Policy Games with Liquidity Constrained Consumers*

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October 2011

Abstract

In the light of the recent financial crisis, we investigate the effects generated by limited asset market participation on optimal monetary and fiscal policy, where monetary and fiscal authority are independent and play strategically. We find that limited asset market participation strongly affects the optimal steady state and the optimal dynamics of the different policy regimes considered. In particular: (i) both in the long run and in short run equilibrium, a greater inflation bias is optimal than in the standard representative agent economy; (ii) in response to a markup shock, fiscal policy becomes more active as the fraction of liquidity constrained agents increases; (iii) optimal discretionary policies imply welfare losses for Ricardian, while liquidity constrained consumers experience welfare gains with respect to Ramsey.

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

JEL codes: E3, E5.

1 Introduction

In this paper we study the strategic interactions between monetary and fiscal policy in an otherwise standard New Keynesian model characterized by limited asset market participation (LAMP henceforth). We model LAMP as it is now standard in the literature (see

*We thank Guido Ascari for helpful comments and directions. We also thank Evi Pappa and Stefano Gnocchi together with the seminar participants at Universitat Autonoma de Barcelona and University of Pavia. The paper has also benefited from comments of participants at the Money, Macro and Finance Conference 2010. The authors thank the Foundation Alma Mater Ticinensis for financial support through the research grant "Promuovere la ricerca d'eccellenza".

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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 game with conservative monetary policy. In both 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 doing this, we first analyze the steady state properties of each policy game, then we look at the dynamics of the model showing the optimal impulse response functions in face of positive technology and negative price markup shocks.

We find that the presence of liquidity constrained consumers alters both the long-run and short run properties characterizing the policy games of a RAE. Regarding the steady state properties, we find that under Ramsey the optimal steady state implies price stability no matter the fraction of liquidity constrained consumers. On the contrary, when the two policy authorities do not cooperate and cannot commit an inflation bias arises and it increases dramatically as the fraction of liquidity constrained consumers increases. The Central Bank annualized inflation target approaches 9% even for a fraction of non-Ricardian agents close to 30%. In the standard representative agent economy a small inflation bias arises because the monetary authority disregards private expectations on inflation. 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. In our model we have an additional source of inflation bias coming from the increase in the monopolistic distortion which occurs as the fraction of liquidity constrained consumers gets higher. Indeed, as limited asset market participation increases, per capita profits earned by Ricardians get higher, 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 liquidity constrained consumer the higher is the need to inflate the economy.

Turning to the optimal dynamics, we show that LAMP plays an important role not only under Nash and under the Fiscal leadership regime, but also under Ramsey. In particular, we find the following. First, under Ramsey, the optimal responses to a markup shock imply deviation from price stability and a positive public spending. However, differently from the RAE, in the presence of LAMP deviation from price stability is achieved through a small reduction of the nominal interest rate, which leaves the real rate almost unchanged. Second, under discretionary policies the optimal inflation volatility is different from zero in response to both shocks. In particular, it more than doubles in response to a technology shock for a fraction of non-Ricardian agents passing from

zero to 50%. Moreover, in response to a markup shock the optimal fiscal policy gets more aggressive the higher the fraction of households who cannot access financial markets. This last result holds for every policy regimes under analysis, suggesting the need of a more active role for the fiscal authority.

Finally, we find that the occurrence of the inflation bias has important implications also for welfare. In fact, it leads to a great loss of welfare for Ricardians with respect to Ramsey. At the same time, the higher real wage makes liquidity constrained consumers consume more and, as a consequence, increase their welfare with respect to Ramsey. Thus, contrary to what happens to Ricardian consumers, when the policy authorities are independent and cannot commit liquidity constrained agents get a welfare gain with respect to Ramsey.

In recent years, many authors concentrated on the issue of heterogeneity of consumers. In particular, they considered the presence of a fraction of consumers which are liquidity constrained, so that the Ricardian equivalence does not hold anymore. This feature brought different results on the dynamics of the economic system with respect to the standard framework. For example, Galì et al. 2007 demonstrate that the presence of liquidity constrained consumers can explain consumption crowding in, which follows an increase in government spending. Bilbiie (2008) shows that limited asset market participation 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. To the best of our knowledge however, the literature on LAMP does not analyze the strategic interaction between monetary and fiscal policy.

Most of the literature which studies fiscal and monetary policy 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.

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, liquidity constrained consumers have assumed an increasingly relevant role in the economy, since after the recent financial crisis the conditions of access to financial markets worsened. At the same time, both monetary and fiscal policies took prompt actions to prevent the economy from falling apart. Therefore, the recent events fostered the theoretical studying of optimal monetary and fiscal policy mix in models characterized by limited asset market participation.

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. 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. The trigger of the crisis was the housing bubble burst in the US, which affected deeply the financial market and the international banking system. The direct consequences of these facts were liquidity shortage and stock markets downturns. Many financial institutions collapsed around the world, contributing to the failure of key businesses, declines in consumer wealth and a significant decline in economic activity. 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[1]. Figures 1 and 2 show the behavior of credit standards for the period 2003-2010.

[1]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.

- Figures 1 and 2 about here -

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, in December 2009, the tightening was still higher than in the pre-crisis period. The US credit standards feature a very similar behavior. However, as shown in Figure 2 the tightening of credit standards started in the mid of 2007, before the EU. Moreover, the tightening 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.

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' 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:

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

and

$$u(C_t^r, N_t^r, G_t) = \frac{C_t^{r\,1-\sigma}}{1-\sigma} - \omega_n \frac{N_t^{r\,1+\varphi}}{1+\varphi} + \omega_g \frac{{G_t}^{1-\sigma}}{1-\sigma}\ , \tag{2}$$

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:

$$P_t C_t^o + \frac{B_t}{1-\lambda} = R_{t-1}\frac{B_{t-1}}{1-\lambda} + P_t w_t N_t^o - P_t T_t^o + \frac{D_t}{1-\lambda}\ , \tag{3}$$

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 $E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^o, N_t^o, G_t)$ subject to (3), taking as given $\{P_t, w_t, R_t, G_t, T_t, D_t\}$.[2] From the first order condition we get:

$$w_t = \frac{\omega_n N_t^{o\varphi}}{C_t^{o-\sigma}} \tag{4}$$

and

$$\frac{C_t^{o-\sigma}}{R_t} = \beta E_t \frac{{C_{t+1}^o}^{-\sigma}}{\pi_{t+1}} \ . \tag{5}$$

Liquidity constrained consumers each period solve a static problem: they maximize their period utility (2) subject to the constraint that all their disposable income is consumed:

$$P_t C_t^r = P_t w_t N_t^r - P_t T_t^r \ . \tag{6}$$

From the first order conditions we get:

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

As we will explain later in the paper, firms are indifferent with respect to the type of consumer to hire, therefore labor is homogenous and the two consumers get the same paid w_t. This leads to the following condition:

$$\frac{\omega_n N_t^{o\varphi}}{C_t^{o-\sigma}} = \frac{\omega_n N_t^{r\varphi}}{C_t^{r-\sigma}} \ , \tag{8}$$

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:

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

$$N_t = \lambda N_t^r + (1-\lambda) N_t^o \ . \tag{10}$$

[2] 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.

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 following technology:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\epsilon_t - 1}{\epsilon_t}} dj \right]^{\frac{\epsilon_t}{\epsilon_t - 1}} . \tag{11}$$

The sector of final good operates in perfect competition. Then profit maximization implies $Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon_t} Y_t$, where ϵ_t represents the elasticity of substitution across varieties and is assumed to be an AR(1) process $\log(\epsilon_t/\epsilon) = \rho_\epsilon \log(\epsilon_{t-1}/\epsilon) + s_t^\epsilon$, with $0 < \rho_\epsilon < 1$ and s_t^ϵ normally distributed innovation with zero mean and standard deviation σ_ϵ. ϵ_t is time-varying, thus induces fluctuations in the monopolistic markup charged by firms. P_t is defined as follows:

$$P_t = \left[\int_0^1 P_t(i)^{1-\epsilon_t} di \right]^{\frac{1}{1-\epsilon_t}} . \tag{12}$$

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:

$$Y_t(i) = Z_t N_t(i) , \tag{13}$$

where $log(Z_t/Z) = z_t$ is an aggregate productivity shock with AR(1) process:

$$z_t = \rho_z z_{t-1} + s_t^z . \tag{14}$$

$0 < \rho_z < 1$ 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:

$$\frac{\theta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 , \tag{15}$$

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:

$$\max_{\{N_t(i),P_t(i)\}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{\gamma_t}{\gamma_0} \left\{ \frac{P_t(i)}{P_t} Y_t(i) - w_t N_t(i) - \frac{\theta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 \right\} \\ \text{s.t. } Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon_t} Y_t = Z_t N_t(i) \ , \tag{16}$$

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 first order condition are:

$$w_t = mc_t Z_t \tag{17}$$

$$0 = [1 - (1 - mc_t)\epsilon_t] Y_t - \theta(\pi_t - 1)\pi_t + \theta\beta E_t \left(\frac{{C_{t+1}^o}^{-\sigma}}{C_t^{o-\sigma}} \right) (\pi_{t+1} - 1)\pi_{t+1} \ . \tag{18}$$

Combining (17) with (4) and (7) yields to such an expression for the real marginal cost:

$$mc_t = \frac{1}{Z_t} (\lambda \omega_n N_t^{r\varphi} C_t^{r\sigma} + (1 - \lambda)\omega_n N_t^{o\varphi} C_t^{o\sigma}) \ . \tag{19}$$

Then, we combine it with (18) and get:

$$C_t^{o-\sigma}(\pi_t - 1)\pi_t = \left[1 - \left(1 - \frac{\lambda \omega_n N_t^{r\varphi} C_t^{r\sigma} + (1 - \lambda)\omega_n N_t^{o\varphi} C_t^{o\sigma}}{Z_t} \right) \epsilon_t \right] \frac{Z_t N_t C_t^{o-\sigma}}{\theta} \\ + \beta E_t {C_{t+1}^o}^{-\sigma} (\pi_{t+1} - 1)\pi_{t+1} \ . \tag{20}$$

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[3].

$$P_t G_t = P_t T_t \ . \tag{21}$$

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 $G_t = T_t = T_t^r = T_t^o$.

[3] 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.

3.4 Equilibrium

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

$$Z_t[\lambda N_t^r + (1-\lambda)N_t^o] = \lambda C_t^r + (1-\lambda)C_t^o + G_t + \frac{\theta}{2}(\pi_t - 1)^2 \ . \tag{22}$$

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 (5), (6), (8), (20) and (22), given the policies $\{G_t, T_t, R_t \geq 1\}$ and the exogenous processes ϵ_t, 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 Fiscal Leadership game. In both cases, the two authorities cannot commit, take their decisions separately and period by period. It follows that their behavior is suboptimal because they fail to fully internalize the welfare cost of generating inflation.

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:

$$\begin{aligned} \max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t\}} & E_0 \sum_{t=0}^{\infty} \beta^t \left\{\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda)u(C_t^o, N_t^o, G_t)\right\} \\ & \text{s.t. (5), (6), (8), (20), (21), (22) for all t .} \end{aligned} \tag{23}$$

where constraints (5), (6), (8), (20), (21), (22) represent the equilibrium of the competitive economy.

