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Optimal Simple Monetary and Fiscal Rules under Limited Asset Market Participation

The combination of limited asset market participation and consumption habits generates indeterminacy for empirically plausible calibrations of a business cycle model characterized by price and nominal wage rigidities. Equilibrium determinacy is restored by demand management policies based on simple fiscal rules. In this regard, fiscal control of nominal income growth is particularly effective. In addition the complementarity between the Taylor rule and the fiscal feedback on nominal income growth produces relatively large welfare gains, limiting both aggregate and intragroup volatilities.

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THE STANDARD NEW KEYNESIAN framework is characterized by optimizing agents and by a number of nominal and real frictions in goods, labor, and financial markets. Following a seminal contribution by Mankiw (2000), a second strand of New Keynesian literature emphasizes the role of rule-of-thumb (henceforth RT) consumers who do not participate to financial markets and therefore cannot save or borrow. Erceg, Guerrieri, and Gust (2006) in their Sigma model calibrate the share of RT consumers at 50% in order to replicate the dynamic performance of the Federal Reserve Board Global Model. Galì, López-Salido, and Vallés (2007) as well as Furlanetto and Seneca (2009) show that RT consumers can rationalize the empirically observed response of aggregate consumption to public spending shocks. In Furlanetto and Seneca (2011), the RT hypothesis helps to account for recent empirical evidence on productivity shocks. Andrés et al. (2008) show that

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nominal rigidities and RT consumers can rationalize the empirically observed negative correlation between government size and consumption volatility in OECD countries. In Boscà et al. (2009), the combination of RT consumers and consumption habits significantly improves the ability of an otherwise standard search model to reproduce some of the stylized facts characterizing the U.S. labor market. Airaudo (2010) and De Graeve et al. (2010) exploit the RT consumers' assumptions to model asset prices.

Empirical research cannot reject the RT consumer hypothesis. Estimates of structural equations for consumption growth report a share of RT consumers ranging from 26% to 40% (Campbell and Mankiw 1989, Jacoviello 2004). More recent estimates of dynamic stochastic general equilibrium models (Coenen and Straub 2005, Forni, Monteforte, and Sessa 2009) obtain values of approximately 35%. The findings in Johnson, Parker, and Souleles (2006), Shapiro and Slemrod (2009), and Parker et al. (2011) are also consistent with RT assumptions. Critics of the approach might argue that the empirical relevance of RT consumer is bound to gradually decline along with the development of financial markets (Bilbiie, Meier, and Müller 2008). In fact, increasing regulation in the aftermath of the 2008 crisis (OECD 2009) is likely to raise the share of liquidity-constrained households in the near future.

The RT consumers hypothesis has triggered a controversy about the properties that simple and implementable interest rate rules must fulfill in order to guarantee the uniqueness of the rational expectations equilibrium and to maximize social welfare. Earlier contributions based on the representative, optimizing agent framework emphasize the importance of satisfying the Taylor principle (Woodford 2003, Schmitt-Grohè and Uribe 2004, 2007). In contrast, Bilbiie (2008) shows that in a world of flexible nominal wages a sufficiently large share of constrained agents leads to an equilibrium where an interest rate policy based on the Taylor principle cannot ensure model determinacy. This happens because wage responses to labor demand changes have a strong impact on profits, causing an inversion of the IS curve. Colciago (2011) downplays this conclusion; his finding is that wage stickiness limits the sensitivity of real wages to changes in demand and employment. As a consequence, a mild degree of wage stickiness is sufficient to restore the standard Taylor principle even for a very large share of RT consumers. In addition, Ascari, Colciago, and Rossi (2010) find that the optimal monetary policy under sticky wages is unaffected by the presence of RT consumers and tolerates inflation in order to limit nominal wage adjustment costs.

