Policy Games, Distributional Conflicts and the Optimal Inflation.*

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Abstract

This paper shows that Limited Asset Market Participation generates an extra inflation bias when the fiscal and the monetary authority play strategically. A fully redistributive fiscal policy eliminates the extra inflation-bias, however, the latter is cancelled at the cost of reducing Ricardians' welfare. A fiscal authority which redistributes income only partially, reduces the inflation-bias, but rises Government spending. Despite 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 price stability cannot be ensured by Ramsey without redistribution.

Keywords: *liquidity constrained consumers, optimal monetary and fiscal policy, strategic interaction, inflation bias, redistribution.*

JEL codes: E3, E5, E62.

1 Introduction

The recent financial crisis lead 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 significant worsening of the conditions of access to credit and financial markets for both households and firms.

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In this paper we study the strategic interactions between monetary and fiscal policy in an otherwise standard New Keynesian model characterized by distributional conflicts due to limited asset market participation (LAMP henceforth) and we investigate on the optimal policy responses, in particular with respect to the optimal inflation. We model LAMP as it is now standard in the literature (see Galì et al. (2004), Bilbiie (2008), among others). We assume that a fraction of households does not hold any asset, thus is liquidity constrained and in each period consumes all its 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 agents) 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 take 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 a 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 face of positive technology shocks.

We find that the presence of liquidity constrained consumers (LC consumers henceforth) alters both the long-run and 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 LC consumers increases. The Central Bank annualized inflation target approaches 9% even for a fraction of non-Ricardian agents close to 30%. A value which is 50% higher than what found by Adam and Billi (2008) in a RAE model.[1] 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 RAE model (see for example Schmitt-Grohe and Uribe 2004, 2007 and 2010 among others). In these papers the optimal steady state inflation rate is often negative (i.e. the Friedman rule is always optimal) or approaches zero.[2] In our model the extra inflation bias arises because, as

[1] 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.

[2] In particular, Schmitt-Grohe 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 turns positive only in a model where the monopolistic distortion, i.e. firms markup, is very high and empirical unplausible. Instead, we find that the absense of commitment and the presence of LAMP is sufficient to ensure positive steady state inflation level even with moderate values of firms markup.

LAMP increases, per capita profits earned by Ricardians get higher and so does their consumption. The monopolistic distortion increases and 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 LC consumer the higher is the need to inflate the economy. In other words, the distributional conflict originated by the presence of the two types of consumers generates an extra inflation bias, which turns out to be necessary to push the economy toward its efficient level.

Turning to the optimal dynamics, again we show that LAMP plays an important role under the non-cooperative games. In particular, we find that under discretionary policies the optimal response of inflation to a positive technology shock is different from zero. Precisely, the impact response more than doubles for a fraction of non-Ricardian agents passing from zero to 50%. This last result holds also for the FL game with partially conservative monetary policy, i.e. when the Central Bank dislikes inflation more than society. Inflation volatility collapses to zero when monetary authority is fully conservative, i.e. when the Central Bank implements a strict inflation targeting policy.

In a second part of the paper we study the same policy games in presence of redistributive fiscal policies to see whether and to what extent these policies affect the extra inflation bias arisen 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 ii) a partially redistributive fiscal policy, where the authority chooses the amount of government spending and exogenously decides to tax less LC consumers. The analysis of the optimal steady state in these cases 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, while LC 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 an higher Government spending.[3] 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 LC consumers followed by a fall in productivity to simulate a crisis scenario. We find that none of the policy regimes

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

is able to avoid the fall down in economic activity. Importantly, we obtain that without redistribution price stability cannot be ensured by the Ramsey regime.

In recent years, many authors concentrated on the issue of consumers heterogeneity due to LAMP. They show that the presence of LC consumers alters the standard results on the dynamics of the New Keynesian model**.** For example, Galì et al. 2007 demonstrate that the presence of LC 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. Galì 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 Galì 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 it tackles redistributive issues. The only exception is Natvik (2012) which analyzes the effect of a government spending shocks with and without redistribution and shows that steady state inequality matters in explaining the short run dynamics.

Most of the literature which studies fiscal and monetary policy instead, assumes that they are both driven by a unique authority (Schmitt-Grohe and Uribe 2004a, 2004b, 2007 among others). This is clearly not the case nowadays 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 such a context it is then relevant to investigate the strategic interactions between the Central Bank and the fiscal authorities, as done by Gnocchi (2008), Beetsma and Jensen (2005), Adam and Billi (2008) among others. Gnocchi (2008) and Beetsma and Jensen (2005) focus on open economies and the role of fiscal policy stabilization. Gnocchi (2008) analyzes the effects of fiscal discretion in a currency area, where a common and independent monetary authority commits to optimally set the union-wide nominal interest rate. The main result is that discretion entails significant welfare costs so that it is not optimal to use fiscal policy as a stabilization tool. Instead, Beetsma and Jensen (2005) investigate the role of policy commitment in a micro-founded New-Keynesian model of a two-country monetary union, finding that monetary policy with identical union members is concerned with stabilizing the union-wide economy, fiscal policy aims at stabilizing inflation differences and the terms of trade. Finally, Adam and Billi (2008) concentrate on a

closed economy environment, studying monetary and fiscal policy games without commitment. They find that the lack of commitment gives rise to excessive public spending and positive optimal inflation rate in steady state. Moreover, in a context where the fiscal policy is determined before monetary policy, a monetary policy which only cares about inflation can eliminate these biases. Overall, all 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, LC consumers have assumed an increasingly relevant role in the economy, since 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 studying of 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 LC consumers and Ricardian consumers coexist.

The paper is organized as follows. Next section shows some evidence on the decline in households' asset market participation following the recent financial crisis. Section 3 introduces the model, while 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 recent tightening of credit standards

Since August 2007, starting date of the recent financial crisis, there has been a strong increase in credit constraints. Questions regarding bank solvency have caused not only an interbank credit crunch but also a decline in credit availability for both firms and households. The main factors contributing to the decline in credit availability were the bad expectations regarding general economic activity and housing market prospects as well as cost of funds and balance sheet constraints for banks.