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:

$$\begin{aligned}\max_{\{C_t^r,N_t^r,C_t^o,N_t^o,\pi_t,G_t\}} & E_t\sum_{t=0}^{\infty}\beta^t\left\{\lambda u(C_t^r,N_t^r,G_t)+(1-\lambda)u(C_t^o,N_t^o,G_t)\right\}\\ & \text{s.t. (5), (6), (8), (20), (21), (22) for all t}\\ & \{C_{t+j}^r,C_{t+j}^o,N_{t+j}^r,N_{t+j}^o,\pi_{t+j},R_{t+j-1}\geq 1,G_{t+j}\}\text{ given for } j\geq 1\ .\end{aligned} \tag{24}$$

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:

$$\begin{aligned}\max_{\{C_t^r,N_t^r,C_t^o,N_t^o,\pi_t,R_t\}} & E_t\sum_{t=0}^{\infty}\beta^t\left\{\lambda u(C_t^r,N_t^r,G_t)+(1-\lambda)u(C_t^o,N_t^o,G_t)\right\}\\ & \text{s.t. (5), (6), (8), (20), (21), (22) for all t}\\ & \{C_{t+j}^r,C_{t+j}^o,N_{t+j}^r,N_{t+j}^o,\pi_{t+j},R_{t+j}\geq 1,G_{t+j-1}\}\text{ given for } j\geq 1\ .\end{aligned} \tag{25}$$

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 Markov-perfect Nash equilibrium with sequential monetary and fiscal policy consists of the following time-invariant policy functions* $C^r\{Z_t,\epsilon_t\}$, $C^o\{Z_t,\epsilon_t\}$, $N^r\{Z_t,\epsilon_t\}$, $N^o\{Z_t,\epsilon_t\}$, $\pi\{Z_t,\epsilon_t\}$, $R\{Z_t,\epsilon_t\}$, $G\{Z_t,\epsilon_t\}$ *solving equations* (5), (6), (8), (20), (21), (22)*, 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[4]. Thus, we assume that the monetary authority is more inflation adverse than society, as in Adam and Billi (2008). For this reason, the objective function of the monetary policy maker is a weighted sum of agents' utility and a cost of inflation. The monetary authority now solves the following:

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

$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{ (1-\alpha)[\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t)] - \alpha \frac{(\pi_t - 1)^2}{2} \right\}$$
$$\text{s.t. (5), (6), (8), (20), (21), (22) for all t}$$
$$\{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j-1}\} \text{ given for } j \geq 1 \ . \tag{26}$$

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*. We may think that a conservative monetary authority is closer to the ECB's mandate of maintaining price stability. 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 (26). The fiscal policy problem at time t is thus given by:

$$\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left\{ \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \right\}$$
$$\text{s.t. (5), (6), (8), (20), (21), (22), FOCs of (26) for all t} \tag{27}$$
$$\{C_{t+j}^r, C_{t+j}^o, N_{t+j}^r, N_{t+j}^o, \pi_{t+j}, R_{t+j} \geq 1, G_{t+j}\} \text{ given for } j \geq 1 \ .$$

4.1 Policy regimes and 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 (20) we get the following:

$$w = \left[\lambda \frac{\omega_n N^{r\varphi}}{C^{r-\sigma}} + (1-\lambda) \frac{\omega_n N^{o\varphi}}{C^{o-\sigma}} \right] = \frac{\epsilon - 1}{\epsilon} \tag{28}$$

which implies that the steady state real wage does not depend on the fraction of rule of thumb consumers. Equation (28) 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). Table 2 resumes the steady state values under Ramsey. Notice that our model nests the RAE model for $\lambda = 0$, which is used as a benchmark model. 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 (6) 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 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. In Table 3 these values are collected.
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, 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%. The intuition is straightforward. The inflation bias arises because the monetary authority disregards private expectations on inflation. Further, 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 seems to prevail and becomes more and more relevant as the fraction of liquidity constrained consumers increases. Therefore, the optimal steady state inflation remains highly positive for empirically plausible values of the Rotemberg adjustment costs[5] and increases as λ gets higher.[6]

[5] 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.

[6] Schmitt-Grohe and Uribe (2004a) study optimal Ramsey monetary and fiscal policy in a NK model with sticky price à la Rotemberg (1982) and 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.

Finally, we also find a government spending bias, as in the RAE. However, this bias is only marginally affected by liquidity constrained 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 liquidity constrained disposable income and thus their consumption and welfare.

Fiscal Leader steady state. Table 4 shows that the optimal steady state values under the Fiscal Leadership with a partially conservative monetary policy ($\alpha = 0.5$) change only marginally with respect to the Nash case.

As expected, when $\alpha = 1$, meaning that the monetary authority only cares about inflation, the Fiscal Leadership leads to the Ramsey steady state (see 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 Fiscal Leadership 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 Policy regimes and the optimal dynamics

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 and to a negative markup shock.

- Figure 3 and 4 about here -

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

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.

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.

In response to a negative price markup shock we get different results. Figure 4 shows the effects of a 1% increase in the elasticity of substitution among intermediate goods (which implies a reduction in firms markup) to the main macroeconomic variables. The optimal IRFs to a markup shock imply deviation from price stability, a positive public spending and an increase in output. Deviation from price stability seems moderately affected by LAMP. However, differently from the RAE model, it is achieved through a small reduction of the nominal interest rate, which leaves the real rate almost unchanged. Interestingly, public spending instead increases as the fraction of liquidity constrained agents gets higher. Furthermore, the response on impact of public spending is significantly higher (in absolute value) and the effect of the shock is reabsorbed after more periods than in the benchmark model. Summing up, an increasing boost to public expenditure and a greater reduction in interest rates are needed to sustain welfare as λ increases.

The effects of λ on inflation and government spending dynamics are emphasized in Figures 5 and 6, which show the optimal inflation volatility and the optimal government spending volatility for $\lambda \in (0, 0.7)$ in face of technology and markup shocks. We find that, optimal inflation volatility increases with λ, while optimal government spending volatility is only moderately affected by the fraction of liquidity constraint consumers.

- Figure 5 and 6 about here -

Nash dynamics. Under Nash some differences emerge with respect to Ramsey dynamics. Figure 7 depicts the optimal deviations from the steady state of the main macroeconomic variables in response to a persistent technology shock and markup shock, for $\lambda = 0$ (dashed lines) and $\lambda = 0.5$ (solid lines).

- Figure 7 and 8 about here -

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.

The IRFs relative to the markup shock are represented in Figure 8. The fiscal policy responds by reducing G_t on impact while monetary policy maker decreases the interest rate. The presence of liquidity constrained consumers ($\lambda = 0.5$) involve a greater reaction of policy decision variables and consequently a greater impact on private sector variables.

Liquidity constrained consumption rises due to the huge reduction of public spending and the expansive monetary policy pushes C_t^o up. This puts pressure on the reduction of hours worked and consequently of output. In particular, as λ increases the stronger reactions of policy makers cause consumption of both types of consumers to rise more and consequently labor supply to decrease. When $\lambda = 0$ the impact effect on hours and output is positive: the greater increase of real wages and the lower rise of consumption cause labor supply to augment

Figures 9 and 10 show the optimal inflation volatility and the optimal government spending volatility for $\lambda \in (0, 0.7)$ in face of technology and markup shocks. We find that, while optimal inflation volatility increases with λ, optimal government spending volatility decreases as the fraction of liquidity constrained consumers increases.

- Figure 9 and 10 about here -

Fiscal Leader dynamics. With $\alpha = 0.5$, i.e. with a partially conservative monetary policy, we observe that the optimal dynamics under the Fiscal leadership change only marginally with respect to the Nash case.[7] Figures 11 and 12 show the IRFs to a technology and to a markup shock.

- Figure 11 and 12 about here -

When $\alpha = 1$ Figures 13 and 14 show that a positive technology shock and a negative markup shock lead to price stability, no matter the value of λ. However, under a markup shock it is interesting to note that in the presence of liquidity constrained consumers, price stability is achieved with a different response of the monetary policy instrument

[7] Analogously, optimal inflation volatility and optimal government spending volatility under a Fiscal leadership with partially conservative monetary policy show very similar figures to the ones with get under Nash.

with respect to the RAE model. The monetary authority slightly raises the interest rate, while the RAE model points to a significant reduction. Moreover, optimal fiscal policy becomes more expansionary in a model with higher LAMP.

- Figure 13 and 14 about here -

Figures 15 and 16 show the optimal inflation volatility and the optimal government spending volatility for $\lambda \in (0, 0.7)$ in face of technology and markup shocks in the case of fully conservative monetary authority ($\alpha = 1$). Optimal inflation volatility does not depend on the fraction of liquidity constrained households. Interestingly, optimal government spending volatility increases with λ.

- Figure 15 and 16 about here -

We state the main finding of this section in Result 2:

Result 2. *Under the Nash game and the Fiscal Leadership game with partially conservative Central Bank, in response to both technology and markup shocks, the inflation bias gets dramatically higher as λ increases. In response to a negative markup shock, a larger decrease of public consumption is needed as λ increases.*

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 Ramsey deterministic steady state. Denote $V^{DSS} = [\lambda u(C^r, N^r, G) + (1-\lambda)u(C^o, N^o, G)]/(1-\beta)$ the period utility for the Ramsey deterministic 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 Ramsey deterministic steady state to be welfare equivalent to the alternative policy regime can be found solving for μ^A the following expression :

$$V^A = \frac{1}{1-\beta}[\lambda u(C^r\left(1+\mu^A\right), N^r, G) + (1-\lambda)u(C^o\left(1+\mu^A\right), N^o, G)]. \tag{29}$$

We use the same formulas to evaluate welfare for each type of consumer, i.e., $V_h^{DSS} =$

$u(C^h, N^h, G)/(1-\beta)$, and

$$V_h^A = \frac{1}{1-\beta}[u(C^h\left(1+\mu_h^A\right), N^h, G)]. \tag{30}$$

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

Table 6 shows the welfare losses in percentage terms resulting from the RAE model and the model with liquidity constrained consumers for each policy regime and distinguishing between total, Ricardian and liquidity constrained welfare. What we note is that the Nash equilibrium leads to a total welfare loss which is bigger than the Fiscal Leadership case where the monetary policy is partially conservative about inflation. As in Adam and Billi (2008), the Fiscal Leader structure with $\alpha = 1$ minimizes the deviation from Ramsey allocations.

Notably, Table 6 shows that the Nash game and the Fiscal Leadership with partially conservative monetary policy involve a great loss of welfare for Ricardians while liquidity constrained consumers experience a gain. This is due to the fact that under these types of policy regimes the equilibrium implies an inflation bias which makes per capita profits lower. On the contrary, the higher production with respect to the Ramsey allocation implies a higher real wage which has a direct positive effect on liquidity constrained agents consumption, thus raising their welfare.

When monetary policy is partially conservative, this result still holds, even if the loss in terms of welfare of Ricardians is slightly lower, due to the fact that the inflation bias is marginally dampened by conservatism of monetary policy.

Summing up, we can state the following:

Result 3. *Under the Nash game and the Fiscal Leadership game with partially conservative Central Bank, liquidity constrained consumers experience a welfare gain with respect to Ramsey, while Ricardians a welfare loss.*

6 Conclusions

In this study we investigate the effects of the presence of a fraction of consumers who cannot smooth consumption and have no access to state-contingent markets nor receive dividends, on policy responses both in the long-run and in the short run. We compare our results to the fully Ricardian model. We concentrate on different structures for policy decision making. After considering the Ramsey problem, we consider two types of discretionary policy regimes: i) the Nash game, where the monetary and fiscal policies are independent and play simultaneously; ii) the Fiscal Leadership game, where the fiscal authority is the Stackelberg leader, deciding before the monetary policy, and the monetary authority is conservative about inflation. The fiscal policy chooses the amount of public

expenditure while the monetary authority decides on the level of the nominal interest rate.

Concerning the long-run equilibrium, we find that under the Nash game and the Fiscal Leadership game with partially conservative Central Bank, the optimal monetary policy implies an inflation bias which strongly increases as the fraction of liquidity constrained consumers increases. This happens because the monetary policy aims at reducing the monopolistic distortion, which increases as λ gets higher.