This paper proves that—just like wage stickiness undermines the RT consumer effect outlined in Bilbiie (2008)—consumption habits may restore it. In the modern New Keynesian business cycle models, consumption habits are relied on to explain movements in aggregate consumption data and to generate the "hump-shaped" impulse responses widely recognized as characterizing the responses of output and consumption to demand and supply shocks (see Dennis 2009 and references therein). We show that habits strengthen the effect of aggregate demand changes on the marginal rate of substitution between consumption and labor effort, thereby increasing the elasticity of real wages to employment. The combination of consumption habits and RT households therefore has dramatic implications for model determinacy, resurrecting Bilbiie's inverted Taylor principle for empirically plausible values of the RT consumers share. In addition, the central bank optimal reaction to inflation is at least four times stronger than in Ascari, Colciago, and Rossi (2010). To understand this result consider that, due to consumption habits, output fluctuations generate important redistributive effects between the two consumer groups in spite of wage stickiness. As a result, monetary policy is very aggressive on inflation because stabilizing profit margins becomes relatively more important that limiting nominal wage adjustment costs. In fact the optimal policy now tolerates a substantial amount of nominal wage volatility.

Demonstrating that RT consumers potentially have important policy implications when the central bank is the sole policymaker, we then consider the impact of fiscal rules on the necessary conditions for equilibrium determinacy and on welfare. In our context, the limited-asset market participation hypothesis paves the way for tax policies that stabilize the disposable income of RT households.

Research on simple monetary policy rules under limited-asset market participation has ignored tax policies, with the notable exception of Natvik (2009). In his model, taxes react to the current output gap and their effect on equilibrium determinacy is ambiguous. This happens because the strength of the tax feedback is tied to the public consumption share of GDP, and the scope for model determinacy ultimately depends on whether government consumption is a complement or a substitute for private consumption, whereas the tax policy plays no autonomous role. We relax the constraint imposed on the strength of the tax feedback. Even more important, in addition to the standard feedback on the current output gap, we investigate the performance of rules that react either to real or to nominal income growth. This choice is related to the role of habits, which increase the importance of controlling profit gaps and limiting persistence. All these rules have desirable stabilizing properties, but only nominal income growth targeting restores the Taylor principle even for economies characterized by a large share of RT consumers. This happens because control of output growth limits habit-induced persistence, whereas the contemporaneous feedback on inflation generates a complementarity between the monetary and the fiscal policy rules: both consumer groups now directly react to a contractionary policy stimulus whenever inflation increases and differences in consumption gaps are therefore reduced.

Finally, we turn to welfare analysis under the assumption that utilities of both Ricardian and RT households enter the policymaker objective function. Limited asset market participation requires that macroeconomic policies should control the differences in consumption gaps between the two households groups, in addition to the standard concern for stabilizing the output gap and price and nominal wage inflation rates. Given that RT consumers do not react to interest rate changes, monetary policy alone does a poor job in achieving this latter objective and fiscal activism is in principle necessary. In this regard the complementarity between the Taylor rule and the fiscal feedback on nominal income growth is particularly effective and produces welfare gains that are unequivocally larger than under the other fiscal rules.

Our results concerning tax rules stand in sharp contrast with those obtained in models based on full asset market participation. Schmitt-Grohé and Uribe (2007) argue that optimal fiscal rules should simply ensure debt solvency. Mattesini and Rossi (2010) show that progressive income taxation introduces a monetary policy trade-off between inflation stabilization and output stabilization, and that progressive taxation shrinks the determinacy region when monetary policy implements a Taylor rule, requiring a stronger response to inflation. A similar conclusion is reached when effective tax rates are raised by inflation (Edge and Rudd 2007). These contributions assume complete financial markets and temporary tax adjustments matter only insofar as they affect the supply side of the economy. Our focus instead is on demand management policies which become potentially important under limited asset market participation. In this regard our contribution is related to Hyunseung and Reis (2011) who model tax/transfer schemes in the context of imperfect credit markets and price rigidities.

The remainder of the paper is organized as follows. In Section 1, we introduce and describe the New Keynesian model we use in our analysis. In Section 2, there is an analysis of determinacy and the robustness of the results under alternative calibrations. In Section 3, the performance on simple optimal monetary and fiscal rules is investigated. Section 4 concludes.

1. THE MODEL

We consider a cashless New Keynesian DSGE model with consumption habits and limited asset market participation. Following Galì, López-Salido, and Vallés (2004, 2007), households are characterized by the same utility function, but a distinction can be drawn between the fraction θ of RT consumers and the $(1-\theta)$ Ricardian agents who have unrestricted access to financial markets. The key difference between the two groups concerns individual intertemporal consumption optimization, which is precluded to households who have no access to financial markets.