In this section we show some empirical evidence on the decline of banking lending to households, for housing and other consumer credit, in the Euro area and in the US[4]. Figures 1 and 2 show the behavior

[4]Data for the euro area are taken from *The Euro Area Bank Lending Survey* of the European Central Bank. Data for the US are taken from the *Senior Loan Officer Opinion Survey on Bank Lending Practices* of the Federal Reserve Board.

of *credit standards* for the period 2003-2012.[5]

As shown in Figure 1 *credit standards* tightened in the Euro area since the first months of 2008. The tightening reached its maximum value in April 2009 and then started decreasing. Nevertheless, if we exclude the forth quarter of 2010 where no tightening were perceived, banks still report tightening in *credit standards* during the last years, which remain higher than in the pre-crisis period.

As shown in Figure 2, in the US the tightening of *credit standards* started in the mid of 2007, before the EU, and was even stronger than in the Euro area. These features of the US *credit standards* are not surprising since the financial crisis was triggered by a liquidity shortfall in the United States banking system at the beginning of the summer 2007, which afterwards spread all over the Euro area and most of the industrialized countries. Contrary to the Euro Area, the tightening partly reabsorbed after the first quarter of 2010. However, *credit standards* may not be back to pre-crisis levels, since the Survey refers to the perception of change in *credit standards* with respect to the previous three months. Thus, even an unchanged perception in *credit standards* indicates that they have remained high and close to the crisis level. Overall, the evidence on *credit standards* shows a sharp decline of credit to households since the beginning of the crisis.

3 The model

3.1 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; the remaining fraction λ are the so called 'liquidity constrained' *(LC)* 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 and rule for thumb consumers are then respectively:

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

[5] As reported in the Euro-Area Bank Lending Survey: "The responses to questions related to credit standards are analysed in this report by focusing on the difference ("net percentage") between the share of banks reporting that credit standards have been tightened and the share of banks reporting that they have been eased. A positive net percentage indicates that a larger proportion of banks have tightened credit standards ("net tightening"), whereas a negative net percentage indicates that a larger proportion of banks have eased credit standards ("net easing")." Roughly the same definition applies for the US.

where C_t^o, N_t^o are Ricardian consumer's consumption and hours worked, C_t^r, N_t^r are liquidity constrained consumer's consumption and hours worked and G_t is public expenditure. Utility is separable in C, N, G and $U_c > 0$, $U_{cc} < 0$, $U_n < 0$, $U_{nn} \leq 0$, $U_g > 0$, $U_{gg} < 0$.

Ricardians' budget constraint is:

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

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 in t and maturing in $t+1$, 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 of 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

[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 $\lim_{j\to\infty} E_t \beta^{t+j} {C_{t+j}^o}^{-\sigma} B_{t+j}/P_{t+j} = 0$ hold.

the two consumers get the same paid w_t. This leads to the following condition:

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

which equals the ratio between the marginal utilities of Ricardian and liquidity constrained consumers respectively.

The aggregate consumption and hours worked are defined as follows:

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

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

3.2 Firms

There is a continuum of intermediate goods, indexed by $i \in [0,1]$ and a sector of final good which uses the technology: $Y_t = \left[\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$. The sector of final good operates in perfect competition. Then profit maximization implies $Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} Y_t$, where ϵ represents the elasticity of substitution across varieties. P_t is defined as $P_t = \left[\int_0^1 P_t(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$. The intermediate good 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 AR(1) process:

$$z_t = \rho_z z_{t-1} + s_t^z. \tag{11}$$

$0 < \rho_z < 1$ and s_t^z is a normally distributed serially 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: $\frac{\theta}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2$, where θ is the degree of price rigidities.

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:

$$\max_{\{N_t(i),P_t(i)\}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{\gamma_t}{\gamma_0} \left\{ \frac{P_t(i)}{P_t} Y_t(i) - w_t N_t(i) - \frac{\theta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 \right\} \\ \text{s.t. } Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t = Z_t N_t(i) \ , \tag{12}$$

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

In 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:

$$w_t = mc_t Z_t \tag{13}$$

$$0 = [1 - (1 - mc_t)\epsilon] Y_t - \theta(\pi_t - 1)\pi_t + \theta\beta E_t \left(\frac{C_{t+1}^{o\,-\sigma}}{C_t^{o\,-\sigma}} \right) (\pi_{t+1} - 1)\pi_{t+1}. \tag{14}$$

Combining (13) with (3) and (6) yields to such an expression for the real marginal cost:

$$mc_t = \frac{1}{Z_t} (\lambda \omega_n N_t^{r\,\varphi} C_t^{r\,\sigma} + (1 - \lambda)\omega_n N_t^{o\,\varphi} C_t^{o\,\sigma}). \tag{15}$$

Then, we combine it with (14) and get:

$$C_t^{o\,-\sigma}(\pi_t - 1)\pi_t = \left[1 - \left(1 - \frac{\lambda \omega_n N_t^{r\,\varphi} C_t^{r\,\sigma} + (1 - \lambda)\omega_n N_t^{o\,\varphi} C_t^{o\,\sigma}}{Z_t} \right) \epsilon \right] \frac{Z_t N_t C_t^{o\,-\sigma}}{\theta} \\ + \beta E_t C_{t+1}^{o\,-\sigma} (\pi_{t+1} - 1)\pi_{t+1} \ . \tag{16}$$

3.3 Government

The government is composed by a monetary authority which sets the nominal interest rate R_t and a fiscal authority which determines the level of public expenditure G_t. The government runs a balanced budget, so that 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

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

is withdrawn from each individual ($T_t^r = T_t^o$), we obtain $G_t = T_t = T_t^r = T_t^o$.

3.4 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), (16) and (18), given the policies $\{G_t, T_t, R_t \geq 1\}$ and the exogenous process Z_t.

4 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 for 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, take 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 the appendix[8].

