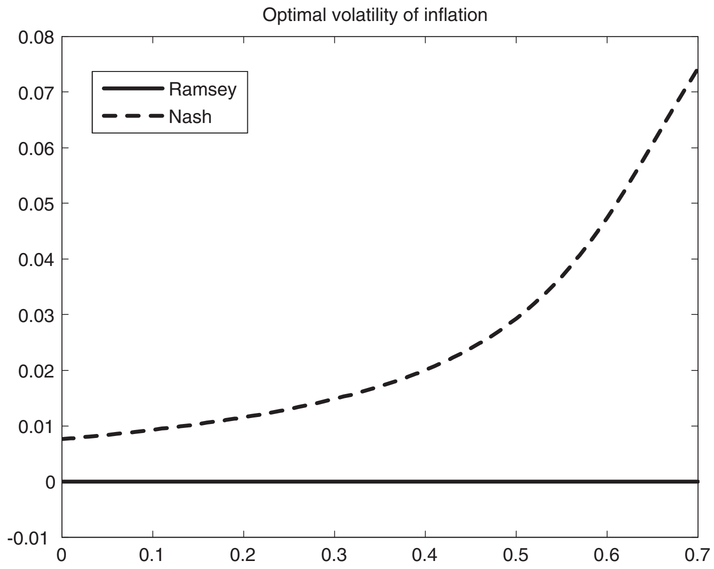

FIGURE 4. Optimal inflation volatility under Ramsey and under Nash.

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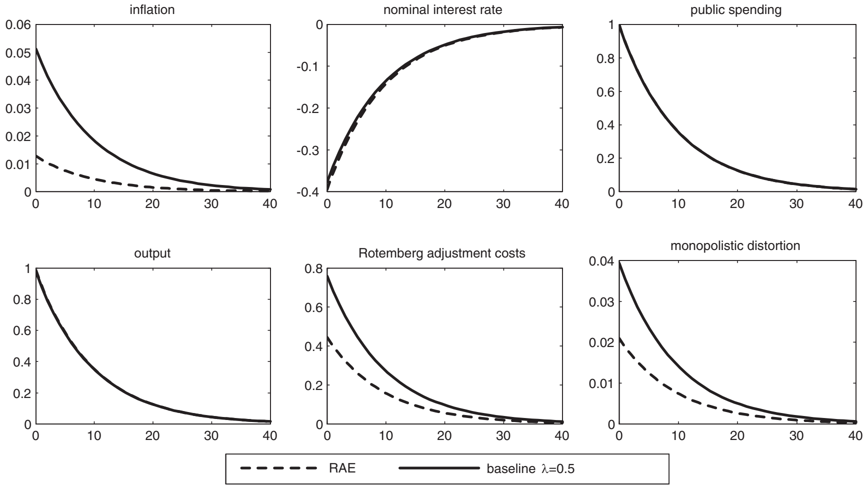

FIGURE 5. IRFs to a 1% positive technology shock with fiscal leadership and partially conservative monetary policy under the baseline model and the RAE model.

spending, which together with the accommodative monetary policy contributes to push output and inflation up. Per capita profits increase, giving an additional boost to Ricardian consumption. This in turn reduces their labor supply. The increase in inflation more than doubles passing from $\lambda = 0$ to $\lambda = 0.5$. This happens because the monetary authority aims at reducing the higher distortion coming from the increase of per capita profits, which otherwise would lower aggregate output. Instead, public spending is not affected by λ.

Figure 3 shows that differently from Ramsey, under Nash the optimal inflation volatility increases more than proportionally as λ increases.

Fiscal leader dynamics. With $\alpha = 0.5$, i.e., with a partially conservative monetary policy, we observe that the optimal dynamics under the FL change only marginally with respect to the Nash case.[15] Figure 5 shows the IRFs to a technology shock.

When $\alpha = 1$, Figure 6 shows that a positive technology shock leads to price stability, no matter the value of λ.

The optimal inflation volatility of the FL game with $\alpha = 0, 5$ coincides with that under Nash, whereas under FL with $\alpha = 1$ the optimal inflation volatility is always zero, as under Ramsey.[16]

We state the main finding of this section in Result 3.

Result 3. Under the Nash game and the FL game with a partially conservative central bank, in response to a technology shock the inflation bias becomes dramatically higher as λ increases.