Analyzing the optimal responses in face of a positive technology and a negative price markup shocks, we find that LAMP plays an important role also under Ramsey. The optimal responses to a markup shock imply deviation from price stability and a positive public spending. Moreover, as the fraction of liquidity constrained agents gets higher public spending increases. The presence of liquidity constrained consumers alters quantitatively also the reaction of discretionary policies. In this case in response to both shocks, the inflation bias gets higher as λ increases. On the contrary, while public spending remains unchanged in face of a technology shock, in response to a negative markup shock, a larger decrease of public consumption is needed.

Finally, we find that contrary to what happens to Ricardian consumers, under discretionary policy regimes liquidity constrained agents get a welfare gain.

We think this paper could give interesting insights on how economic policy should be run when the presence of LAMP is taken into account. LAMP typically increases after a financial crisis. There is evidence that the condition of access to credit have worsened after the 2007-2010 crisis. In response to a markup shock, the presence of liquidity constrained consumers makes the role of fiscal policy become more relevant. Thus, policy makers should probably rely more on fiscal policy in periods of recession, in particular if the downturn originated from a financial crisis, which is often associated with a shortage of liquidity and a worsening of the conditions of access to credit, which correspond to a higher fraction of liquidity constrained consumers in our model.

Further developments of this study include the possibility of considering different fiscal structures, given that the balanced budget requirement is a very simplifying assumption and it is not always such a proper description of a country's fiscal structure. It would also be interesting to have a game structure where there are several fiscal authorities playing with a unique monetary authority, which is a case very close to the EU context. Allowing for a shock to the fraction of liquidity constrained consumers is also an issue under analysis for future research.

References

Adam, K. and R. M. Billi (2008). Monetary conservatism and fiscal policy. *Journal of Monetary Economics 55*, 1376–1388.

Beetsma, R. and H. Jensen (2005). Monetary and fiscal policy interactions in a micro-founded model of a monetary union. *Journal of International Economics 67(2)*, 320–352.

Bilbiie, F. O. (2008). Limited asset market participation, monetary policy and (inverted) aggregate demand logic. *Journal of Economic Theory 140*, 162–196.

Campbell J. Y. and Mankiw N. G. (1989). Consumption, income and interest rates: Reinterpreting the time series evidence. *NBER Chapters, in: NBER Macroeconomics Annual 4*, 185–246.

Di Bartolomeo, G. and L. Rossi (2007). Effectiveness of monetary policy and limited asset market participation: Neoclassical versus keynesian effects. *International Journal of Economic Theory 3*, 213–218.

Galí, J., D. López-Salido, and J. Valles (2004). Rule-of-thumb consumers and the design of interest rate rules. *Journal of Money, Credit and Banking 36*, 739–764.

Galí, J., D. López-Salido, and J. Valles (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association 5*(1), 227–270.

Galí, J. and P. Rabanal (2004). Technology shocks and aggregate fluctuations: How well does the RBC model fit postwar U.S. data? In M. Gertler and K. Rogoff (Eds.), *NBER Macroeconomics Annual*, pp. 225–288. Cambridge, MA: The MIT Press.

Gnocchi, S (2008). Discretionary fiscal policy and optimal monetary policy in a currency area. *Working Paper No. 602, Economics Department of Bologna University*.

Rotemberg, J.J. (1982). Sticky prices in the united states. *Journal of Political Economy 90*, 1187–1211.

Schmitt-Grohé, S. and M. Uribe (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics 54*(6), 1702–1725.

Schmitt-Grohé S. and Uribe M (2004a). Optimal fiscal and monetary policy under imperfect competition. *Journal of Macroeconomics 26*, 183–209.

Schmitt-Grohé S. and Uribe M. (2004b). Optimal fiscal and monetary policy under sticky prices. *Journal of Economic Theory 114*, 198–230.

7 Technical Appendix

7.1 The Ramsey Problem

The Lagrangian of the Ramsey problem (23) is

$$\begin{aligned}\max_{\{C_t^r,N_t^r,C_t^o,N_t^o,\pi_t,R_t,G_t\}} E_0\sum_{t=0}^{\infty}\beta^t\{&\lambda u(C_t^r,N_t^r,G_t)+(1-\lambda)u(C_t^o,N_t^o,G_t)\\ &+\gamma_t^1[C_t^{o-\sigma}(\pi_t-1)\pi_t-\frac{(1-\epsilon_t)}{\theta}C_t^{o-\sigma}Z_t[\lambda N_t^r+(1-\lambda)N_t^o]\\ &-\frac{\epsilon_t}{\theta}[\lambda N_t^r+(1-\lambda)N_t^o]C_t^{o-\sigma}[\lambda\omega_n N_t^{r\varphi}C_t^{r\sigma}+(1-\lambda)\omega_n N_t^{o\varphi}C_t^{o\sigma}]\\ &-\beta E_t {C_{t+1}^o}^{-\sigma}(\pi_{t+1}-1)\pi_{t+1}]\\ &+\gamma_t^2\left[\frac{C_t^{o-\sigma}}{R_t}-\beta E_t\frac{{C_{t+1}^o}^{-\sigma}}{\pi_{t+1}}\right]\\ &+\gamma_t^3\left[Z_t[\lambda N_t^r+(1-\lambda)N_t^o]-\lambda C_t^r-(1-\lambda)C_t^o-G_t-\frac{\theta}{2}(\pi_t-1)^2\right]\\ &+\gamma_t^4\left[N_t^{o\varphi}C_t^{o\sigma}-N_t^{r\varphi}C_t^{r\sigma}\right]\\ &+\gamma_t^5\left[C_t^r-w_tN_t^r+G_t\right]\}\end{aligned}$$

The first order condition w.r.t. $(C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t)$ respectively are

$$\lambda C_t^{r-\sigma}-\gamma_t^1\lambda\frac{\epsilon_t}{\theta}N_t\sigma\omega_n N_t^{r\varphi}C_t^{r\sigma}-1C_t^{o-\sigma}-\gamma_t^3\lambda+\gamma_t^4N_t^{r\varphi}\sigma C_t^{r\sigma-1}+\gamma_t^5(1-\omega_n N_t^{r\varphi+1}\sigma C_t^{r\sigma-1})=0 \tag{31}$$

$$\begin{aligned}-\lambda\omega_n N_t^{r\varphi}+\gamma_t^1\frac{\lambda}{\theta}C_t^{o-\sigma}[Z_t(\epsilon_t-1)-\epsilon_t\omega_n(\lambda N_t^{r\varphi}C_t^{r\sigma}+(1-\lambda)N_t^{o\varphi}C_t^{o\sigma}+\varphi N_tN_t^{r\varphi-1}C_t^{r\sigma})]\\ +\gamma_t^3\lambda Z_t+\gamma_t^4\varphi N_t^{r\varphi-1}C_t^{r\sigma}-\gamma_t^5\omega_nC_t^{r\sigma}N_t^{r\varphi}(\varphi+1)=0\end{aligned} \tag{32}$$

$$\begin{aligned}&(1-\lambda)C_t^{o-\sigma}-(\gamma_t^1-\gamma_{t-1}^1)\sigma C_t^{o-\sigma-1}(\pi_t-1)\pi_t-\gamma_t^1\frac{N_t}{\theta}\sigma C_t^{o-\sigma-1}[Z_t(\epsilon_t-1)-\epsilon_t\omega_n\lambda N_t^{r\varphi}C_t^{r\sigma}]\\ &-\gamma_t^2\sigma\frac{C_t^{o-\sigma-1}}{R_t}+\gamma_{t-1}^2\sigma\frac{C_t^{o-\sigma-1}}{\pi_t}-\gamma_t^3(1-\lambda)-\gamma_t^4N_t^{o\varphi}\sigma C_t^{o\sigma-1}=0\end{aligned} \tag{33}$$

$$\begin{aligned}&-(1-\lambda)\omega_nN_t^{o\varphi}+\gamma_t^1\frac{1-\lambda}{\theta}C_t^{o-\sigma}[Z_t(\epsilon_t-1)-\epsilon_t\omega_n[\lambda N_t^{r\varphi}C_t^{r\sigma}+(1-\lambda)N_t^{o\varphi}C_t^{o\sigma}\\ &+N_t\varphi N_t^{o\varphi-1}C_t^{o\sigma}]]+\gamma_t^3(1-\lambda)Z_t-\gamma_t^4\varphi C_t^{o\sigma}N_t^{o\varphi-1}=0\end{aligned} \tag{34}$$

$$(\gamma_t^1 - \gamma_{t-1}^1)C_t^{o-\sigma}(2\pi_t - 1) + \gamma_{t-1}^2 \frac{C_t^{o-\sigma}}{\pi_t^2} - \gamma_t^3 \theta(\pi_t - 1) = 0 \tag{35}$$

$$-\gamma_t^2 \frac{C_t^{o-\sigma}}{R_t^2} = 0 \tag{36}$$

$$\omega_g G_t^{-\sigma} - \gamma_t^3 + \gamma_t^5 = 0 \tag{37}$$

7.2 Ramsey steady state

We impose the steady state and get

$$\gamma^2 = 0 \tag{38}$$

$$\gamma^3 = \omega_g G^{-\sigma} + \gamma^5 \tag{39}$$

from (36) and (37). Then combining (38) with (35) we obtain

$$\pi = 1 \tag{40}$$

Combining these results with (5) and (20) leads to

$$R = \frac{1}{\beta} \tag{41}$$

and

$$w = \left[\lambda \frac{\omega_n N^{r\varphi}}{C^{r-\sigma}} + (1-\lambda) \frac{\omega_n N^{o\varphi}}{C^{o-\sigma}} \right] = \frac{\epsilon - 1}{\epsilon} \tag{42}$$

The steady state values of the other variables are obtained through numerical methods.

7.3 Nash policy game

7.3.1 Fiscal policy problem

The Lagrangian of the fiscal policy problem (24) is:

$$\begin{aligned}
\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, G_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \{ & \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \\
& + \gamma_t^1 [C_t^{o-\sigma}(\pi_t - 1)\pi_t - \frac{(1-\epsilon_t)}{\theta} C_t^{o-\sigma} Z_t [\lambda N_t^r + (1-\lambda) N_t^o] \\
& - \frac{\epsilon_t}{\theta} [\lambda N_t^r + (1-\lambda) N_t^o] C_t^{o-\sigma} [\lambda \omega_n N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda)\omega_n N_t^{o\varphi} C_t^{o\sigma}] \\
& - \beta E_t {C_{t+1}^o}^{-\sigma} (\pi_{t+1} - 1)\pi_{t+1}] \\
& + \gamma_t^2 \left[\frac{C_t^{o-\sigma}}{R_t} - \beta E_t \frac{{C_{t+1}^o}^{-\sigma}}{\pi_{t+1}} \right] \\
& + \gamma_t^3 \left[Z_t [\lambda N_t^r + (1-\lambda) N_t^o] - \lambda C_t^r - (1-\lambda) C_t^o - G_t - \frac{\theta}{2} (\pi_t - 1)^2 \right] \\
& + \gamma_t^4 \left[N_t^{o\varphi} C_t^{o\sigma} - N_t^{r\varphi} C_t^{r\sigma} \right] \\
& + \gamma_t^5 \left[C_t^r - w_t N_t^r + G_t \right] \}
\end{aligned}$$