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, Ramsey solution corresponds to a second best allocation solving the following problem:

$$\begin{aligned} \max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t\}} & E_0 \sum_{t=0}^{\infty} \beta^t \left\{\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda)u(C_t^o, N_t^o, G_t)\right\} \\ & \text{s.t. (4), (5), (7), (16), (17), (18) for all t .} \end{aligned} \tag{19}$$

where constraints (4), (5), (7), (16), (17), (18) represent the equilibrium of the competitive economy.

Before introducing the structures of the policy games it is worth to notice that the competitive equilibrium of our model does not include any endogenous state variable. This happens because, as in

[8] The technical appendix is available on the authors' webpages.

Adam and Billi (2008) we consider: i) a cash-less 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. Since 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 modelling choice give us the opportunity to directly compare our results with those obtained by Adam and Billi (2008), by easily disentangling the role played by LC consumers.

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

Nash Game. In this case, policy makers do not cooperate and cannot commit, 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:

$$\begin{aligned} \max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, G_t\}} & E_t \sum_{t=0}^{\infty} \beta^t \left\{ \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \right\} \\ & \text{s.t. (4), (5), (7), (16), (17), (18) for all t} \\ & \{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j-1} \geq 1, G_{t+j}\} \text{ given for } j \geq 1 \ . \end{aligned} \tag{20}$$

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:

$$\begin{aligned} \max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} & E_t \sum_{t=0}^{\infty} \beta^t \left\{ \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \right\} \\ & \text{s.t. (4), (5), (7), (16), (17), (18) for all t} \\ & \{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j-1}\} \text{ given for } j \geq 1 \ . \end{aligned} \tag{21}$$

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). Then, 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), (16), (17), (18), *the FRF and the MRF.*

Fiscal Leadership game. As for the Nash game, policy makers cannot commit and 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, while the monetary authority is the Stackelberg follower.

The Stackelberg structure becomes relevant only when the utility functions of the monetary or the fiscal authority are different[9]. 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:

$$\begin{aligned} \max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{ (1-\alpha)[\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t)] - \alpha \frac{(\pi_t - 1)^2}{2} \right\} \\ \text{s.t. (4), (5), (7), (16), (17), (18) for all t} \\ \{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j-1}\} \text{ given for } j \geq 1 \ . \end{aligned} \tag{22}$$

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*. Instead, 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:

$$\begin{aligned} \max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{ \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \right\} \\ \text{s.t. (4), (5), (7), (16), (17), (18), FOCs of (22) for all t} \\ \{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j}\} \text{ given for } j \geq 1 \ . \end{aligned} \tag{23}$$

[9] We find that otherwise both the monetary leadership and the fiscal leadership in this case collapse to the Nash game. Results are available upon requests.

4.1 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 (16) we get the following:

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

which implies that the steady state real wage does not depend on the fraction of rule of thumb consumers. 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 calibrating parameters. From now on, we will refer to the calibration shown in Table 1 which is in line with Adam and Billi (2008).

The upper panel of Table 2 resumes the steady state values under Ramsey.[10] Notice that, we consider three alternative values for the fraction of LC consumers, that is $\lambda = (0; 0.3; 0.5)$. When $\lambda = 0$, our model nests the RAE model, which is used as a benchmark model. Empirical evidence on limited asset market participation found values in between 0.3 and 0.5. In particular, Campbell and Mankiw (1989) as well as 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%, while 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, while the steady state inflation rate is always equal to 1, no matter the value of λ, public spending reduces with λ increasing, even if 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. Liquidity constrained consumption slightly increases as λ becomes greater than 0.3 due to a small reduction of G. In fact, the steady state of the Government budget constraint implies $G = T = T^o = T^r$, 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, since 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

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

welfare when λ increases, because it rises 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. In our model, however, the inflation bias increases dramatically as the fraction of liquidity constrained households λ gets higher. 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 LC consumers is 0.5. The intuition is straightforward. The inflation bias arises because the monetary authority disregards private expectations on inflation. Limited asset market participation is an additional distortion in the economy with respect to the two usually faced by the Central Bank, i.e.: i) the monopolistic competition distortion; ii) the sticky price distortion. The first one reduces as the steady state inflation increases. This happens because the steady state inflation rate acts as an implicit tax on profits. On the contrary, 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. $D/(1-\lambda)$, get 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 LC consumers increases. Therefore, the optimal steady state inflation remains highly positive for empirically plausible values of the Rotemberg adjustment costs[11] and increases as λ gets higher.

Finally, we also find a government spending bias, as in the RAE. However, this bias is only marginally affected by LC consumers. This happens because the fiscal authority takes into account that an increase in public spending has two effects. First, government spending enters directly households' utility function. Therefore, an increase in spending increases welfare. Second, an increase in G, by implying higher taxes, reduces LC consumers disposable income and thus their consumption and welfare. This second effect does not concern Ricardian agents since they have an additional source of income represented by profits.

Fiscal Leader steady state. The third panel of Table 2 shows that the optimal steady state

[11] We consider also a value of θ alternative to the baseline value consider by Adam and Billi (2008). We translate the cost of adjusting prices into an equivalent Calvo probability, i.e. $\theta = \frac{\varepsilon-1}{\kappa}$, where $\kappa = \frac{(1-\psi)(1-\psi\beta)}{\psi}$ and $\psi = 0.75$ is the Calvo probability that firms do not adjust prices. This allows to generate a slope of the Phillips curve consistent with empirical and theoretical studies. We get a value of $\theta = 58$, which is more than three times higher than the one considered by Adam and Billi (2008). The results about the inflation bias remains relevant although the optimal steady state inflation slightly lowers.

values under the FL with a partially conservative monetary policy ($\alpha = 0.5$) change only marginally with respect to the Nash case.

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 (bottom panel of Table 5). 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 rise the interest rate to contain inflationary pressures. The fiscal policy maker benefits of 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 partially conservative Central Bank, the optimal monetary policy implies an inflation bias which strongly increases as the fraction of liquidity constrained consumers, λ, increases.*

4.2 The optimal steady state with redistributive fiscal policies

In the policy regimes considered sofar 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 $\left(TB^r = \frac{T^r}{WN^r}\right)$ is greater than the one of Ricardians $\left(TB^o = \frac{T^o}{WN^o + D^o}\right)$. It amounts to 21% of total income for liquidity constrained consumers and to 18% for Ricardians, for $\lambda = 0.5$ (see Table 3).