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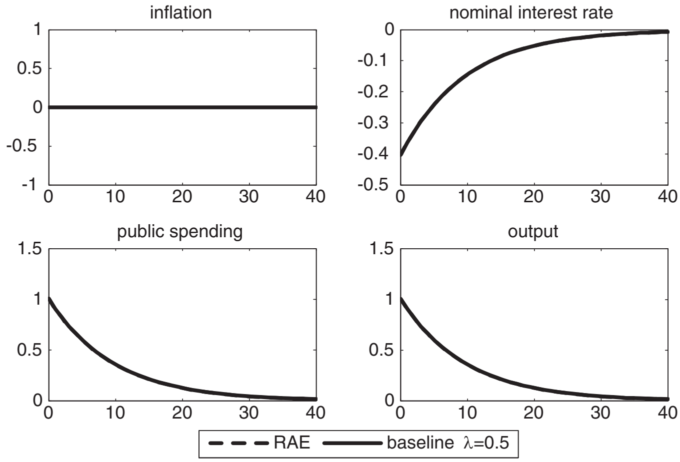

FIGURE 6. IRFs to a 1% positive technology shock with fiscal leadership and fully conservative monetary policy under the baseline model and the RAE model.

3.7. The Optimal Dynamics with Redistributive Fiscal Policies

We now analyze the optimal responses to a positive technology shock when the fiscal authority is fully or partially redistributive.

As we will explain in the following, the responses under full redistribution lead to the RAE responses no matter what the policy game.

Ramsey. In this case the responses to a technology shock always coincide with those generated under no redistribution, which were analyzed in the preceding section.

Nash and fiscal leadership with partially conservative monetary policy. Figure 7 collects the IRFs obtained under Nash, comparing redistributive policies with the no-redistribution case analyzed in the preceding section. We present IRFs only for the Nash game, as the FL with a partially conservative monetary policy leads to the same outcome. Under redistributive policies, a technology shock involves lower volatility of inflation. In particular, inflation volatility is minimized with full redistribution, but it also reduces considerably (about 40%) under partial redistribution. The reason underlying this is that inflation is used as an implicit tax on profits to limit the monopolistic distortion. In fact, the response of per capita profits is higher when there is no redistribution policy. Public spending and taxes rise but, under full redistribution, taxes for LAMP agents increase less, to support their consumption. Finally, notice that LAMP consumers greatly reduce the number of hours worked in the full redistribution case, whereas this remains almost unchanged under a partially redistributive fiscal policy.

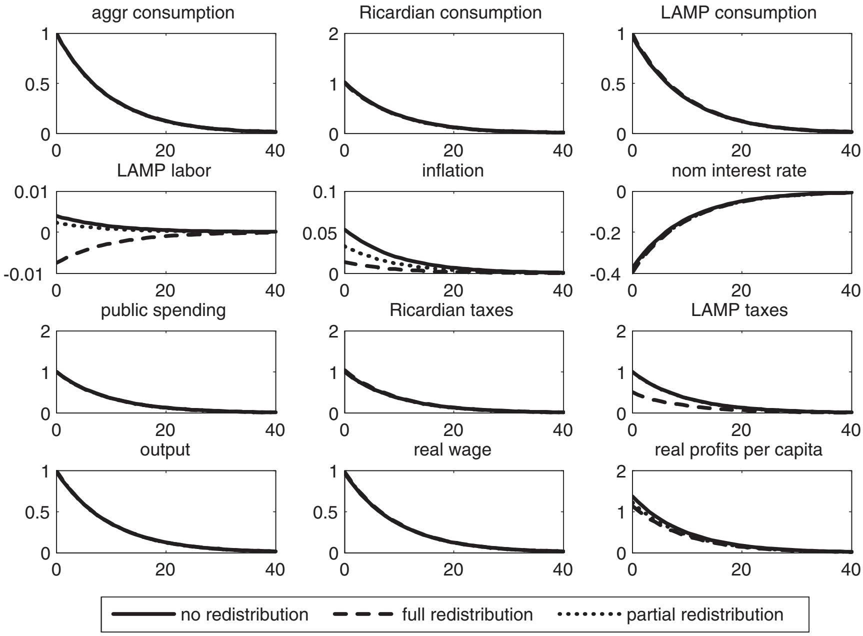

FIGURE 7. Nash: IRFs to a positive technology shock with redistributive fiscal policies.