1.1 Household Preferences

Preferences are defined as follows:

$$U_t^i = E_0 \sum_{t=o}^{\infty} \beta^t \left\{ \ln\left(C_t^i - bC_{t-1}^i\right) - \frac{1}{1+\phi_l}\left(h_t^i\right)^{1+\phi_l} \right\}, \tag{1}$$

where $i : o, rt$ stands for the household type (Ricardian and RT consumers, respectively), β is the discount factor, C_t^i represents total individual consumption, b denotes internal habits, $\phi_l > 0$ is the inverse of the labor supply elasticity, and $h_t^i = (\int_0^1 (h_t^{i,j})^{\frac{\alpha_w - 1}{\alpha_w}} dj)^{\frac{\alpha_w}{\alpha_{w-1}}}$ denotes individual supply of the labor bundle. C_t^i is a standard consumption bundle[1]

$$C_t^i = \left[\int_0^1 \left(c_t^i(z) \right)^{\frac{\eta-1}{\eta}} dz \right]^{\frac{\eta}{\eta-1}} ; \quad z \in [0,1]. \tag{2}$$

The marginal utility of consumption, $\hat{\lambda}_t^i$, is[2]

$$\hat{\lambda}_t^i = \frac{\beta b}{(1-\beta b)(1-b)} E_t \hat{c}_{t+1}^i - \frac{(1+\beta b^2)}{(1-\beta b)(1-b)} \hat{c}_t^i + \frac{b}{(1-\beta b)(1-b)} \hat{c}_{t-1}^i. \tag{3}$$

Ricardian households. Ricardian households maximize (1) subject to the following period budget constraint:

$$P_t C_t^o + \frac{1}{R_t} B_t + E_t \Lambda_{t,t+1} (Q_{t+1}) = B_{t-1} + Q_t + P_t (D_t - S_t) + W_t h_t. \tag{4}$$

In each time period t, they can purchase any desired state-contingent nominal payment Q_{t+1} in period $t+1$ at the dollar cost $E_t \Lambda_{t,t+1} Q_{t+1}$. The variable $\Lambda_{t,t+1}$ denotes the stochastic discount factor between period t and $t+1$. Real profits are denoted by D_t, while B_t is the quantity of nominally riskless bonds purchased in period t at price R_t^{-1} and paying one unit of the consumption numeraire at period $t+1$. $P_t S_t$ represents nominal lump-sum taxes.

The solution for the optimizing household problem is standard. The log-linear Euler equation is

$$\hat{c}_t^o = \left\{ \begin{array}{l} \left(\frac{b}{1+b+\beta b^2} \right) \hat{c}_{t-1}^o - \left(\frac{\beta b}{1+b+\beta b^2} \right) E_t \hat{c}_{t+2}^o \\ + \left(\frac{1+\beta b+\beta b^2}{1+b+\beta b^2} \right) E_t \hat{c}_{t+1}^o - \frac{(1-\beta b)(1-b)}{1+b+\beta b^2} (\hat{r}_t) \end{array} \right\}, \tag{5}$$

where $\hat{r}_t = \hat{R}_t - E_t \hat{\pi}_{t+1}$.

RT households. As pointed out above, RT consumers neither save nor borrow; in each period they entirely consume their labor income net of taxes

$$\hat{c}_t^{rt} = \hat{w}_t + \hat{h}_t - \hat{s}_t. \tag{6}$$

1. Demand for good z therefore is $c_t^i(z) = C_t^i \left(\frac{P_t(z)}{P_t} \right)^{-\eta}$.
2. Hatted variables denote log-deviations from steady state.

1.2 Labor Market

Each labor market j is monopolistically competitive and there is a union j that sets the nominal wage, W_t^j, subject to

$$h_t^j(z) = \left(\frac{W_t^j}{W_t}\right)^{-\alpha_w} h_t(z), \tag{7}$$

where $W_t = (\int_0^1 (W_t^j)^{1-\alpha_w} dj)^{1/(1-\alpha_w)}$ is the standard wage index. Each household i supplies all labor types at the given wage rates[3] and the total number of hours allocated to the different labor markets must satisfy the time-resource constraint

$$h_t^i = \int_0^1 h_t^{i,j} dj = \int_0^1 \left(\frac{W_t^j}{W_t}\right)^{-\alpha_w} h_t dj. \tag{8}$$

As in Galì, López-Salido, and Vallés (2007), we assume that the proportion of RT and Ricardian consumers is uniformly distributed across unions, and demand for each labor type is uniformly distributed across households. Ricardian and non-Ricardian households therefore work for the same amount of time, h_t. We posit that the representative union objective function is a weighted average $(1-\theta, \theta)$ of the utility functions of the two households types, where $\mu_w = \frac{\alpha_w}{(\alpha_w - 1)}$ represents the wage markup.