This rises a distributional conflict between the two 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 among 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; ii) a partial redistributive policy.

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, labeled as T_t^o and those paid by LC consumers, T_t^r. Since the fiscal authority has now 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 balance budget condition equation, $T_t = G_t$, holds and thus public expenditure G_t becomes endogenous.[12] Table 3 presents the steady state values for all the policy games.

Notice that for all games, the fully redistributive fiscal policy enables to control the insurgence of the inflation bias which remains at its respective RAE level no matter the fraction of liquidity constrained consumers. However, with respect to the economy with no redistribution, while LC consumers are better off, Ricardian are worse off in terms of welfare. Total welfare remains at its RAE level. Thus, the 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 with a higher amount of per capita taxes, which increases as the fraction of liquidity constrained consumers increases. The reason for the latter result is the following. Ricardians have an additional form of income with respect to liquidity constrained consumers represented by profits. Since 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 Ricardian with higher taxes in order to restore equity as λ gets higher. In particular, under Ramsey and the FL game with fully conservative monetary policy (both cases characterized by full price stability), the higher 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 stronger 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.[13]

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

[12] The budget constraint of the two consumers is rewritten by substituting T_t with their respective lump-sum tax. All the other equations of the economy remain unchanged.

[13] As for the economy with no redistribution, since results change only marginally from the fiscal leadership game, we do not show the steady state results of the Nash game with a conservative monetary policy and those of the monetary leader. Results are available upon request.

Partially redistributive Fiscal Policy

We now consider a Fiscal Policy which 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 which are reluctant, for example for electoral reasons, to fully redistribute income. In both cases the Fiscal authority may be in favour of a partial redistributive scheme instead of a fully redistributive one. Following this idea, we assume that the Fiscal authority controls spending and redistribute a lower fraction of income from Ricardians to LC 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 at which $\delta < \lambda$ the monetary authority taxes LC consumers less than Ricardian, and thus its policy is redistributive in favor of LC 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.[14] In particular, as shown in Table 3, with $\delta = 0.3$ and $\lambda = 0.5$, the tax burden of the LC household in steady state is 14%, while that of Ricardian households is 26% under Nash.[15] The latter is a value very close to the tax burden of the US 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 than what we obtained without redistribution policies. Similar results hold for the FL regime with partial 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

[14] Results with different values of δ are available upon request.

[15] Notice that under a fully redistributive fiscal policies 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 partial 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.

reason is the following. Ceteris paribus, an increase in government expenditure does not imply a one to one reduction in LC disposable income, with a partial redistributive fiscal policy. Consequently, LC consumption is higher than that occurring under both a non redistributive fiscal policy and a fully redistributive one. Thus, with partial redistribution the fiscal authority has a stronger incentive in rising government spending. The government spending is higher under the Nash game and the FL game with partially conservative monetary policy. 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 partial redistributive fiscal policy. Thus we can state that a partial redistributive fiscal policy, while reducing the inflation bias, generates an extra government spending bias under discretionary policies. Finally, as expected, Ricardians are always better off than under a fully redistributive policy, while they are worse off with respect to the welfare they can afford with no redistributive fiscal policies. Total welfare is slightly higher than that of the RAE economy.

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. While total welfare remains at its RAE level, LC consumers are better off and Ricardians experience a loss of welfare. A partial redistributive policy reduces the extra inflation bias, but causes a higher government spending bias.*

4.3 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 will allow to compare IRFs to a productivity shocks with those already presented in the literature in RAE model.

Ramsey dynamics. We analyze the model dynamics in the case of Ramsey optimum through impulse response functions (IRFs henceforth). We look at the optimal dynamics in response to a positive technology.

Figure 3 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 feature price stability and a persistent increase of aggregate output, no matter the value of λ.

Moreover, as shown in Figure 5, 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 recent US evidence (see, for example, Galì and Rabanal, 2004). The inflation bias increases as λ increases, while the reduction in labor hours gets higher. The intuition for these results is the following. The monetary policy is not forward looking, it 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 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 double when passing from $\lambda = 0$ to $\lambda = 0.5$. This happens because the monetary authority is aimed 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 5 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.[16] Figures 6 shows the IRFs to a technology shock.

When $\alpha = 1$ Figure 7 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, while

[16] Analogously, optimal inflation volatility under a Fiscal leadership with $\alpha = 0.5$ show very similar figures to the ones we get under Nash.

under FL with $\alpha = 1$ the optimal inflation volatility is always zero as under Ramsey.[17]

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

Result 3. *Under the Nash game and the FL game with partially conservative Central Bank, in response to a technology shock the inflation bias gets dramatically higher as λ increases.*

4.4 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 below, the responses under full redistribution lead to the RAE responses no matter 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 previous section.

Nash and Fiscal Leadership with partially conservative monetary policy. Figure 8 collects the impulse response functions obtained under Nash, comparing redistribution policies to the no redistribution case analyzed in the previous section. We present impulse response functions only for the Nash game, as the FL with 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 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 LC agents increase less to support their consumption. Finally, notice that LC consumers highly reduce the amount of hours worked in the full redistribution case, while the latter remain almost unchanged under a partially redistributive fiscal policy.

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.[18]

The main finding of this section is the following.

[17] Figures are available upon request.

[18] All impulse response functions not included in the paper are availble upon request.