Fiscal leadership with fully conservative monetary policy. As in Ramsey, in this case the technology shock produces the same responses no matter the degree of LAMP.[17]

The main finding of this section is the following.

Result 4. If the policy regimes cannot ensure price stability and the fiscal authority cannot implement a fully redistributive fiscal policy, at least a partially redistributive fiscal policy is needed to reduce inflation volatility.

3.8. Crisis Scenarios and the Optimal Policies

In this section our intention is to simulate a financial crisis scenario. One way of modeling the crisis in our model is through an unanticipated and temporary increase in the fraction of LAMP consumers. Thus, we now study the dynamics of the model under the different policy regimes in response to a 1% standard deviation positive shock to the fraction of LAMP consumers. This shock in fact is able to generate a negative response of real interest rates, typical of a financial crisis. It can be interpreted as an abrupt decrease of credit availability for households. In particular, we assume that

$$\lambda_t = \lambda l_t, \tag{26}$$

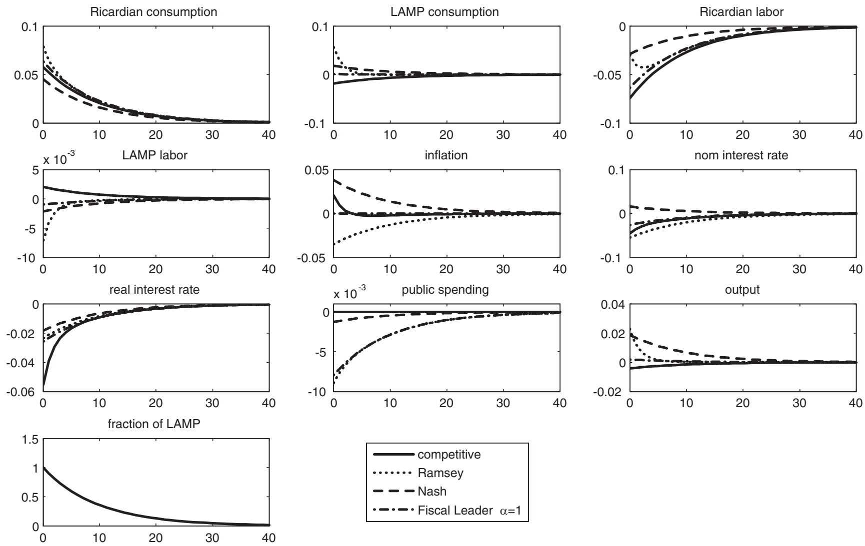

FIGURE 8. Shock to the fraction of LAMP (no redistribution).

where λ is the steady state fraction of LAMP, which we set to 0.3, and $\ln(l_t/l) = \rho_l \ln(l_t/l) + \varepsilon_t^l$ is an exogenous AR(1) process, with $\varepsilon_t^l \sim WN(0, \sigma_l^2)$.

Figures 8 and 9 collect IRFs in response to a 1% shock to λ under nonredistributive and fully redistributive policies. We compare the optimal responses to the competitive equilibrium responses to gain intuition about the behavior of the optimizing authorities. In this case, we assume that the nominal interest rate is determined through a standard Taylor rule $[R_t/R = (\pi_t/\pi)^{\phi_\pi}(Y_t/Y)^{\phi_y}]$ and that government spending is an exogenous shock with AR(1) process.

In a competitive equilibrium, a shock that increases the fraction of LAMP has the expected effect of reducing the real interest rate on impact. At the same time, it generates a recession by decreasing LAMP consumption and thus output.

Now consider the optimal IRFs. Figure 8 shows the optimal responses under nonredistributive policies for different types of policy regimes. In general, we find that optimal policies are able to avoid the recession. In fact, the response of the fiscal policy, which reduces public spending (thus also reducing taxation), is such that LAMP consumption does not decrease under all the policy regimes considered. At the same time, the reduction of the real interest rate supports Ricardian consumption. Thus, aggregate demand increases and so does production.