Sticky wages. In each period, a union faces a constant probability $(1-\lambda_w)$ of being able to reoptimize the nominal wage. Unions that cannot reoptimize simply set their wages equal to the one in the previous period.

Following Colciago (2011), the representative union maximizes[4]

$$L^u = E_t \sum_{s=0}^{\infty} (\beta\lambda_w)^s \left\{ \begin{bmatrix} (1-\theta)\ln\left(C_{t+s}^o - bC_{t+s-1}^o\right) \\ +\,\theta\ln\left(C_{t+s}^{rt} - bC_{t+s-1}^{rt}\right) \end{bmatrix} - \frac{1}{1+\phi_l}(h_{t+s})^{1+\phi_l} \right\}, \tag{9}$$

subject to (4), (6), and (8). The real wage-setting equation in log-linear form is

$$\begin{bmatrix} \frac{\left(1+\beta\lambda_w^2\right)}{(1-\lambda_w)}\hat{w}_t - \beta\frac{\lambda_w}{(1-\lambda_w)}E_t\hat{\pi}_{t+1} \\ +\frac{\lambda_w}{(1-\lambda_w)}\hat{\pi}_t - \beta\frac{\lambda_w}{(1-\lambda_w)}E_t\hat{w}_{t+1} \\ -\frac{\lambda_w}{(1-\lambda_w)}\hat{w}_{t-1} \end{bmatrix} = \begin{bmatrix} (1-\beta\lambda_w)\varphi\hat{h}_t \\ -(1-\beta\lambda_w)\left[\theta\hat{\lambda}_t^{rt} \right. \\ \left. +(1-\theta)\hat{\lambda}_t^o\right] \end{bmatrix}. \tag{10}$$

3. The assumption is that wages always remain above the marginal rate of substitution of all households. Therefore, households are willing to meet the labor demand of firms.

4. It should be noted that the combination of centralized wage setting and wage stickiness introduces an indirect form of consumption smoothing for RT consumers.

1.3 Firms

Good z is produced in monopolistically competitive markets with the following technology

$$y_t(z) = a_t h_t(z),$$

where a_t defines a technology process. Firm z's real marginal costs are:

$$mc_t = (1-\rho)\frac{w_t}{a_t}, \tag{11}$$

where $w_t = \frac{W_t}{P_t}$ is the real wageand ρ is a production subsidy. We make the assumption of an efficient steady state in order to study the welfare properties of the economy without resorting to a second-order approximation to the equations of the model. We therefore posit that the production subsidy ρ brings production at the competitive level.[5] In log-linear form, production and marginal costs are defined as

$$\hat{y}_t = \hat{h}_t + \hat{a}_t, \tag{12}$$

$$\widehat{mc}_t = \hat{w}_t - \hat{a}_t, \tag{13}$$

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right).$$

Note that profits are the inverse of marginal costs deviations from steady state[6]

$$\hat{d}_t = -\widehat{mc}_t. \tag{14}$$

Sticky prices. In each period, firm z faces a probability $(1-\lambda_p)$ of being able to reoptimize its price. All the $(1-\lambda_p)$ firms that reoptimize at time t will face symmetrical conditions and set the same $\widetilde{P}_t$, chosen to maximize a discounted sum of expected future profits

$$E_t \sum_{s=0}^{\infty} \left(\beta\lambda_p\right)^s \Lambda_{t+s}(\widetilde{P}_t - P_{t+s}mc_{t+s})y_{t+s}(z)$$

5. The real wage in the zero-inflation steady state equilibrium is

$$w = \frac{1}{(1-\rho)\,\mu_p} MPL = \mu_w \frac{\psi_l h^{\phi_l}}{[(1-\theta)\,\lambda^o + \theta\lambda^{rt}]},$$

where $\mu_p = \frac{\eta}{(\eta-1)}$ and μ_w, respectively, define the price and wage markups. Since $MPL = 1$ must hold at the efficient steady state, the optimal subsidy is $\rho^* = 1 - \frac{1}{\mu_p\mu_w}$. Following Ascari, Colciago, and Rossi (2010), it can be assumed that in each period the subsidy is entirely financed by lump-sum taxes, T, levied on firms. This, in turn, implies that steady-state firms profits are $D = Y - (1-\tau)h\frac{W}{P} - T = 0$, and both consumption and the marginal rate of substitution are identical for the two consumer groups.