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

4.5 A crisis scenario and the optimal policies

In this section our intention is to simulate a financial crisis scenario. One way of modelling the crisis in our model would be through an unanticipated and temporary increase in the fraction of LC consumers, accompanied by a fall in productivity, Z_t.[19] 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 LC consumers, accompanied by a fall in productivity, Z_t. In this context, the fraction of LC consumers λ becomes an exogenous variable. In particular, we assume that

$$\ln(\lambda_t/\lambda) = \rho_\lambda \ln(\lambda_t/\lambda) + \varepsilon_t^\lambda, \tag{26}$$

which is an exogenous AR(1) process, with $\varepsilon_t^\lambda \sim WN\left(0, \sigma_\lambda^2\right)$. Further, we assume that the shock to λ and the productivity shock are negatively correlated, with the contemporaneous correlation equal to $\rho_{z,\lambda} = -0.1$. This will allow to capture the possibility of having a negative financial shock accompanied by an unexpected reduction in productivity.

A crisis scenario with no redistributive Fiscal Policies

Figures 9-11 present the IRFs under the different policy regimes, respectively Ramsey, Nash and the FL with fully conservative monetary policy.[20]

As shown in the figures, when the fiscal authority makes no redistribution the increase in the fraction of LC consumers accompanied by a reduction in productivity is always followed by a strong reduction in consumption of both Ricardian and LC consumers. Hours worked of both consumers fall as well and so does the aggregate output. Differently from what stated in the previous 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

[19] We thank an anonymous referee for suggesting this kind of experiment to simulate the crisis.

[20] The IRFs under a Fiscal Leader regime with $\alpha = 0.5$ are indentical to those obtained under Nash. Thus, we do not present the figure.

is completely stabilized. However, inflation stabilization is obtained at the cost of an higher decrease in output. Finally, notice that, while the Nash game implies an higher increase in inflation than under Ramsey, the fall in output is almost identical to that obtained under the latter game.

A crisis scenario with fully redistributive Fiscal Policies

Figures 9-11 present also the IRFs under Ramsey, Nash and FL with fully conservative monetary policy respectively with full redistribution (dashed lines).[21] 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 of 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 coincides with Ramsey responses.

The main finding of this section is the following.

Result 5. *Under a crisis scenario, none of the policy regimes is able to avoid the fall down in output. In the case of non redistributive fiscal policies, the Ramsey regime cannot ensure price stability, only the FL regime with fully conservative monetary policy can guarantee inflation stabilization.*

5 Welfare analysis

In this section we show a measure for the utility losses associated to a particular game structure. We calculate the percent loss of each game structure with respect to the Social Planner stochastic steady state. Denote $V^{SP} = [\lambda u(C^r, N^r, G) + (1-\lambda)u(C^o, N^o, G)]/(1-\beta)$ 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, $\mu^A \leq 0$ (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 solving for μ^A the following expression:

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

[21] In this case, the IRFs under a Fiscal Leader regime with partial conservative monetary policy and those obtained under Nash are indentical. Thus, we do not present this figure.

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

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

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 LC consumers (with $\lambda = 0.3, 0.5$) for each policy regime without redistribution and distinguishing between total, Ricardians' and LC 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 which is not only considerably larger than in Ramsey (as well as in FL game with fully conservative monetary policy) but also slightly bigger than the FL case with 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 LC consumers while Ricardians experience a gain and this holds for all policy setups considered. Moreover, while LC losses remains almost unchanged in percentage terms, Ricardians' gains are significantly lower in the Nash game and FL game with partially conservative monetary. Again, this is due to the inflation bias arising with discretion, which dampens Ricardians' profits and thus their consumption and welfare.

Turning the 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 minimize 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 favour of LC 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 LC consumers, which are also due to the high tax burden faced by these consumers, a full redistributive fiscal policy may be preferred whenever the fiscal authority aims at reducing the distributional conflict. As shown in Table 4, this policy is able to considerably reduce LC losses at the expenses of Ricardians. Under Nash and FL with partially conservative monetary policy, LC consumer even get a welfare gain while Ricardians' experience a loss in consumption. However, these losses are smaller than the ones experienced by LC consumers under no redistribution.

A partial redistributive fiscal policy is able to reduce total losses with respect to a non redistributive fiscal policy and this implies a huge reduction of losses for LC 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 lower reduction of their gain than that they would get under Nash and a FL game with partially conservative monetary policy. Nevertheless, the welfare gain with respect to the first best remains higher under Ramsey and under a FL game with a fully conservative monetary policy.

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

Finally, despite a fully conservative monetary policy is necessary to get price stability, it implies a very strong reduction in LC 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 together with a fully conservative monetary policy is needed to restore 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 in order to restore both efficiency and equity.*

6 Conclusions

In this paper we investigate the effects of LAMP on policy responses, in particular with respect to the optimal inflation, both in the long-run and in the short run. We compare our results to those obtained in a RAE model and to 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 LC consumers increases. A fully redistributive fiscal authority eliminates the extra inflation biases

created by LAMP, however the latter is cancelled out at the cost of strongly reducing Ricardians' welfare in terms of consumption equivalent. Partial redistributive fiscal policies reduce the extra inflation bias, but they give rise to a strong Government spending bias.

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

Finally, we find that under a financial crisis scenario the Ramsey regime is not anymore able to ensure price stability without redistribution, and only the FL regime with 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. Above all the balance 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 to allow us to easily find the solution of the model 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.

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7 Figures and Tables

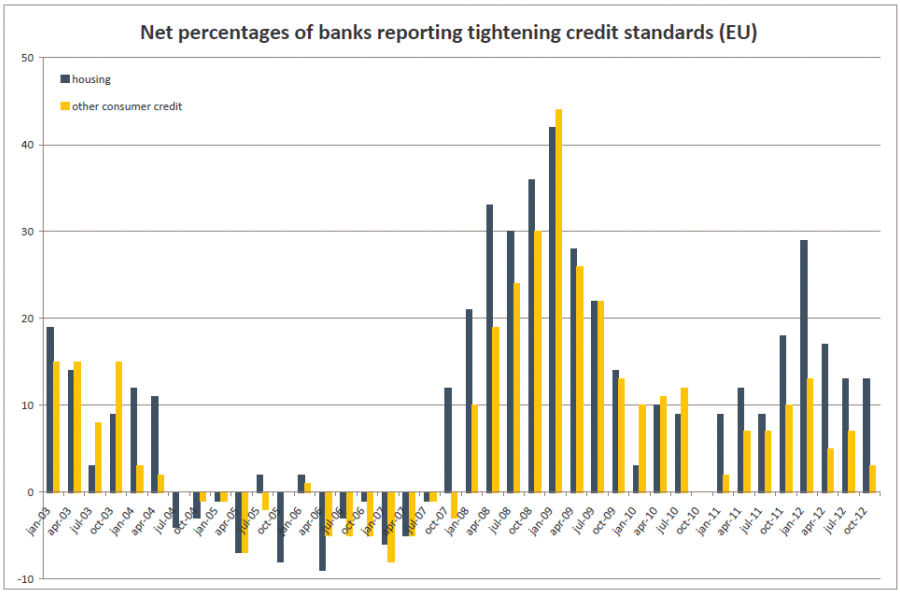

Fig. 1. Credit standards in the EU economy.