Figure 9 presents the optimal IRFs with fully redistributive policies. Notably, under Ramsey and fiscal leadership with fully conservative monetary policy, the reaction to the shock occurs only through taxes on Ricardians, which are increased. This leaves Ricardians' consumption almost unchanged. Public spending and LAMP taxes remain unchanged, so that LAMP consumption also stays constant and output is unchanged. Under Nash, there is also little variation in the IRFs,

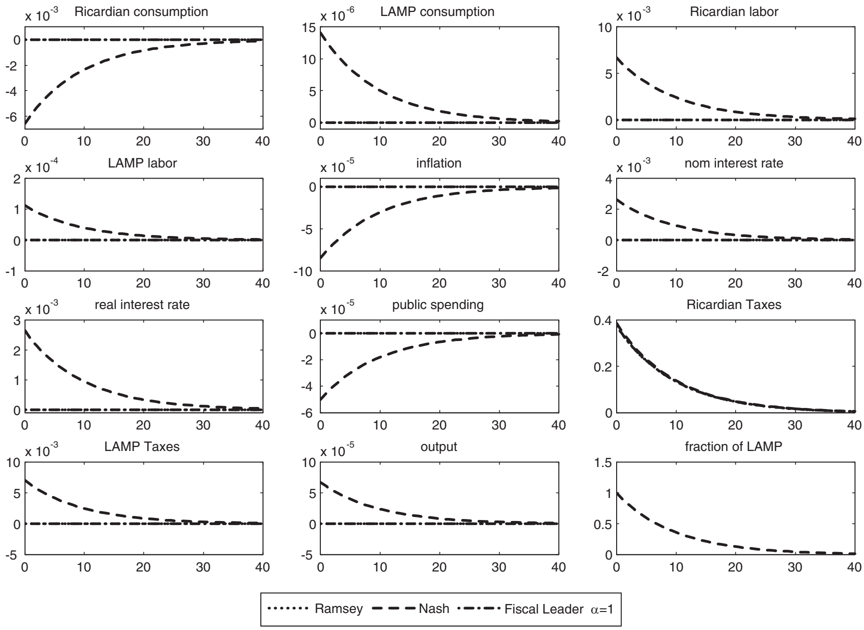

FIGURE 9. Shock to the fraction of LAMP (full redistribution).

but LAMP taxes are slightly used. The nominal interest rate is slightly increased, which, together with a small reduction in inflation, makes the real interest rate slightly above its steady state.

Another way of modeling the crisis in our model would be through an unanticipated and temporary increase in the fraction of LAMP consumers, accompanied by a fall in productivity, Z_t.[18] Thus, we assume that the shock to λ and the productivity shock are negatively correlated, with a contemporaneous correlation equal to $\rho_{z,l} = -0.1$. This makes it possible to capture the possibility of having a negative financial shock accompanied by an unexpected reduction in productivity.

Figures 10–12 present the IRFs under the different policy regimes, respectively Ramsey, Nash, and the FL with fully conservative monetary policy.[19]

As shown in the figures, when the fiscal authority makes no redistribution, the increase in the fraction of LAMP consumers accompanied by a reduction in productivity is always followed by a strong reduction in consumption byf both Ricardian and LAMP consumers. Hours worked for both consumers fall as well, and so does the aggregate output. Differently from what was stated in the preceding section, under Ramsey inflation deviates from zero. Indeed it increases on impact, even if it goes back to its steady state level in a very short period of time. The sharp increase in inflation allows output to decrease less than under the FL regime with fully conservative monetary policy. In this case, in fact, as shown in Figure 12, inflation is completely stabilized. However, inflation stabilization is obtained