6. Due to the efficient steady state assumption, profits are defined here as a fraction of steady state output.

subject to

$$y_{t+s}(z) = Y^d_{t+s}\left(\frac{\widetilde{P}_t}{P_{t+s}}\right)^{-\eta}, \tag{15}$$

where Y^d_{t+s} is aggregate demand. Straightforward manipulations allow to obtain the log-linear Phillips curve

$$\hat{\pi}_t = \frac{(1-\lambda_p)(1-\beta\lambda_p)}{\lambda_p}\widehat{mc}_t + \beta E_t\hat{\pi}_{t+1}. \tag{16}$$

1.4 Aggregate Resource Constraint

The aggregate resource constraint is

$$\hat{y}_t = \hat{c}_t = (1-\theta)\,\hat{c}^o_t + \theta\hat{c}^{rt}_t. \tag{17}$$

1.5 Policy Rules

Monetary policy follows a standard Taylor rule[7]

$$\hat{R}_t = \phi_\pi\hat{\pi}_t. \tag{18}$$

As noted in the introduction, the RT consumer assumption paves the way for fiscal stabilization policies. To keep complications at a minimum, we neglect cyclical adjustments of public consumption (as in Schmitt-Grohé and Uribe 2007), and assume that fiscal policy is based on the lump-sum tax, S_t, which is levied on households.[8] The government's flow budget constraint in log-linear form is given by[9]

$$\hat{b}_t = R\hat{b}_{t-1} - \hat{s}_t, \tag{19}$$

where $R = \frac{1}{\beta}$ defines the steady state real interest rate. This approach is apparently similar to Natvik (2009) who assumes that $\hat{s}_t$ targets current output deviations from steady state. He investigates how government size affects equilibrium determinacy when public consumption enters the households utility function and the scope for tax policies is restricted because the strength of the fiscal feedback τ_s is tied to the exogenous steady-state ratio of public consumption to GDP. In his framework the determinacy implications of the procyclical tax policy depend on whether public consumption is a complement or a substitute for private consumption. Our focus is

7. We also experimented with several alternative specifications, such as a forward-looking rule, and a rule including a feedback on the output gap, but the results were basically unaffected (results available upon request).

8. It is then straightforward to show that optimizing consumers would not react to cyclical variations of taxes. We have also controlled for supply side effects of the rule by modeling S as a labor income tax. Our conclusions are fully confirmed (results available on request).

9. Both $\hat{s}$ and $\hat{b}$ are defined as percentages of steady-state output.

different as we are interested in investigating how different rules affect determinacy and in identifying the optimal fiscal policy feedbacks associated to such rules.

The fiscal rule is:

$$\hat{s}_t = \tau_s\,(\hat{y}_t - \alpha_1 \hat{y}_{t-1} + \alpha_2 \hat{\pi}_t) + \tau^b \hat{b}_{t-1}. \quad (20)$$

Condition (20) encompasses three alternative specifications that we consider in the paper: (i) when $\alpha_1 = \alpha_2 = 1$ fiscal policy controls nominal income growth; (ii) when $\alpha_1 = 1$, $\alpha_2 = 0$, the fiscal feedback reacts to current output growth; and (iii) when $\alpha_1 = \alpha_2 = 0$ fiscal policy targets the current output deviations from the steady state. Rule 1, our preferred specification, is consistent with empirical evidence suggesting that revenues are more sensitive to output growth than to the output gap and that the real progression of tax rates may be affected by inflation (Auerbach and Feenberg 2000, Auerbach 2009).[10]