The first order condition w.r.t. $(C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, G_t)$ respectively are

$$\lambda C_t^{r-\sigma} - \gamma_t^1 \lambda \frac{\epsilon_t}{\theta} N_t \sigma \omega_n N_t^{r\varphi} C_t^{r\sigma} - 1 C_t^{o-\sigma} - \gamma_t^3 \lambda + \gamma_t^4 N_t^{r\varphi} \sigma C_t^{r\sigma-1} + \gamma_t^5 (1 - \omega_n N_t^{r\varphi+1} \sigma C_t^{r\sigma-1}) = 0 \tag{43}$$

$$\begin{aligned}
& - \lambda \omega_n N_t^{r\varphi} + \gamma_t^1 \frac{\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} + \varphi N_t N_t^{r\varphi-1} C_t^{r\sigma})] \\
& + \gamma_t^3 \lambda Z_t + \gamma_t^4 \varphi N_t^{r\varphi-1} C_t^{r\sigma} - \gamma_t^5 \omega_n C_t^{r\sigma} N_t^{r\varphi} (\varphi + 1) = 0
\end{aligned} \tag{44}$$

$$\begin{aligned}
& (1-\lambda) C_t^{o-\sigma} - \gamma_t^1 \sigma C_t^{o-\sigma-1} (\pi_t - 1)\pi_t - \gamma_t^1 \frac{N_t}{\theta} \sigma C_t^{o-\sigma-1} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n \lambda N_t^{r\varphi} C_t^{r\sigma}] \\
& - \gamma_t^2 \sigma \frac{C_t^{o-\sigma-1}}{R_t} - \gamma_t^3 (1-\lambda) - \gamma_t^4 N_t^{o\varphi} \sigma C_t^{o\sigma-1} = 0
\end{aligned} \tag{45}$$

$$\begin{aligned}
& - (1-\lambda) \omega_n N_t^{o\varphi} + \gamma_t^1 \frac{1-\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n [\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} \\
& + N_t \varphi N_t^{o\varphi-1} C_t^{o\sigma}]] + \gamma_t^3 (1-\lambda) Z_t - \gamma_t^4 \varphi C_t^{o\sigma} N_t^{o\varphi-1} = 0
\end{aligned} \tag{46}$$

$$\gamma_t^1 C_t^{o-\sigma}(2\pi_t - 1) - \gamma_t^3 \theta(\pi_t - 1) = 0 \tag{47}$$

$$\omega_g G_t^{-\sigma} - \gamma_t^3 + \gamma_t^5 = 0 \tag{48}$$

7.3.2 Monetary policy problem

The Lagrangian of the monetary policy problem (25) is:

$$\begin{aligned}
\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \{ & \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \\
& + \gamma_t^1 [C_t^{o-\sigma}(\pi_t - 1)\pi_t - \frac{(1-\epsilon_t)}{\theta} C_t^{o-\sigma} Z_t [\lambda N_t^r + (1-\lambda) N_t^o] \\
& - \frac{\epsilon_t}{\theta} [\lambda N_t^r + (1-\lambda) N_t^o] C_t^{o-\sigma} [\lambda \omega_n N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda)\omega_n N_t^{o\varphi} C_t^{o\sigma}] \\
& - \beta E_t {C_{t+1}^o}^{-\sigma} (\pi_{t+1} - 1)\pi_{t+1}] \\
& + \gamma_t^2 \left[\frac{C_t^{o-\sigma}}{R_t} - \beta E_t \frac{{C_{t+1}^o}^{-\sigma}}{\pi_{t+1}} \right] \\
& + \gamma_t^3 \left[Z_t [\lambda N_t^r + (1-\lambda) N_t^o] - \lambda C_t^r - (1-\lambda) C_t^o - G_t - \frac{\theta}{2} (\pi_t - 1)^2 \right] \\
& + \gamma_t^4 \left[N_t^{o\varphi} C_t^{o\sigma} - N_t^{r\varphi} C_t^{r\sigma} \right] \\
& + \gamma_t^5 \left[C_t^r - w_t N_t^r + L_t^r \right] \}
\end{aligned}$$

The first order condition w.r.t. $(C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t)$ respectively are

$$\lambda C_t^{r-\sigma} - \gamma_t^1 \lambda \frac{\epsilon_t}{\theta} N_t \sigma \omega_n N_t^{r\varphi} C_t^{r\sigma} - 1 C_t^{o-\sigma} - \gamma_t^3 \lambda + \gamma_t^4 N_t^{r\varphi} \sigma C_t^{r\sigma-1} + \gamma_t^5 (1 - \omega_n N_t^{r\varphi+1} \sigma C_t^{r\sigma-1}) = 0 \tag{49}$$

$$\begin{aligned}
& - \lambda \omega_n N_t^{r\varphi} + \gamma_t^1 \frac{\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} + \varphi N_t N_t^{r\varphi-1} C_t^{r\sigma})] \\
& + \gamma_t^3 \lambda Z_t + \gamma_t^4 \varphi N_t^{r\varphi-1} C_t^{r\sigma} - \gamma_t^5 \omega_n C_t^{r\sigma} N_t^{r\varphi} (\varphi + 1) = 0
\end{aligned} \tag{50}$$

$$\begin{aligned}
& (1-\lambda) C_t^{o-\sigma} - \gamma_t^1 \sigma C_t^{o-\sigma-1} (\pi_t - 1)\pi_t - \gamma_t^1 \frac{N_t}{\theta} \sigma C_t^{o-\sigma-1} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n \lambda N_t^{r\varphi} C_t^{r\sigma}] \\
& - \gamma_t^2 \sigma \frac{C_t^{o-\sigma-1}}{R_t} - \gamma_t^3 (1-\lambda) - \gamma_t^4 N_t^{o\varphi} \sigma C_t^{o\sigma-1} = 0
\end{aligned} \tag{51}$$

$$
\begin{aligned}
&-(1-\lambda)\omega_n N_t^{o\varphi} + \gamma_t^1 \frac{1-\lambda}{\theta} C_t^{o-\sigma}[Z_t(\epsilon_t - 1) - \epsilon_t \omega_n [\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} \\
&+ N_t \varphi N_t^{o\varphi-1} C_t^{o\sigma}]] + \gamma_t^3 (1-\lambda) Z_t - \gamma_t^4 \varphi C_t^{o\sigma} N_t^{o\varphi-1} = 0
\end{aligned} \tag{52}
$$

$$
\gamma_t^1 C_t^{o-\sigma}(2\pi_t - 1) - \gamma_t^3 \theta(\pi_t - 1) = 0 \tag{53}
$$

$$
-\gamma_t^2 \frac{C_t^{o-\sigma}}{R_t^2} = 0 \tag{54}
$$

In steady state (38) and (39) still hold, but there is no more price stability ($\pi > 1$). In this case all other steady state values are obtained through numerical methods.

7.4 Conservative monetary policy problem

The monetary policy problem becomes:

$$
\begin{aligned}
\max_{\{C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t\}} E_t \sum_{t=0}^{\infty} \beta^t \{ & (1-\alpha)[\lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t)] - \alpha \frac{(\pi_t - 1)^2}{2} \\
& + \gamma_t^{12} [C_t^{o-\sigma}(\pi_t - 1)\pi_t - \frac{(1-\epsilon_t)}{\theta} C_t^{o-\sigma} Z_t [\lambda N_t^r + (1-\lambda) N_t^o] \\
& - \frac{\epsilon_t}{\theta} [\lambda N_t^r + (1-\lambda) N_t^o] C_t^{o-\sigma} [\lambda \omega_n N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) \omega_n N_t^{o\varphi} C_t^{o\sigma}] \\
& - \beta E_t {C_{t+1}^o}^{-\sigma} (\pi_{t+1} - 1)\pi_{t+1}] \\
& + \gamma_t^{13} \left[\frac{C_t^{o-\sigma}}{R_t} - \beta E_t \frac{{C_{t+1}^o}^{-\sigma}}{\pi_{t+1}} \right] \\
& + \gamma_t^{14} \left[Z_t [\lambda N_t^r + (1-\lambda) N_t^o] - \lambda C_t^r - (1-\lambda) C_t^o - G_t - \frac{\theta}{2} (\pi_t - 1)^2 \right] \\
& + \gamma_t^{15} [N_t^{o\varphi} C_t^{o\sigma} - N_t^{r\varphi} C_t^{r\sigma}] \\
& + \gamma_t^{16} [C_t^r - w_t N_t^r + G_t] \}
\end{aligned}
$$

The first order condition w.r.t. $(C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t)$ respectively are

$$
(1-\alpha)\lambda C_t^{r-\sigma} - \gamma_t^{12} \lambda \frac{\epsilon_t}{\theta} N_t \sigma \omega_n N_t^{r\varphi} C_t^{r\sigma} - 1 C_t^{o-\sigma} - \gamma_t^{14} \lambda + \gamma_t^{15} N_t^{r\varphi} \sigma C_t^{r\sigma-1} + \gamma_t^{16} (1 - \omega_n N_t^{r\varphi+1} \sigma C_t^{r\sigma-1}) = 0 \tag{55}
$$

$$
\begin{aligned}
&-(1-\alpha)\lambda\omega_n N_t^{r\varphi} + \gamma_t^{12} \frac{\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} + \varphi N_t N_t^{r\varphi-1} C_t^{r\sigma})] \\
&+ \gamma_t^{14} \lambda Z_t + \gamma_t^{15} \varphi N_t^{r\varphi-1} C_t^{r\sigma} - \gamma_t^{16} \omega_n C_t^{r\sigma} N_t^{r\varphi} (\varphi + 1) = 0
\end{aligned} \tag{56}
$$

$$(1-\alpha)(1-\lambda)C_t^{o-\sigma} - \gamma_t^{12}\sigma C_t^{o-\sigma-1}(\pi_t-1)\pi_t - \gamma_t^{12}\frac{N_t}{\theta}\sigma C_t^{o-\sigma-1}[Z_t(\epsilon_t-1) - \epsilon_t\omega_n\lambda N_t^{r\varphi}C_t^{r\sigma}]$$
$$-\gamma_t^{13}\sigma\frac{C_t^{o-\sigma-1}}{R_t} - \gamma_t^{14}(1-\lambda) - \gamma_t^{15}N_t^{o\varphi}\sigma C_t^{o\sigma-1} = 0 \tag{57}$$

$$-(1-\alpha)(1-\lambda)\omega_n N_t^{o\varphi} + \gamma_t^{12}\frac{1-\lambda}{\theta}C_t^{o-\sigma}[Z_t(\epsilon_t-1) - \epsilon_t\omega_n[\lambda N_t^{r\varphi}C_t^{r\sigma} + (1-\lambda)N_t^{o\varphi}C_t^{o\sigma}$$
$$+ N_t\varphi N_t^{o\varphi-1}C_t^{o\sigma}]] + \gamma_t^{14}(1-\lambda)Z_t - \gamma_t^{15}\varphi C_t^{o\sigma}N_t^{o\varphi-1} = 0 \tag{58}$$

$$\gamma_t^{12}C_t^{o-\sigma}(2\pi_t-1) - \gamma_t^{14}\theta(\pi_t-1) - \alpha(\pi-1) = 0 \tag{59}$$

$$-\gamma_t^{13}\frac{C_t^{o-\sigma}}{R_t^2} = 0 \tag{60}$$

Solving for the steady state we find analogously:

$$\gamma^{13} = 0 \tag{61}$$

7.5 Fiscal leadership with conservative monetary policy

The Lagrangian of the fiscal policy problem (27) is:

$$\begin{aligned}
\max_{\{C_t^r,N_t^r,C_t^o,N_t^o,\pi_t,G_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \{ & \lambda u(C_t^r, N_t^r, G_t) + (1-\lambda) u(C_t^o, N_t^o, G_t) \\
& + \gamma_t^1 [C_t^{o-\sigma}(\pi_t - 1)\pi_t - \frac{(1-\epsilon_t)}{\theta} C_t^{o-\sigma} Z_t [\lambda N_t^r + (1-\lambda) N_t^o] \\
& - \frac{\epsilon_t}{\theta} [\lambda N_t^r + (1-\lambda) N_t^o] C_t^{o-\sigma} [\lambda \omega_n N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda)\omega_n N_t^{o\varphi} C_t^{o\sigma}] \\
& - \beta E_t {C_{t+1}^o}^{-\sigma} (\pi_{t+1} - 1)\pi_{t+1}] \\
& + \gamma_t^2 \left[\frac{C_t^{o-\sigma}}{R_t} - \beta E_t \frac{{C_{t+1}^o}^{-\sigma}}{\pi_{t+1}} \right] \\
& + \gamma_t^3 \left[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 \right] \\
& + \gamma_t^4 \left[N_t^{o\varphi} C_t^{o\sigma} - N_t^{r\varphi} C_t^{r\sigma} \right] \\
& + \gamma_t^5 \left[C_t^r - w_t N_t^r + G_t \right] \\
& + \gamma_t^6 [(1-\alpha)\lambda C_t^{r-\sigma} - \gamma_t^{12} \lambda \frac{\epsilon_t}{\theta} N_t \sigma \omega_n N_t^{r\varphi} C_t^{r\sigma} - 1 C_t^{o-\sigma} - \gamma_t^{14} \lambda + \gamma_t^{15} N_t^{r\varphi} \sigma C_t^{r\sigma-1} \\
& + \gamma_t^{16} (1 - \omega_n N_t^{r\varphi+1} \sigma C_t^{r\sigma-1})] \\
& + \gamma_t^7 [-(1-\alpha)\lambda \omega_n N_t^{r\varphi} + \gamma_t^{12} \frac{\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} \\
& + \varphi N_t N_t^{r\varphi-1} C_t^{r\sigma})] + \gamma_t^{14} \lambda Z_t + \gamma_t^{15} \varphi N_t^{r\varphi-1} C_t^{r\sigma} - \gamma_t^{16} \omega_n C_t^{r\sigma} N_t^{r\varphi} (\varphi + 1)] \\
& + \gamma_t^8 [(1-\alpha)(1-\lambda) C_t^{o-\sigma} - \gamma_t^{12} \sigma C_t^{o-\sigma-1} (\pi_t - 1)\pi_t - \gamma_t^{12} \frac{N_t}{\theta} \sigma C_t^{o-\sigma-1} [Z_t(\epsilon_t - 1) \\
& - \epsilon_t \omega_n \lambda N_t^{r\varphi} C_t^{r\sigma}] - \gamma_t^{13} \sigma \frac{C_t^{o-\sigma-1}}{R_t} - \gamma_t^{14} (1-\lambda) - \gamma_t^{15} N_t^{o\varphi} \sigma C_t^{o\sigma-1}] \\
& + \gamma_t^9 [-(1-\alpha)(1-\lambda)\omega_n N_t^{o\varphi} + \gamma_t^{12} \frac{1-\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n [\lambda N_t^{r\varphi} C_t^{r\sigma} \\
& + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} + N_t \varphi N_t^{o\varphi-1} C_t^{o\sigma}]] + \gamma_t^{14} (1-\lambda) Z_t - \gamma_t^{15} \varphi C_t^{o\sigma} N_t^{o\varphi-1}] \\
& \gamma_t^{10} [\gamma_t^{12} C_t^{o-\sigma} (2\pi_t - 1) - \gamma_t^{14} \theta (\pi_t - 1) - \alpha(\pi_t - 1)] \\
& \gamma_t^{11} [-\gamma_t^{13} \frac{C_t^{o-\sigma}}{R_t^2}] \}
\end{aligned}$$

The first order conditions w.r.t. $(C_t^r, N_t^r, C_t^o, N_t^o, \pi_t, R_t, G_t, \gamma_t^{12}, \gamma_t^{13}, \gamma_t^{14}, \gamma_t^{15}, \gamma_t^{16})$ are then respectively

$$\lambda C_t^{r-\sigma} - \gamma_t^1 \lambda \frac{\epsilon_t}{\theta} N_t \sigma \omega_n N_t^{r\varphi} C_t^{r\sigma-1} C_t^{o-\sigma} - \gamma_t^3 \lambda + \gamma_t^4 N_t^{r\varphi} \sigma C_t^{r\sigma-1} + \gamma_t^5 [1 - N_t^{r\varphi+1} \omega_n \sigma C_t^{r\sigma-1}]$$
$$+ \gamma_t^6 [-\sigma(1-\alpha)\lambda C_t^{r-\sigma-1} - \gamma_t^{12} \frac{\epsilon_t}{\theta} \lambda N_t C_t^{o-\sigma} \omega_n \sigma N_t^{r\varphi} (\sigma-1) C_t^{r\sigma-2} + \gamma_t^{15} \sigma N_t^{r\varphi} * (\sigma-1) C_t^{r\sigma-2}$$
$$- \gamma_t^{16} \omega_n \sigma N_t^{r\varphi+1} (\sigma-1) C_t^{r\sigma-2}] + \gamma_t^7 [-\gamma_t^{12} \frac{\lambda}{\theta} C_t^{o-\sigma} \epsilon_t \omega_n (\varphi N_t N_t^{r\varphi-1} \sigma C_t^{r\sigma-1} + \lambda N_t^{r\varphi} \sigma C_t^{r\sigma-1})$$
$$+ \gamma_t^{15} \varphi N_t^{r\varphi-1} \sigma C_t^{r\sigma-1} - \gamma_t^{16} \omega_n N_t^{r\varphi} (\varphi+1) \sigma C_t^{r\sigma-1}] + \gamma_t^8 [\gamma_t^{12} \frac{N_t}{\theta} \sigma C_t^{o-\sigma-1} \epsilon_t \lambda \omega_n N_t^{r\varphi} \sigma C_t^{r\sigma-1}]$$
$$+ \gamma_t^9 [-\gamma_t^{12} \frac{1-\lambda}{\theta} C_t^{o-\sigma} \epsilon_t \omega_n \lambda N_t^{r\varphi} \sigma C_t^{r\sigma-1}] = 0 \tag{62}$$

$$- \lambda \omega_n N_t^{r\varphi} + \gamma_t^1 [\frac{\lambda}{\theta} C_t^{o-\sigma} Z_t (\epsilon_t - 1) - \epsilon \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} + \varphi N_t N_t^{r\varphi-1} C_t^{r\sigma})]$$
$$+ \gamma_t^3 \lambda Z_t + \gamma_t^4 \varphi N_t^{r\varphi-1} C_t^{r\sigma} - \gamma_t^5 \omega_n C_t^{r\sigma} N_t^{r\varphi} (\varphi+1)$$
$$+ \gamma_t^6 [-\gamma_t^{12} \frac{\epsilon_t}{\theta} \lambda C_t^{o-\sigma} \omega_n \sigma C_t^{r\sigma-1} (\lambda N_t^{r\varphi} + N_t \varphi N_t^{r\varphi-1}) + \gamma_t^{15} \sigma C_t^{r\sigma-1} \varphi N_t^{r\varphi-1}$$
$$- \gamma_t^{16} \omega_n \sigma C_t^{r\sigma-1} (\varphi+1) N_t^{r\varphi}]$$
$$+ \gamma_t^7 [-(1-\alpha)\lambda \omega_n \varphi N_t^{r\varphi-1} - \gamma_t^{12} \frac{\lambda}{\theta} C_t^{o-\sigma} \epsilon_t \omega_n (\varphi C_t^{r\sigma} (\lambda N_t^{r\varphi-1} + N_t (\varphi-1) N_t^{r\varphi-2}) + \lambda C_t^{r\sigma} \varphi N_t^{r\varphi-1})$$
$$+ \gamma_t^{15} \varphi C_t^{r\sigma} (\varphi-1) N_t^{r\varphi-2} - \gamma_t^{16} \omega_n (\varphi+1) C_t^{r\sigma} \varphi N_t^{r\varphi-1}]$$
$$+ \gamma_t^8 [\gamma_t^{12} \frac{\sigma}{\theta} C_t^{o-\sigma-1} \epsilon_t \omega_n \lambda C_t^{r\sigma} (\lambda N_t^{r\varphi} + \varphi N_t N_t^{r\varphi-1})]$$
$$+ \gamma_t^9 [-\gamma_t^{12} \frac{1-\lambda}{\theta} C_t^{o-\sigma} \epsilon \omega_n \lambda C_t^{r\sigma} \varphi N_t^{r\varphi-1}] = 0 \tag{63}$$

$$
\begin{aligned}
&(1-\lambda)C_t^{o-\sigma} - \gamma_t^1\sigma C_t^{o-\sigma-1}(\pi_t-1)\pi_t - \gamma_t^1\frac{N_t}{\theta}\sigma C_t^{o-\sigma-1}[Z_t(\epsilon_t-1) - \epsilon_t\omega_n\lambda N_t^{r\varphi}C_t^{r\sigma}] \\
&- \gamma_t^2\sigma\frac{C_t^{o-\sigma-1}}{R_t} - \gamma_t^3(1-\lambda) - \gamma_t^4 N_t^{o\varphi}\sigma C_t^{o\sigma-1} + \gamma_t^6[\gamma_t^1 2\frac{\epsilon_t}{\theta}\lambda\omega_n\sigma^2 N_t N_t^{r\varphi}C_t^{r\sigma-1}C_t^{o-\sigma-1}] \\
&+ \gamma_t^7[\gamma_t^{12}\frac{\lambda}{\theta}(-\sigma C_t^{o-\sigma-1}(Z_t(\epsilon_t-1) - \epsilon\omega_n(\varphi N_t N_t^{r\varphi-1}C_t^{r\sigma} + \lambda N_t^{r\varphi}C_t^{r\sigma} + (1-\lambda)N_t^{o\varphi}C_t^{o\sigma})) \\
&- C_t^{o-\sigma}\epsilon_t\omega_n(1-\lambda)N_t^{o\varphi}\sigma C_t^{o\sigma-1})] + \gamma_t^8[-\sigma(1-\alpha)(1-\lambda)C_t^{o-\sigma-1} \\
&+ \gamma_t^{12}(\pi_t-1)\pi_t\sigma(\sigma+1)C_t^{o-\sigma-2} + \gamma_t^{12}\frac{N_t}{\theta}\sigma(\sigma+1)(Z_t(\epsilon_t-1) - \epsilon\lambda\omega_n N_t^{r\varphi}C_t^{r\sigma})C_t^{o-\sigma-2} \\
&+ \gamma_t^{13}\sigma(\sigma+1)\frac{C_t^{o-\sigma-2}}{R_t} - \gamma_t^{15}\sigma N_t^{o\varphi}(\sigma-1)C_t^{o\sigma-2}] + \gamma_t^9[\gamma_t^{12}\frac{1-\lambda}{\theta}(-\sigma C_t^{o-\sigma-1}(Z_t(\epsilon_t-1) \\
&- \epsilon_t\omega_n(\lambda N_t^{r\varphi}C_t^{r\sigma} + (1-\lambda)N_t^{o\varphi}C_t^{o\sigma} + N_t\varphi N_t^{o\varphi-1}C_t^{o\sigma})) - C_t^{o-\sigma}\epsilon_t\omega_n((1-\lambda)N_t^{o\varphi}\sigma C_t^{o\sigma-1} \\
&+ \varphi N_t N_t^{o\varphi-1}\sigma C_t^{o\sigma-1})) - \gamma_t^{15}\varphi N_t^{o\varphi-1}\sigma C_t^{o\sigma-1}] - \gamma_t^{10}\gamma_t^{12}(2\pi_t-1)\sigma C_t^{o-\sigma-1} \\
&+ \gamma_t^{11}\gamma_t^{13}\frac{\sigma C_t^{o-\sigma-1}}{R_t^2} = 0
\end{aligned}
\tag{64}
$$