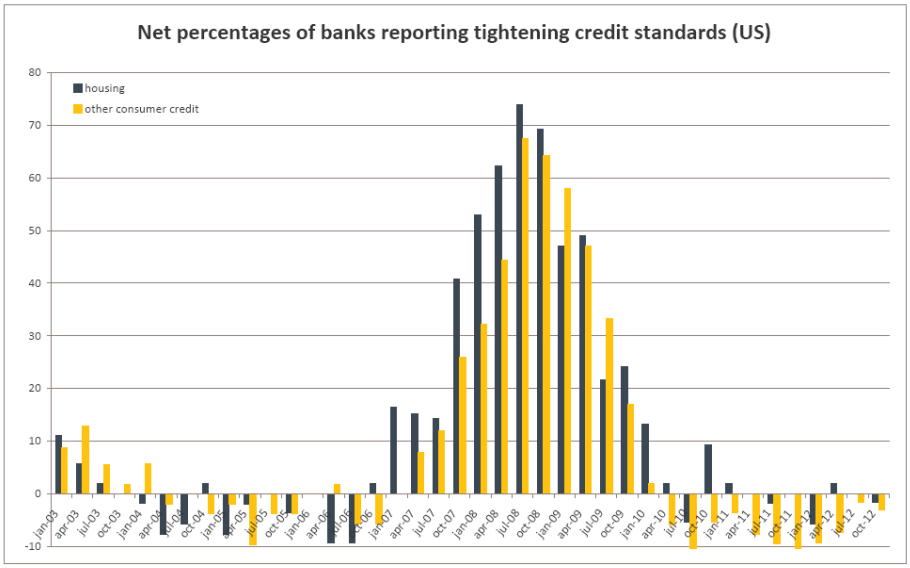

Fig. 2. Credit standards in the US economy.

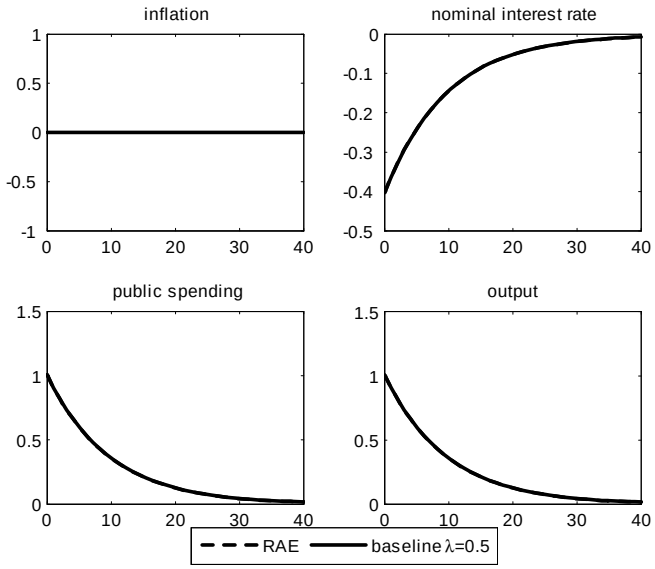

Fig. 3. Ramsey IRFs to a 1% positive technology shock under the baseline model and the RAE model.

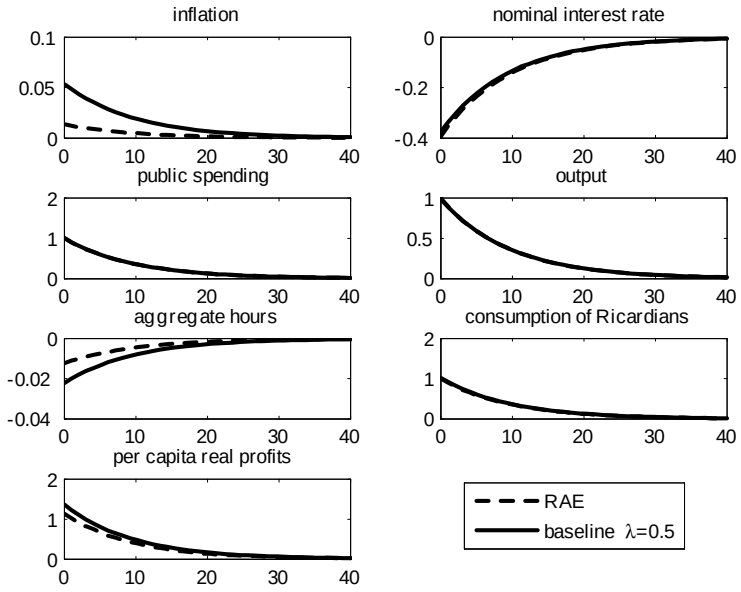

Fig. 4. Nash IRFs in response to a 1% positive technology shock under the baseline model and the RAE model.