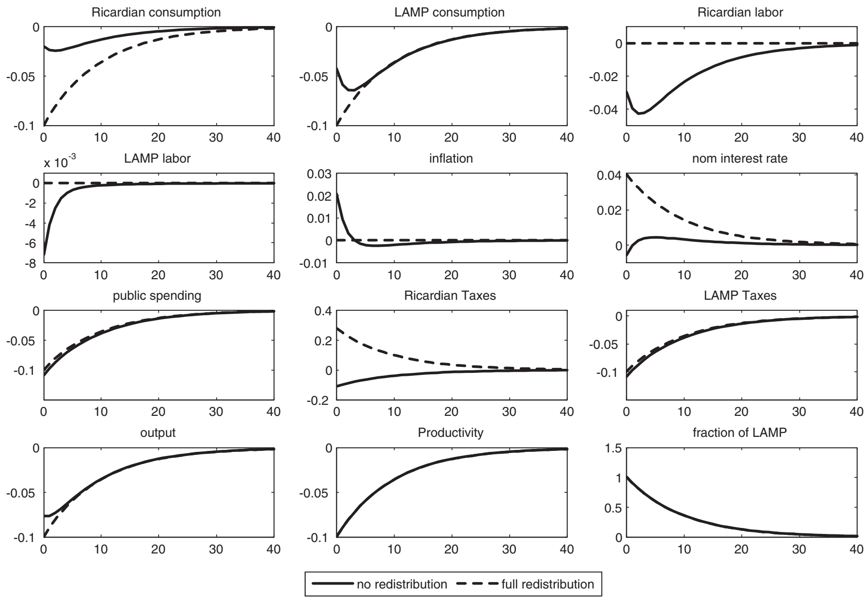

FIGURE 10. Ramsey: IRFs to a positive shock to λ accompanied by a reduction in productivity.

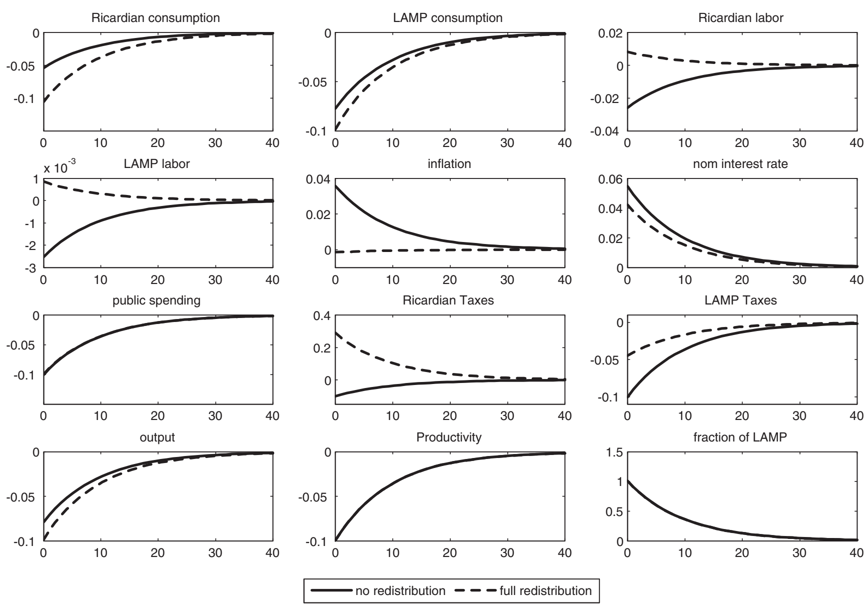

FIGURE 11. Nash: IRFs to a positive shock to λ accompanied by a reduction in productivity.

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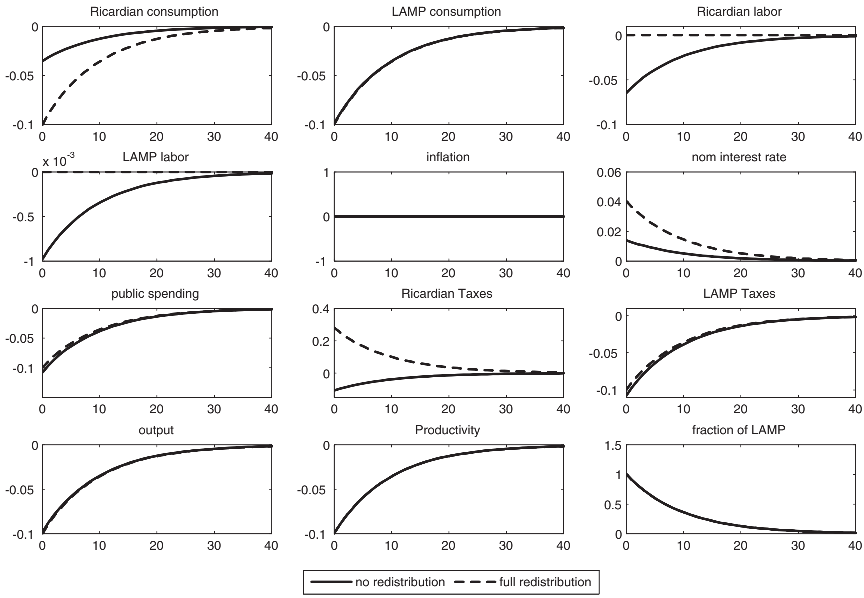

FIGURE 12. Fiscal leadership ($\alpha = 1$): IRFs to a positive shock to λ accompanied by a reduction in productivity.

at the cost of an greater decrease in output. Finally, notice that, although the Nash game implies a greater increase in inflation than under Ramsey, the fall in output is almost identical to that obtained under Ramsey.