$$
\begin{aligned}
&- (1-\lambda)\omega_n N_t^{o\varphi} + \gamma_t^1\frac{1-\lambda}{\theta}C_t^{o-\sigma}[Z_t(\epsilon_t-1) - \epsilon_t\omega_n[\lambda N_t^{r\varphi}C_t^{r\sigma} + (1-\lambda)N_t^{o\varphi}C_t^{o\sigma} \\
&+ N_t\varphi N_t^{o\varphi-1}C_t^{o\sigma}]] + \gamma_t^3(1-\lambda)Z_t - \gamma_t^4\varphi C_t^{o\sigma}N_t^{o\varphi-1} + \gamma_t^6[-\gamma_t^{12}\frac{\epsilon_t}{\theta}\lambda C_t^{o-\sigma}\omega_n\sigma N_t^{r\varphi}C_t^{r\sigma-1}(1-\lambda)] \\
&+ \gamma_t^7[-\gamma_t^{12}\lambda\theta C_t^{o-\sigma}\epsilon_t\omega_n(\varphi N_t^{r\varphi-1}C_t^{r\sigma}(1-\lambda) + (1-\lambda)C_t^{o\sigma}\varphi N_t^{o\varphi-1})] \\
&+ \gamma_t^8[-\gamma_t^{12}\frac{\sigma}{\theta}C_t^{o-\sigma-1}(1-\lambda)(Z_t(\epsilon_t-1) - \epsilon\lambda\omega_n N_t^{r\varphi}C_t^{r\sigma}) - \gamma_t^{15}\sigma C_t^{o\sigma-1}\varphi N_t^{o\varphi-1}] \\
&+ \gamma_t^9[-\varphi(1-\alpha)(1-\lambda)\omega_n N_t^{o\varphi-1} - \gamma_t^{12}\frac{1-\lambda}{\theta}C_t^{o-\sigma}\epsilon\omega_n((1-\lambda)C_t^{o\sigma}\varphi N_t^{o\varphi-1} \\
&+ \varphi C_t^{o\sigma}(N_t^{o\varphi-1}(1-\lambda) + N_t(\varphi-1)N_t^{o\varphi-2})) - \gamma_t^{15}\varphi C_t^{o\sigma}(\varphi-1)N_t^{o\varphi-2}] = 0
\end{aligned}
\tag{65}
$$

$$
\gamma_t^1 C_t^{o-\sigma}(2\pi_t-1) - \gamma_t^3\theta(\pi_t-1) + \gamma_t^8(-\gamma_t^{12}\sigma C_t^{o-\sigma-1}(2\pi_t-1)) + \gamma_t^{10}(2\gamma_t^{12}C_t^{o-\sigma} - \gamma_t^{14}\theta - \alpha) = 0 \tag{66}
$$

$$
-\gamma_t^2\frac{C_t^{o-\sigma}}{R_t^2} + \gamma_t^8\gamma_t^{13}\frac{\sigma C_t^{o-\sigma-1}}{R_t^2} + \gamma_t^{11}\gamma_t^{13}\frac{2C_t^{o-\sigma}}{R_t^3} = 0 \tag{67}
$$

$$
\omega_g G_t^{-\sigma} - \gamma_t^3 + \gamma_t^5 = 0 \tag{68}
$$

$$
\begin{aligned}
&- \gamma_t^6 \lambda \frac{\epsilon_t}{\theta} N_t \sigma \omega_n N_t^{r\varphi} C_t^{r\sigma-1} C_t^{o-\sigma} + \gamma_t^7 \frac{\lambda}{\theta} C_t^{o-\sigma} (Z_t(\epsilon_t - 1) - \epsilon \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} \\
&+ \varphi N_t N_t^{r\varphi-1} C_t^{r\sigma})) - \gamma_t^8 \sigma C_t^{o-\sigma-1} (\pi_t - 1)\pi_t - \gamma_t^8 \frac{N_t}{\theta} \sigma C_t^{o-\sigma-1} (Z_t(\epsilon_t - 1) - \epsilon \omega_n \lambda N_t^{r\varphi} C_t^{r\sigma}) \\
&+ \gamma_t^9 [\frac{1-\lambda}{\theta} C_t^{o-\sigma} [Z_t(\epsilon_t - 1) - \epsilon_t \omega_n (\lambda N_t^{r\varphi} C_t^{r\sigma} + (1-\lambda) N_t^{o\varphi} C_t^{o\sigma} + N_t \varphi N_t^{o\varphi-1} C_t^{o\sigma})] \\
&+ \gamma_t^{10} C_t^{o-\sigma} (2\pi_t - 1) = 0
\end{aligned} \tag{69}
$$

$$
-\gamma_t^8 \frac{\sigma C_t^{o-\sigma-1}}{R_t} - \gamma_t^{11} \frac{C_t^{o-\sigma}}{R_t^2} = 0 \tag{70}
$$

$$
\lambda(\gamma_t^7 Z_t - \gamma_t^6) + (1-\lambda)(\gamma_t^9 Z_t - \gamma_t^8) - \gamma_t^{10} \theta (\pi_t - 1) = 0 \tag{71}
$$

$$
N_t^{r\varphi} C_t^{r\sigma} (\gamma_t^6 \frac{\sigma}{C_t^r} + \gamma_t^7 \frac{\varphi}{N_t^r}) - N_t^{o\varphi} C_t^{o\sigma} (\gamma_t^8 \frac{\sigma}{C_t^o} + \gamma_t^9 \frac{\varphi}{N_t^o}) = 0 \tag{72}
$$

$$
\gamma_t^6 - \omega_n C_t^{r\sigma} N_t^{r\varphi} (\gamma_t^6 \frac{\sigma N_t^r}{C_t^r} + \gamma_t^7 (\varphi + 1)) = 0 \tag{73}
$$

8 Figures and Tables

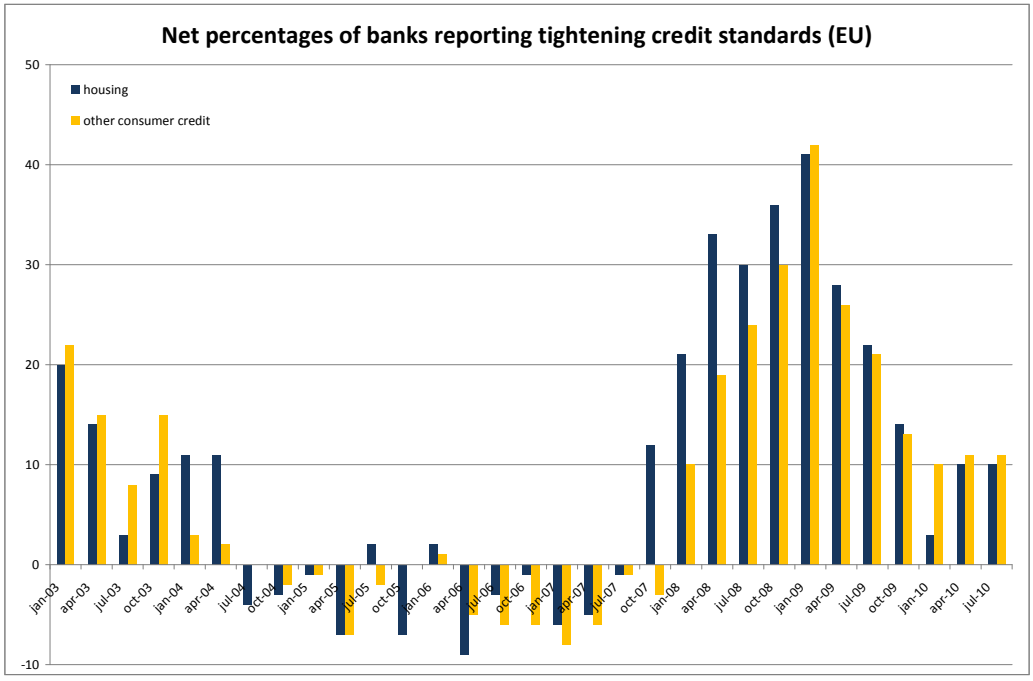

Fig. 1. Credit standards in the Euro Area economy.

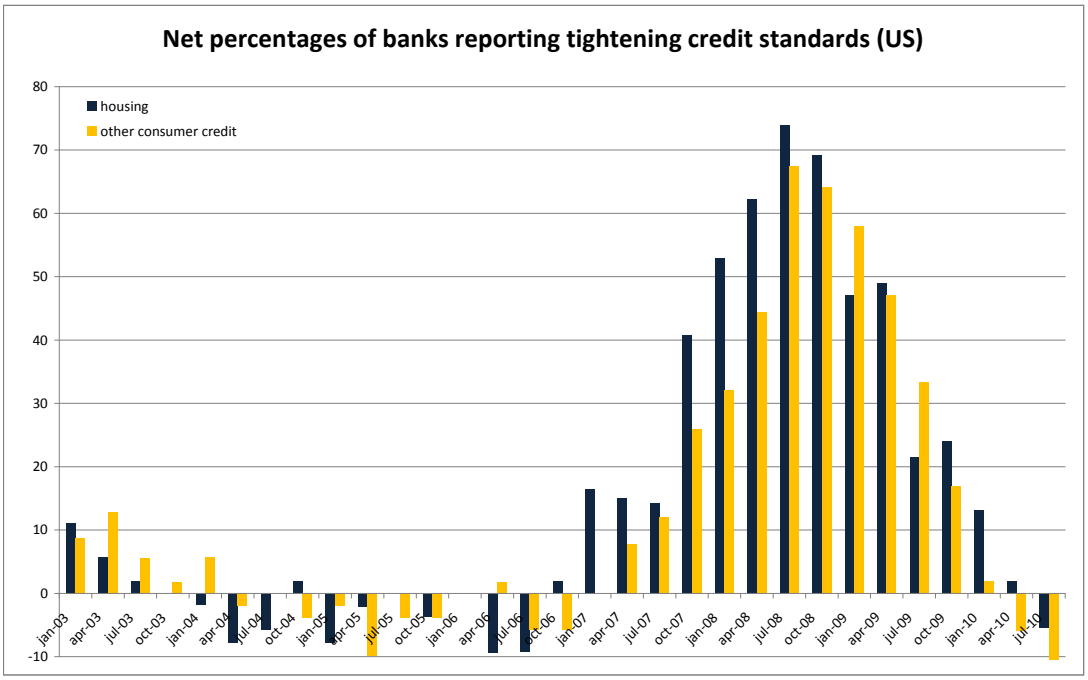

Fig. 2. Credit standards in the US economy.

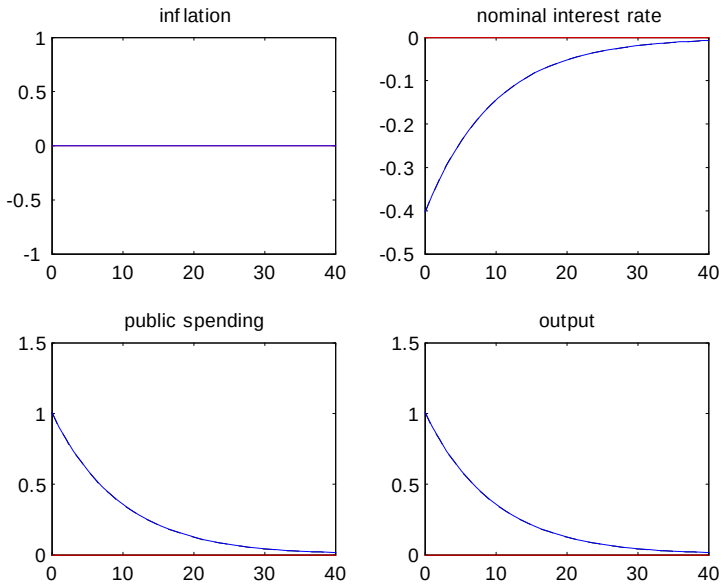

Fig. 3. Ramsey IRFs to a 1% positive technology shock under the baseline model (solid lines) and the RAE model (dashed lines).