1.6 Calibration

The technology process is modeled as in Schmitt-Grohe and Uribe (2007). We set $\beta = (1.03)^{-0.25}$, which implies a steady-state annualized real interest rate of about 3%. The parameter $\phi_l = 1$ is chosen as in Christiano, Eichenbaum, and Evans (2005). Numerical simulations were ϕ_l takes values between 0.2 and 5 confirm our results. Parameter values for consumption habits, price, and nominal wage stickiness are also taken from Christiano, Eichenbau, and Evans ($\lambda_p = 0.6$, $\lambda_w = 0.64$), implying that prices and nominal wages are optimized every 2.5 and 2.8 quarters, respectively. The relatively high frequency of price adjustments "stakes the cards" against the indeterminate equilibrium result. The consumption habit parameter, $b = 0.7$, is taken from Boldrin et al. (2001).[11] Parameters λ_p, λ_w, and b play a key role in our model. The sensitivity of our results to alternative values for these parameters is discussed in Section 3.1

2. DETERMINACY

Bilbiie (2008) shows that when the labor market is competitive and prices are sticky, a sufficiently large share of constrained agents leads to an equilibrium where an interest rate policy based on the Taylor principle cannot ensure model determinacy. Suppose there is a sunspot increase in output that raises marginal costs and inflation. When all consumers are Ricardians, the interest rate reaction generates a negative demand response that is sufficient to rule out the initial output increase as a possible

10. To ensure stability of the debt accumulation process the fiscal rule includes a feedback on $\hat{b}_{t-1}$. In our simulations, coefficient τ^b takes the value 0.02. For a detailed discussion on the stabilizing properties of τ^b in a model with LAMP, see Rossi (Forthcoming).

11. Parameter calibrations are reported in Table 1.

equilibrium. By contrast a relatively large share of RT consumers, coupled with the flexible wage response to increased labor demand, has a strong impact on profits and causes an inverse relationship between $\hat{c}_t^o$ and $\hat{w}_t$.[12] Using (12), (17), and (14) it is easy to see that in equilibrium each optimizing household must consume

$$\hat{c}_t^o = \hat{w}_t + \hat{h}_t + \frac{\hat{d}_t}{1-\theta} = \hat{y}_t - \frac{\theta \hat{w}_t}{1-\theta}. \tag{21}$$

The policy-induced fall in $\hat{c}_t^o$ is therefore consistent with the sunspot increase in output, and the increase in output is validated by the expansion of RT consumption. In this case an inverted Taylor principle ($\phi_\pi < 1$) is required to restore determinacy. Colciago (2011) shows that a mild degree of wage stickiness is sufficient to dampen the Keynesian multiplier effect generated by RT consumers on real wages, restoring the standard Taylor principle even for large values of θ.

Without consumption habits, that is, when we set $b = 0$, our model replicates Colciago's result even if fiscal policy is switched off. By contrast, under our calibration of b, determinacy requires an inversion of the Taylor principle when $\theta > 0.42$ and fiscal policy is inactive (Figure 1). Note that habits raise the sensitivity of wages to employment. In fact, substituting (3), (12), and (17) into (10) we obtain the elasticity of wages with respect to worked hours[13]

$$\frac{\partial \hat{w}_t}{\partial \hat{h}_t} = \frac{(1-\lambda_w)(1-\beta\lambda_w)}{\left(1+\beta\lambda_w^2\right)} \left[\phi_l + \frac{\left(1+\beta b^2\right)}{(1-\beta b)(1-b)} \right]. \tag{22}$$

It is easy to see that habits have a powerful impact on $\frac{\partial \hat{w}_t}{\partial \hat{h}_t}$, which compensates the dampening role of the nominal wage stickiness parameter λ_w. This effect would not matter for determinacy in standard models based on the representative Ricardian agent (Christiano, Eichenbaum and Evans 2005, Schmitt-Grohé and Uribe 2007), but it is quite important here, because it strengthens the income redistribution between the two consumers groups.

Note that habits also weaken the Ricardian agents response to interest rate changes. If we remove the effect of habits from the Euler equation (5) and maintain it in the wage setting equation an inversion of the Taylor principle is required when $\theta > 0.46$. By contrast, if we remove the effect of habits from the wage-setting equation determinacy obtains under the Taylor principle unless $\theta > 0.98$. The basic message of this section therefore is that habit persistence should always be taken into account for determinacy analysis of models that account for limited asset market participation.

12. To grasp intuition one should bear in mind that due to price stickiness, firms profits are the inverse of real marginal costs deviations from steady state.