Figures 10–12 also present the IRFs under Ramsey, Nash, and FL with fully conservative monetary policy, respectively with full redistribution (dashed lines).[20] Notice that consumption and output decrease under all policy regimes. Instead, inflation is completely stabilized both under a FL regime with fully conservative monetary policy and under Ramsey. These two policy regimes also stabilize hours worked. On the other hand, the Nash game is deflationary and pushes hours worked by both households above their steady state level when the fiscal policy is fully redistributive; thus it is much more welfare-detrimental. The FL game responses with fully conservative monetary policy and full redistribution coincide with Ramsey responses.

The main finding of this section is the following.

Result 5. Under a crisis scenario, mimicked by an increase in the fraction of LAMP alone, optimal policy with nonredistributive stances is able to avoid the recession by lowering public spending. However, if the worsening in credit availability is coupled with a fall in aggregate productivity, none of the policy regimes is able to avoid the fall in output. In the case of nonredistributive fiscal policies, the Ramsey regime cannot ensure price stability; only the FL regime with fully conservative monetary policy can guarantee inflation stabilization.

4. WELFARE ANALYSIS

In this section we show a measure for the utility losses associated with a particular game structure. We calculate the percentage loss of each game structure with respect to the social planner stochastic steady state. Let $V^{\mathrm{SP}} = [\lambda u(C^r, N^r, G) + (1-\lambda)u(C^o, N^o, G)]/(1-\beta)$ be the utility for the social planner stochastic steady state and V^{A} the stochastic steady state of the value function of an alternative policy regime. The permanent reduction in private consumption, $\mu^{\mathrm{A}} \leq 0$ (supposing to withdraw the same amount from each type of consumer), that would imply the social planner deterministic steady state to be welfare-equivalent to the alternative policy regime can be found by solving for μ^{A} the following expression:

$$V^{\mathrm{A}} = \frac{1}{1-\beta}\left[\lambda u(C^r\left(1+\mu^{\mathrm{A}}\right), N^r, G) + (1-\lambda)u(C^o\left(1+\mu^{\mathrm{A}}\right), N^o, G)\right]. \tag{27}$$

We use the same formulas to evaluate welfare for each type of consumer, i.e., $V_h^{\mathrm{SP}} = u(C^h, N^h, G)/(1-\beta)$ and

$$V_h^{\mathrm{A}} = \frac{1}{1-\beta}\left[u(C^h\left(1+\mu_h^{\mathrm{A}}\right), N^h, G)\right], \tag{28}$$

where $h \in (r, o)$ identifies the two types of consumers.

The left panels of Table 4 show the welfare losses in percentage terms resulting from the RAE model and the model with LAMP consumers (with $\lambda = 0.3, 0.5$) for each policy regime without redistribution and distinguishing between total, Ricardians', and LAMP consumers' welfare. Leading to the Ramsey steady state, the FL structure with $\alpha = 1$ minimizes the deviation from social planner allocations. At the same time, the Nash equilibrium leads to a total welfare loss that is not only considerably larger than in Ramsey (as well as in FL game with fully conservative monetary policy) but also slightly larger than the FL case with a partially conservative monetary policy. This is due to the fact that the inflation bias is marginally dampened by the conservatism of monetary policy.

Notably, Table 4 shows that no redistribution policies involve a great loss of welfare for LAMP consumers while Ricardians experience a gain, and this holds for all policy setups considered. Moreover, although LAMP losses remains almost unchanged in percentage terms, Ricardians' gains are significantly lower in the Nash game and in the FL game with partially conservative monetary policy. Again, this is due to the inflation bias arising with discretion, which dampens Ricardians' profits and thus their consumption and welfare.