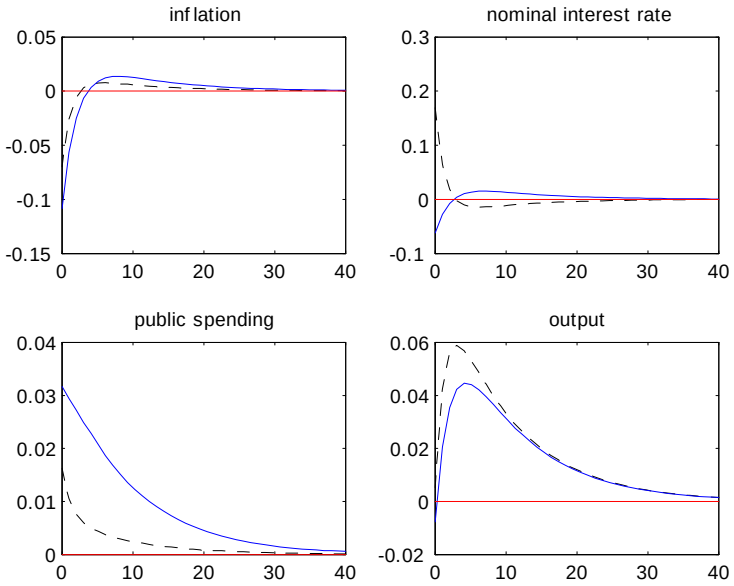

Fig. 4. Ramsey IRFs to a 1% negative markup shock under the baseline model (solid lines) and the RAE model (dashed lines).

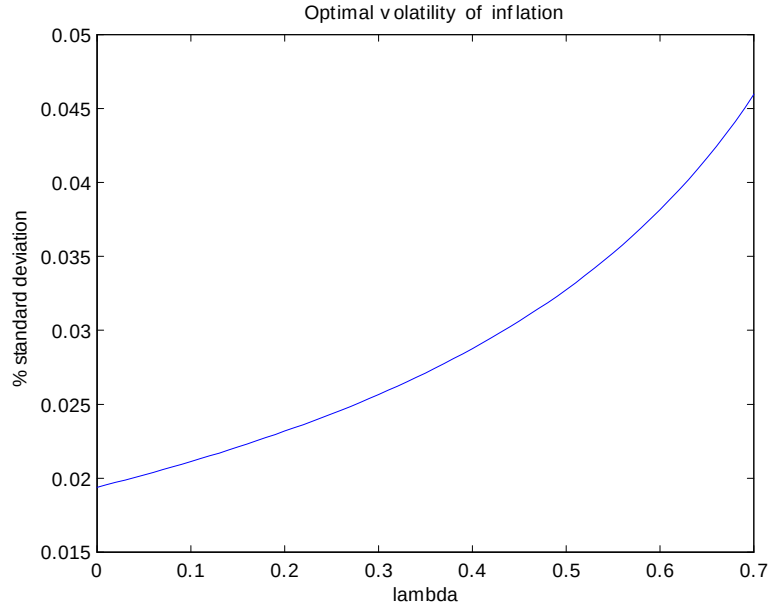

Fig. 5. LAMP and optimal inflation volatility under Ramsey.

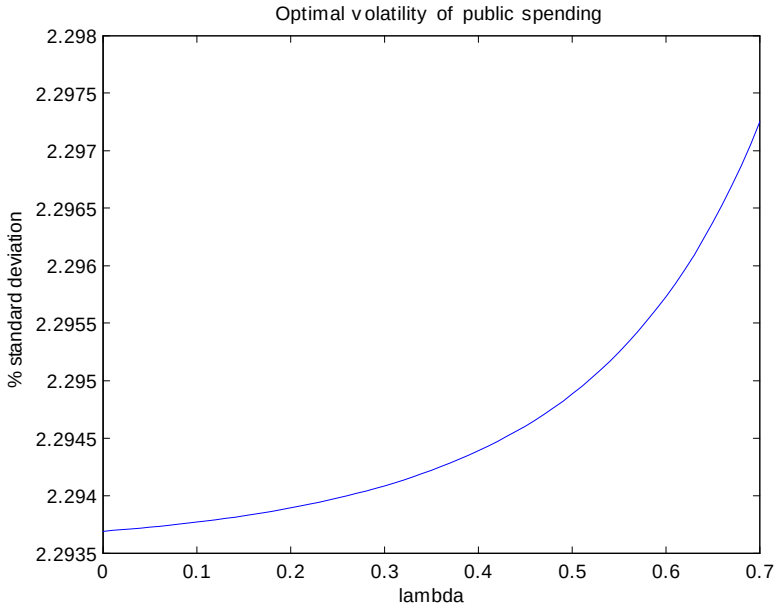

Fig. 6. LAMP and optimal government spending volatility under Ramsey.

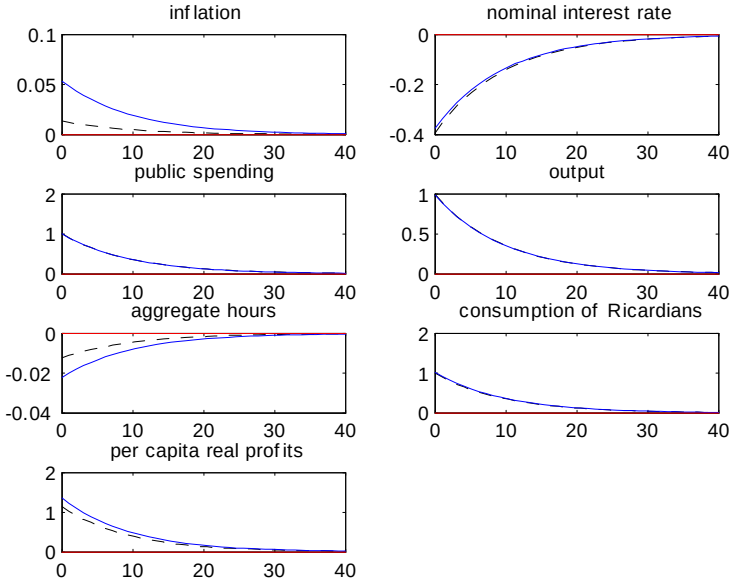

Fig. 7. Nash IRFs in response to a 1% positive technology shock under the baseline model (solid lines) and the RAE model (dashed lines).

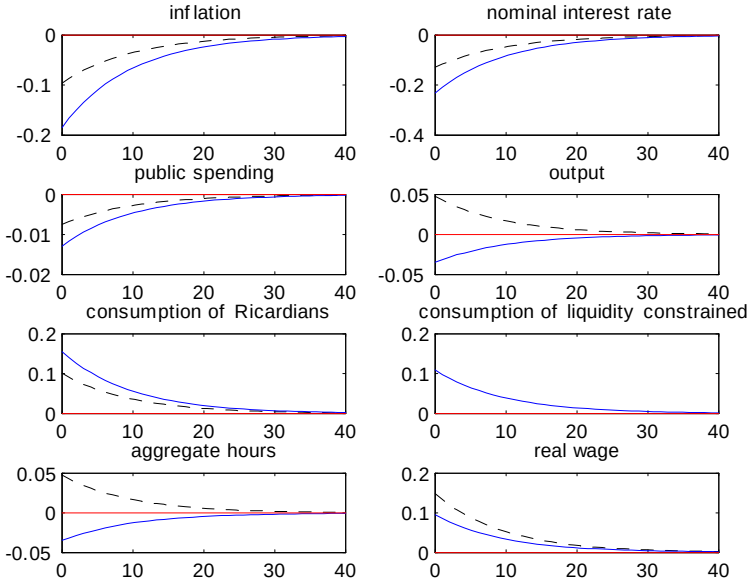

Fig. 8. Nash IRFs to a 1% negative markup shock under the baseline model (solid lines) and the RAE model (dashed lines).

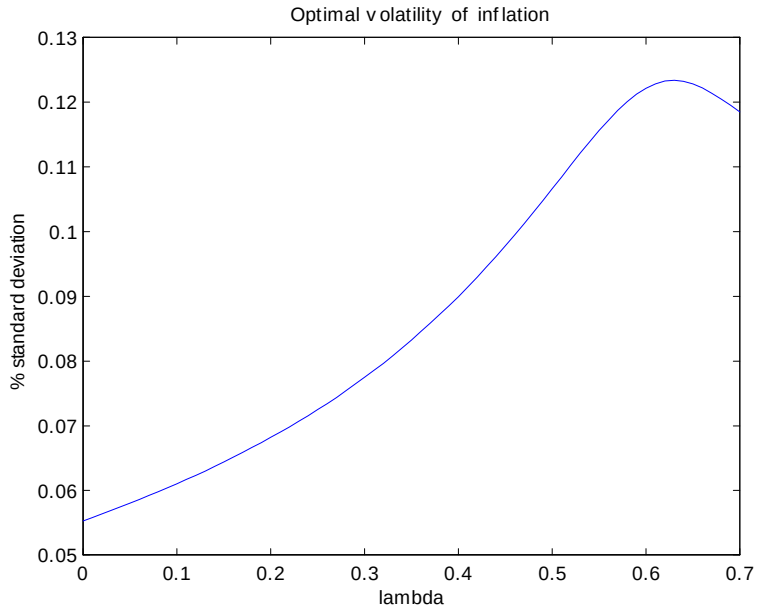

Fig. 9. LAMP and optimal inflation volatility under Nash.

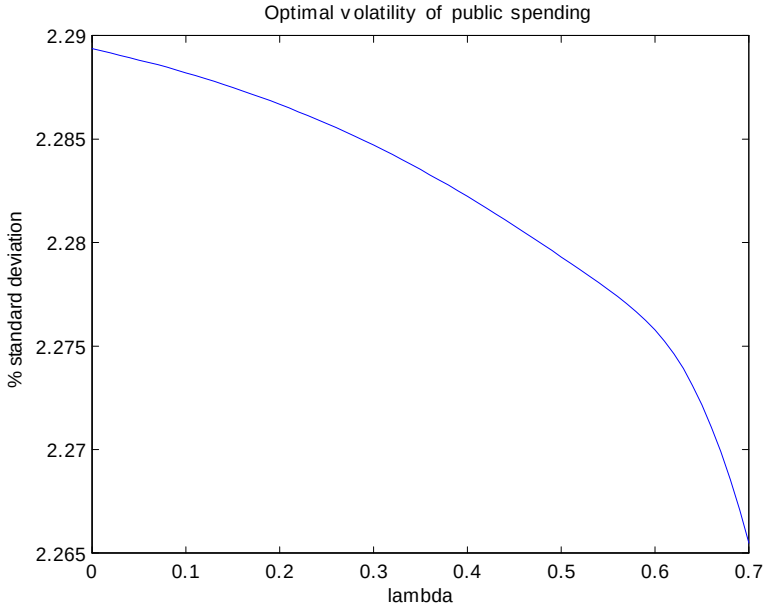

Fig. 10. LAMP and optimal government spending volatility under Nash.