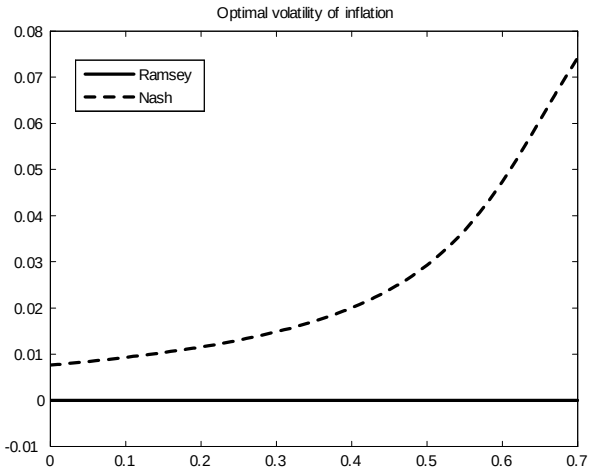

Fig. 5. Optimal inflation volatility under Ramsey and under Nash

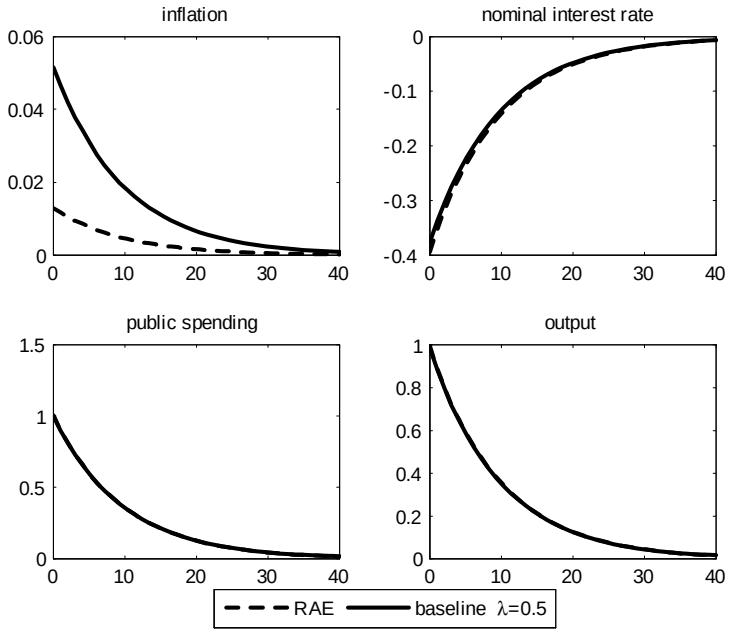

Fig. 6. IRFs to a 1% positive technology shock with Fiscal Leadership and partially conservative monetary policy under the baseline model and the RAE model.

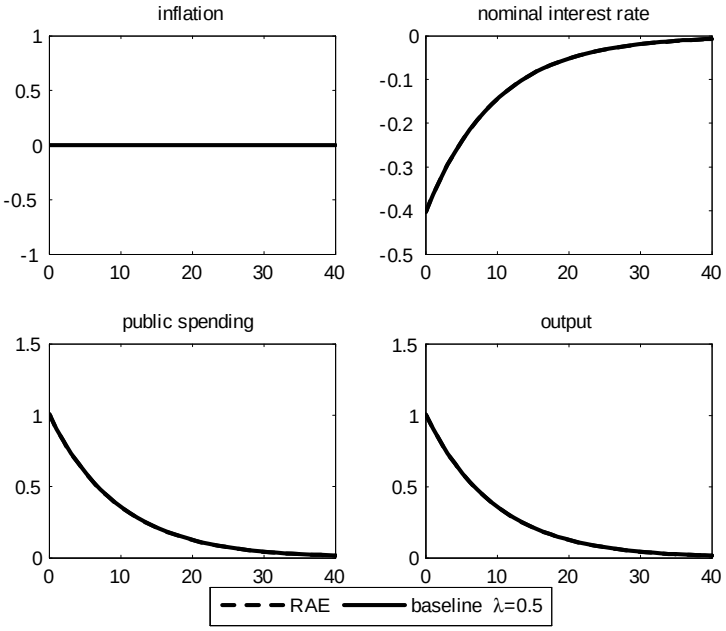

Fig. 7. IRFs to a 1% positive technology shock with Fiscal Leadership and fully conservative monetary policy under the baseline model and the RAE model.

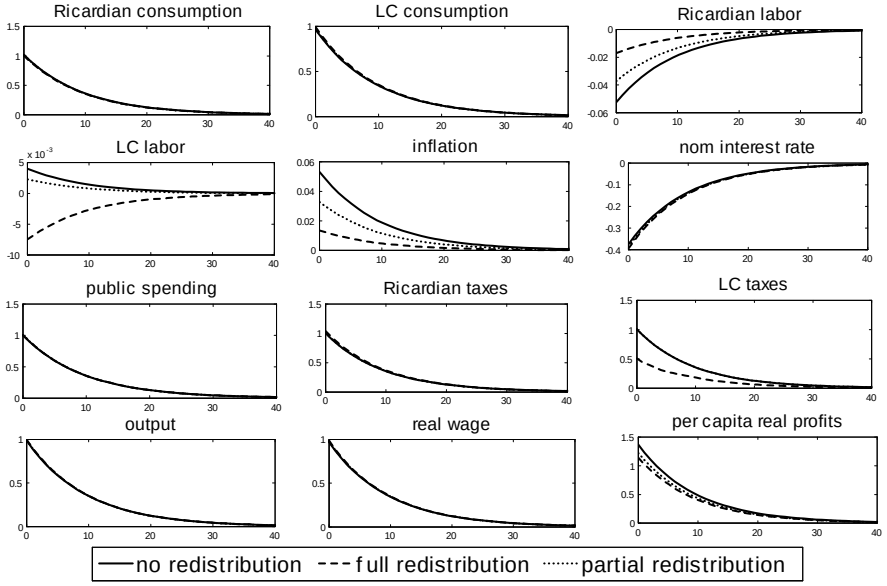

Fig. 8. Nash. IRFs to a Positive Technology shock with redistributive fiscal policies.