Turning attention to the welfare implications of the redistributive policies, we find the following (see the central and right-hand panels of Table 4). Full redistribution allows to minimizing welfare losses in terms of total welfare. This is because we get the RAE long-run equilibrium for the aggregate. At the same time, a partial redistribution in favor of LAMP consumers, λ being equal, reduces total losses with respect to the no-redistribution case. This means that at least some form of redistribution would be desirable in terms of aggregate welfare.

Given the huge losses of LAMP consumers, which are also due to the high tax burden faced by these consumers, a fully redistributive fiscal policy may be preferred whenever the fiscal authority aims at reducing the distributional conflict. As shown in Table 5, this policy is able to reduce LAMP losses considerably at the expenses of Ricardians. Under Nash and FL with partially conservative monetary policy, LAMP consumers even get a welfare gain while Ricardians experience a loss. However, these losses are smaller than the ones experienced by LAMP consumers under no redistribution.

A partially redistributive fiscal policy is able to reduce total losses with respect to a nonredistributive fiscal policy, and this implies a huge reduction of losses for LAMP consumers but also a reduction of Ricardians' gains. Note that under Ramsey and under a FL game with a fully conservative monetary policy (i.e., in the absence of inflation bias), Ricardians experience a smaller reduction of their gain than that they would get under Nash or a FL game with partially conservative monetary policy.

Given these results, it appears that even a partially redistributive fiscal policy remains desirable with respect to a nonredistributive one. In fact, this policy is useful to (i) decrease the inflation bias; (ii) decrease LAMP welfare losses; (iii) decrease total welfare losses.

Finally, although a fully conservative monetary policy is necessary to get price stability, it implies a very strong reduction in LAMP consumers' welfare, in the absence of a redistributive fiscal policy. Furthermore, and differently from Adam and Billi (2008), a fully conservative monetary policy alone is not able to restore the welfare arising under Ramsey in a RAE model. A fully redistributive fiscal policy together with a fully conservative monetary policy is needed to restore the Ramsey efficiency result. The fully redistributive policy alone strongly reduces Ricardians' welfare and thus is not Pareto-superior.

Summing up, we can state the following.

Result 6. If the monetary and the fiscal authorities do not cooperate and play strategically, a fully conservative monetary policy alone is not able to remove the distributional conflict. A fully redistributive fiscal policy together with a fully conservative monetary policy is needed to restore both efficiency and equity.

5. CONCLUSIONS

In this paper we investigate the effects of LAMP on policy responses, in particular with respect to optimal inflation, both in the long run and in the short run. We compare our results with those obtained in a RAE model and with alternative redistributive fiscal policies. We find that when the fiscal authority is not concerned with redistributive issues, the Nash game and the FL game with partially conservative central bank imply a steady state inflation bias, which strongly increases as the fraction of LAMP consumers increases. A fully redistributive fiscal authority eliminates the extra inflation bias created by LAMP; however, this is cancelled out at the cost of strongly reducing Ricardians' welfare in terms of consumption equivalent. Partially redistributive fiscal policies reduce the extra inflation bias, but they give rise to a strong government spending bias.

Further, we show that LAMP increases inflation volatility in the face of a positive technology shock when the two authorities play strategically and neither is the fiscal authority involved in some form of redistribution nor is the monetary authority fully conservative.

Finally, we find that under a crisis scenario, the optimal policy is able to avoid the recession unless the reduction in credit availability is coupled with a negative technology shock. In this case, the Ramsey regime is no longer able to ensure price stability without redistribution, and only the FL regime with a fully conservative monetary policy can guarantee inflation stabilization.

We are aware of the fact that we restrict our analysis to a limited set of policy instruments. For this reason, our results are not meant to be adopted as policies rather, they offer another margin the government might want to consider in designing optimal policy. The balanced budget hypothesis may limit the channel through which the presence of LAMP might affect the optimal policies. However, the balanced budget assumption has the advantage of allow us to find the solution of the model easily to compare our results with those obtained previously in the literature on policies games, in primis by Adam and Billi (2008). Further developments of this study thus include the possibility of considering different fiscal structures, such as distortionary taxation.