13. Given lagged variables and the expectations about the future.

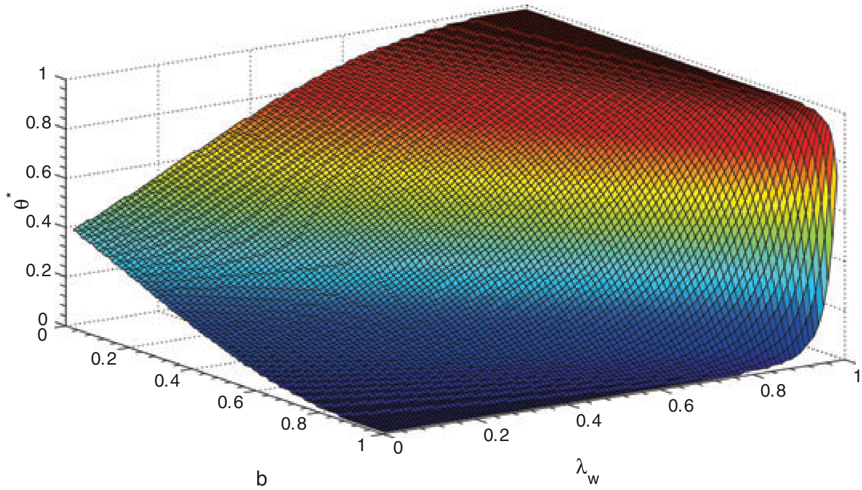

FIG. 1. Threshold Share of RT Households, θ^*, as a Function of Consumption Habits, b, and Wage Stickiness, λ_w.

2.1 *Sensitivity Analysis*

The threshold value θ^* that triggers an inversion of the Taylor principle is crucially affected by three key parameters: the degrees of price and nominal wage stickiness, respectively, λ_p and λ_w, and consumption habits, b. Empirical DSGE models yield different estimates for these parameters. Fernandez-Villaverde and Rubio-Ramirez (2008) obtain a relatively large habit parameter ($b = 0.88$) and find that prices and nominal wages are reoptimized every 11 and 1.8 quarters, respectively. With these parameter values, a low share of RT consumers ($\theta = 0.04$) is sufficient to require an inversion of the Taylor principle. An almost identical result is obtained if we follow Guerron-Quintana (2010) who estimates an even stronger degree of habit formation ($b = 0.91$), but finds that prices and nominal wages are reoptimized every 5.5 and 2.6 quarters, respectively. By contrast, in Smets and Wouters (2003) $b = 0.71$ and prices and wages are reoptimized every 3 and 3.3 quarters, respectively. In this case, the inversion of the Taylor principle is obtained at $\theta = 0.5$.[14] Given our benchmark calibration of b, Figure 1 shows that wage stickiness overturns consumption habits effects when either b is far below existing estimates or when nominal wages are implausibly rigid.

2.2 *The Fiscal Rules and the Taylor Principle*

Rule 1 has substantial implications for dynamic stability (Figure 2). For instance, the Taylor principle holds irrespective of the size of θ when $\tau_s = 0.55$. Figure 2 also

14. These estimated models allow for price and wage indexation to past inflation. Introducing inflation indexation in our model has no effect on the threshold for the value of θ that causes inversion of the Taylor principle. Results available upon request.

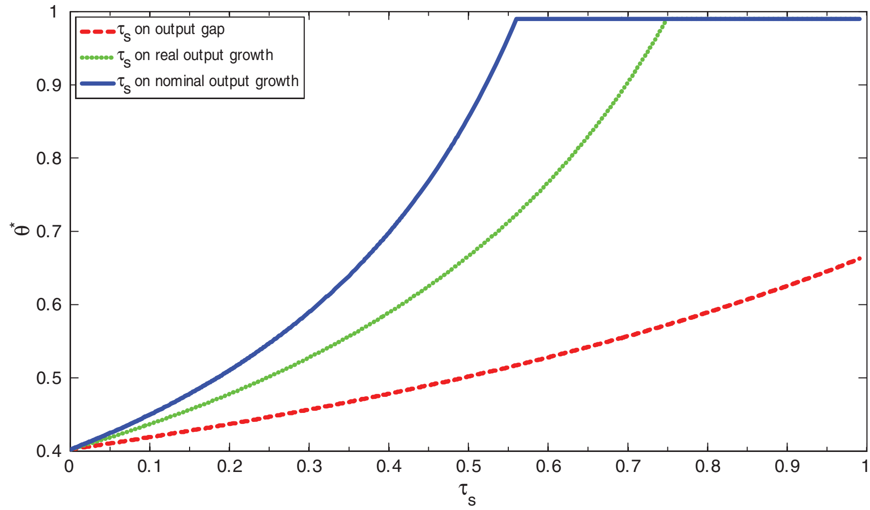

FIG. 2. Threshold Share of RT Households, θ^* as a Function of the Tax Coefficient τ_s.

shows that the fiscal policy effects would be weaker if, instead of reacting to nominal income growth, the tax feedback targeted either real output growth or the current output deviation from steady state, $\hat{y}_t$.