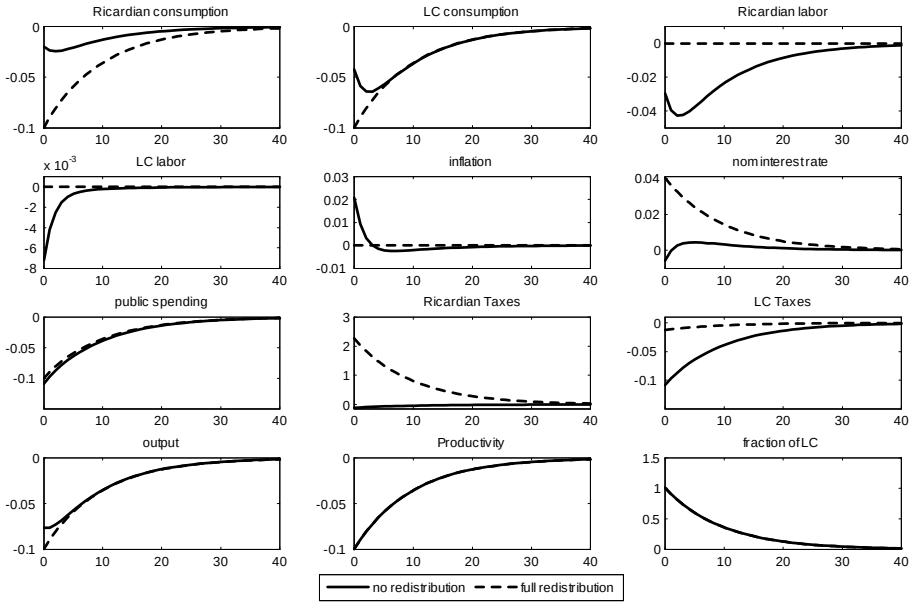

Fig. 9. Ramsey. IRFs to a Positive shock to λ accompanied by a reduction in productivity.

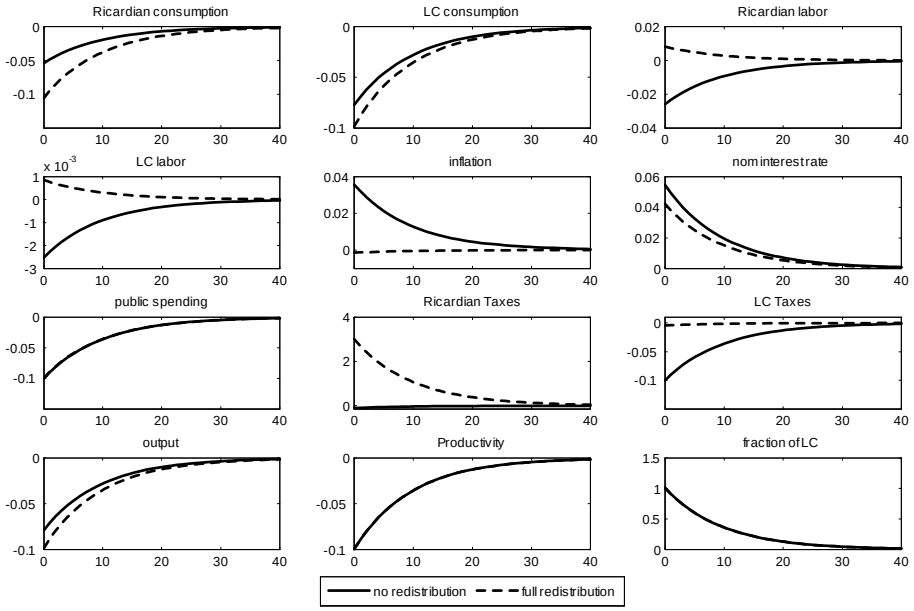

Fig.10. Nash. IRFs to a Positive shock to λ accompanied by a reduction in productivity.

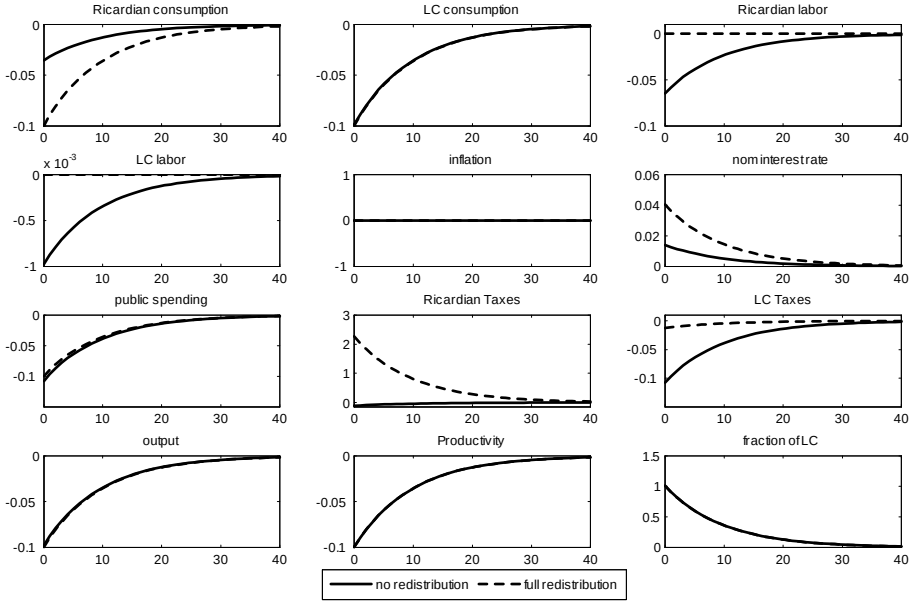

Fig.11. Fiscal Leadership ($\alpha = 1$). IRFs to a Positive shock to λ accompanied by a reduction in productivity.

parameters	value	source
β	0.9913	Adam and Billi (2008)
θ	17.5	Adam and Billi (2008) and Schmitt-Grohé and Uribe (2007)
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 Galì 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 Galì et al. (2004)
λ (dynamics)	0.5	Campbell and Mankiw (1989) and Galì et al. (2004)
ρ_z	0.9	
σ_z	0.01	
ρ_λ	0.9	
σ_λ	0.01	

Table 1: Calibration

	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

Table 2: Stochastic steady state under no 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

Table 3: 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						
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

Table 4: Welfare losses in consumption equivalents (in percentage terms)