NOTES

1. Data sources: Federal Reserve Bank of St. Louis (Total Consumer Credit Owned and Securitized Outstanding and Gross Domestic Product); ECB's Statistical Data Warehouse (Credit for consumption, Total maturity, Outstanding amounts at the end of the period, Euro Area); Eurostat (Gross Domestic Product, Euro Area).

2. In the standard RAE model, a small inflation bias arises because the monetary authority disregards private expectations on inflation under discretion. As a result, policy makers underestimate the welfare costs of generating inflation today and are tempted to move output toward its efficient steady state level.

3. In particular, Schmitt-Grohé and Uribe (2004a) study optimal Ramsey monetary and fiscal policy in a NK model with sticky price à la Rotemberg (1982). They find that the optimal inflation rate becomes positive only in a model where the monopolistic distortion, i.e., firms' markup, is very high and empirically implausible. Instead, we find that the absence of commitment and the presence of LAMP are sufficient to ensure positive steady state inflation level even with moderate values of firms' markup.

4. Adam and Billi (2008) have already pointed out that the lack of fiscal commitment gives rise to a spending bias. As will be clear in the paper, we find that this bias is even stronger under a partial redistributive fiscal policy.

5. We assume a utility function separable between private and public consumption also. Considering a not separable utility function, even if relevant, is beyond the scope of this paper, because we want to compare our results with those of Adam and Billi (2008) and also with most of the papers dealing with DSGE and optimal fiscal and monetary policy [see Schmidt Grohé and Uribe (2004b), among others].

6. The no-Ponzi-scheme constraint $\lim_{j\to\infty} E_t \prod_{i=0}^{t+j-1} \frac{1}{R_t} B_{t+j} \geq 0$ and the transversality condition $\lim_{j\to\infty} E_t \beta^{t+j} {C^o_{t+j}}^{-\sigma} B_{t+j}/P_{t+j} = 0$ hold.

7. As will be clear, the presence of liquidity-constrained agents makes it possible to get significant results even in the absence of public debt. We leave the introduction of public debt to future research.

8. The Technical Appendix is available at https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxhbGljZWFsYm9uaWNvfGd4OjU3M2ViZWFjY2IzYTQ1NDg.

9. The use of this terminology follows Adam and Billi (2008). The word "leader" stands for "first mover" and abstracts from considerations on whether the authority turns out to be dominant or not.

10. We find that the fiscal leadership in this case collapses to the Nash game. Results are presented in the Online Appendix (Table 1) available at https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxhbGljZWFsYm9uaWNvfGd4OjU3M2ViZWFjY2IzYTQ1NDg.

11. The tables present the result in terms of the stochastic steady state under a 1% standard deviation technology shock.

12. Table 2 in the Online Appendix provides steady state results for the Nash game with a partially conservative monetary policy. We do not include these results in the paper because the differences with respect to the Nash case and the FL with partially conservative monetary policy are negligible.

13. The budget constraint of the two consumers is rewritten by replacing T_t with their respective lump-sum taxs. All the other equations of the economy remain unchanged.

14. Notice that under a fully redistributive fiscal policy the values of the tax burden were 0.0318 and 0.3227 for the LC consumers and for the Ricardians, respectively, when $\lambda = 0.5$. Under fiscal leadership with a partially conservative monetary policy, with $\lambda = 0.5$, the tax burden is equal to 0.0324 and 0.3223 for the LC and the Ricardian household, respectively.

15. Analogously, optimal inflation volatility under a fiscal leadership with $\alpha = 0.5$ shows figures very similar to the ones we get under Nash. We also consider the case of a Nash game with a partially conservative monetary policy, and we find that results are unchanged with respect to the standard Nash game. The IRFs are shown in Figure A of the Online Appendix.

16. Figures are available upon request.

17. All IRFs not included in the paper are available upon request.

18. We thank an anonymous referee for suggesting an alternative experiment to simulate the crisis, which is presented in the Online Appendix (see Section 4.1 for details). In this case the fraction of LAMP reacts endogenously to a negative technology shock. We find that the results presented in Figures 10–12 remain mainly unchanged.

19. The IRFs under a fiscal leader regime with $\alpha = 0.5$ are identical to those obtained under Nash. Thus, we do not present the figure.

20. In this case, the IRFs under a fiscal leader regime with partially conservative monetary policy and those obtained under Nash are identical. Thus, we do not present this figure.

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