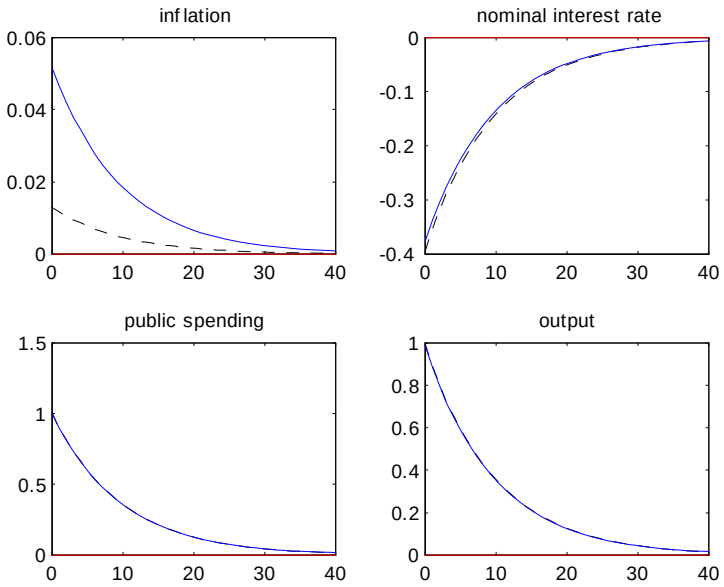

Fig. 11. IRFs to a 1% positive technology shock with Fiscal Leadership and partially conservative monetary policy under the baseline model (solid lines) and the RAE model (dashed lines).

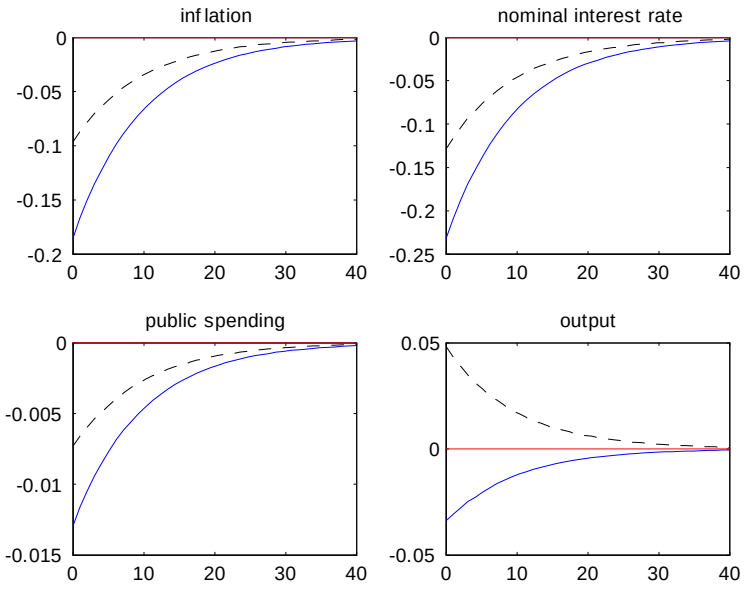

Fig. 12. IRFs to a 1% negative markup shock with Fiscal Leadership and partially conservative monetary policy under the baseline model (solid lines) and the RAE model (dashed lines).

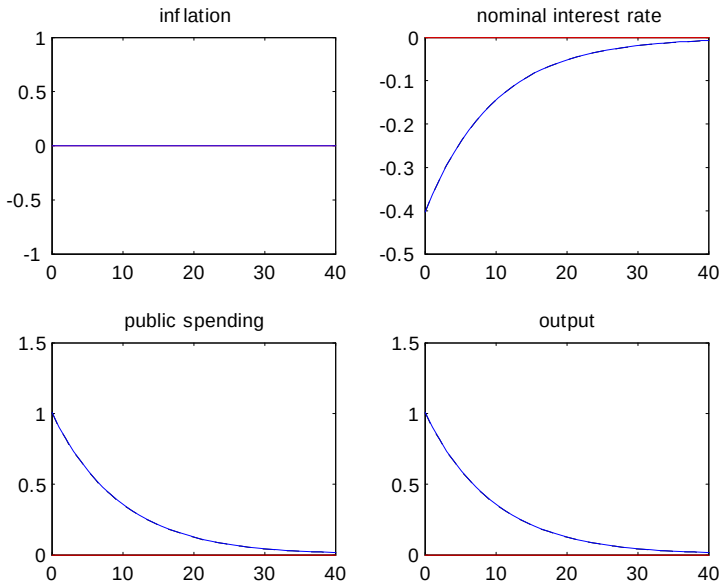

Fig. 13. IRFs to a 1% positive technology shock with Fiscal Leadership and fully conservative monetary policy under the baseline model (solid lines) and the RAE model (dashed lines).

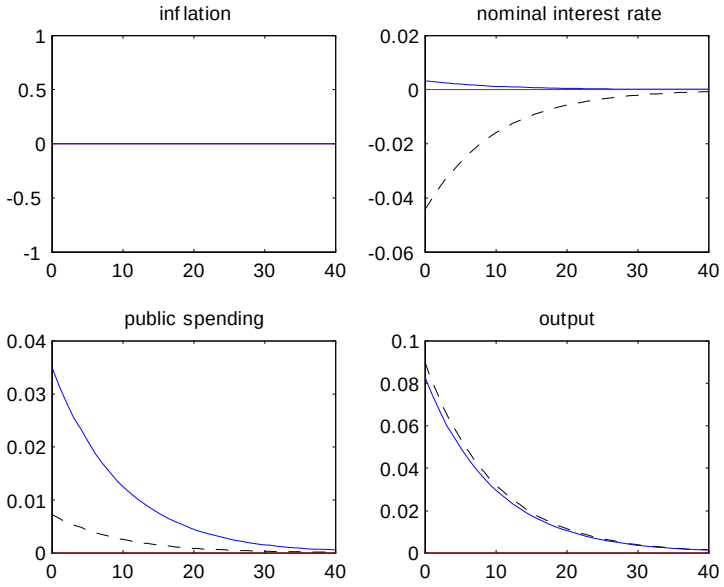

Fig. 14. IRFs to a 1% negative markup shock with Fiscal Leadership and fully conservative monetary policy under the baseline model (solid lines) and the RAE model (dashed lines).

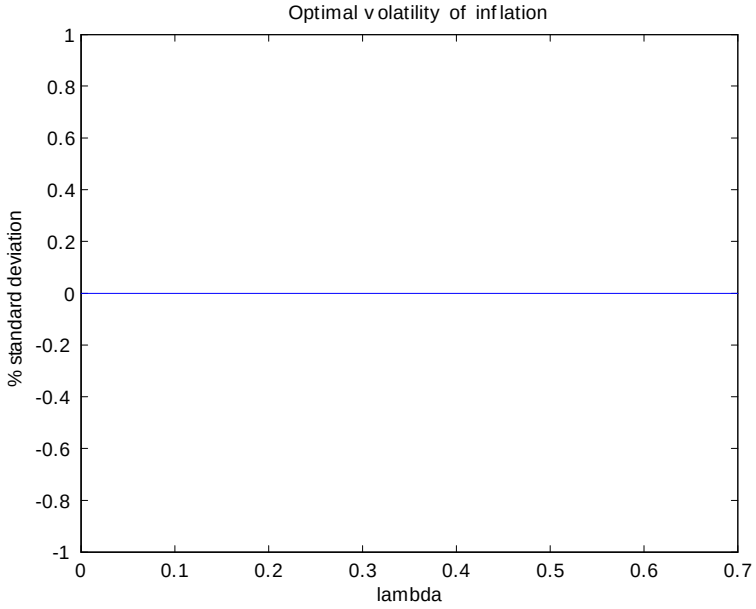

Fig. 15. LAMP and optimal inflation volatility under Fiscal Leadership with fully conservative monetary policy.

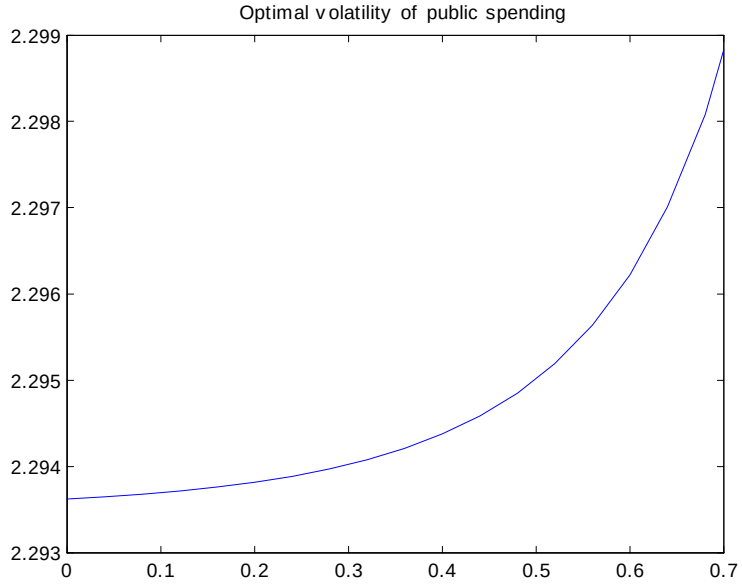

Fig. 16. LAMP and Optimal government spending volatility under Fiscal Leadership with fully conservative monetary policy

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)	varying	
λ (dynamics)	0.5	Campbell and Mankiw (1989) and Galì et al. (2004)
ρ_z	0.9	
ρ_ϵ	0.9	
σ_z	0.01	
σ_ϵ	0.01	

Table 1: Calibration

	RAE,$\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$
π	1.0000	1.0000	1.0000
R	1.0087	1.0087	1.0087
G	0.0400	0.0398	0.0395
Y	0.2001	0.2003	0.2007
C^r		0.1446	0.1448
C^o	0.1600	0.1673	0.1776
N^r		0.2213	0.2211
N^o	0.2000	0.1913	0.1802
D^o	0.0333	0.0477	0.0669

Table 2: Stochastic steady state values under Ramsey

	RAE,$\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$
π	1.0146	1.0222	1.0341
R	1.0234	1.0311	1.0431
G	0.0402	0.0402	0.0403
Y	0.2014	0.2032	0.2068
C^r		0.1450	0.1453
C^o	0.1593	0.1645	0.1675
N^r		0.2215	0.2215
N^o	0.2014	0.1952	0.1921
D^o	0.0313	0.0414	0.0468

Table 3: Stochastic steady state values under Nash

	RAE,$\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$
π	1.0144	1.0220	1.0338
R	1.0233	1.0309	1.0428
G	0.0402	0.0402	0.0403
Y	0.2014	0.2031	0.2067
C^r		0.1450	0.1453
C^o	0.1593	0.1645	0.1676
N^r		0.2215	0.2215
N^o	0.2013	0.1952	0.1919
D^o	0.0314	0.0415	0.0471

Table 4: Stochastic steady state values under Fiscal Leadership and partially conservative monetary policy ($\alpha = 0.5$)

	RAE,$\lambda = 0$	$\lambda = 0.3$	$\lambda = 0.5$
π	1.0000	1.0000	1.0000
R	1.0087	1.0087	1.0087
G	0.0400	0.0398	0.0395
Y	0.2001	0.2003	0.2007
C^r		0.1446	0.1448
C^o	0.1600	0.1673	0.1776
N^r		0.2213	0.2211
N^o	0.2000	0.1913	0.1802
D^o	0.0334	0.0477	0.0669

Table 5: Stochastic steady state values under Fiscal Leadership and fully conservative monetary policy ($\alpha = 1$)

	RAE, $\lambda = 0$	$\lambda = 0.3$			$\lambda = 0.5$		
	total	total	Ricardians	LC	total	Ricardians	LC
Nash	-1.03	-2.30	-3.42	0.38	-5.18	-10.60	0.57
Fiscal Leader with $\alpha = 0.5$	-1.01	-2.26	-3.36	0.38	-5.10	-10.44	0.56

Table 6: Welfare losses from Ramsey allocations in consumption equivalents (percentages)