To understand our results, we characterize here output dynamics using (5), (17), and (20).

$$\Delta\hat{y}_t = (y_0)^{-1}\left\{\begin{array}{l} y_1\Delta\hat{y}_{t-1} + y_2E_t\Delta\hat{y}_{t+1} - y_3E_t\Delta\hat{y}_{t+2} - y_4\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) \\ +\,\theta\left[\begin{array}{l} -(\hat{w}_{t-1} - \tau_s\alpha_2\hat{\pi}_{t-1}) + y_5(\hat{w}_t - \tau_s\alpha_2\hat{\pi}_t) \\ -\,y_6E_t(\hat{w}_{t+1} - \tau_s\alpha_2\hat{\pi}_{t+1}) \\ +\,b\beta E_t(\hat{w}_{t+2} - \tau_s\alpha_2\hat{\pi}_{t+2}) \\ +\,\tau^b(-b\Delta\hat{b}_{t-1} + y_7\Delta\hat{b}_t - b\beta E_t\Delta\hat{b}_{t+1}) \end{array}\right] \end{array}\right\}, \quad (23)$$

where $y_0 = b - \theta[b - \tau_s(b + 1 + \beta b^2\alpha_1)]$; $y_1 = b\alpha_1\tau_s$; $y_2 = 1 + \beta b^2 - \theta[1 + \beta b^2(1 - \tau_s) - b\alpha_1\beta\tau_s]$; $y_3 = b\beta[1 - \theta(1 - \tau_s)]$; $y_4 = (1 - \beta b)(1 - b)$; $y_5 = (b + 1 + \beta b^2)$; $y_6 = b(\beta + 1 + \beta b^2)$; $y_7 = 1 + \beta b^2$.

Consider rule 3 ($\alpha_1 = \alpha_2 = 0$). It is easy to see that the tax response to the current output gap strengthens the sensitivity of current output growth to the real interest rate. In addition, the impact of current and expected RT consumption decisions on $\Delta\hat{y}_t$ is unambiguously falling in the fiscal policy parameter τ_s.

It is interesting to compare this result with Natvik (2009), when households utility is separable in consumption of public and private goods. He finds that the threshold value θ associated to indeterminacy is a nonmonotonic concave function of τ_s, reaching a maximum when $\tau_s \simeq 10\%$. This result is easily understood bearing in mind that

TABLE 1
CALIBRATION

Parameter	Value	Description
b	0.7	Degree of habit persistence
β	$(1.03)^{-0.25}$	Subjective discount factor
λ_p	0.6	Price stickiness
λ_w	0.64	Wage stickiness
ϕ_l	1	Inverse of Frisch elasticity
ρ_a	0.855	Persistence of technology process
σ_ε	0.0064	Shock std. deviation

in his model τ_s also defines the size of the government-to-GDP ratio. In this case, a change in τ_s has a twofold effect. On the one hand the variation in government size raises the sensitivity of gross wages (and gross income) to sunspot shocks. On the other hand, the stronger procyclical fiscal feedback dampens the volatility of RT consumption and weakens the correlation between gross and net labor income.

Turning to rule 2 ($\alpha_1 = 1$, $\alpha_2 = 0$), it is easy to see that the desirable effects of procyclical taxation are enhanced when the fiscal rule targets output growth instead of the current output deviation from steady state. In this regard it would be straightforward to show that the stabilizing effect of targeting output growth instead of $\hat{y}_t$ arises in so far as $b \neq 0$. Finally, control of nominal income growth ($\alpha_1 = \alpha_2 = 1$) adds a fiscal feedback on inflation that dampens effect of real wage changes on demand. This happens because a real wage variation causes a change in marginal costs and inflation. The fiscal response to inflation impacts on RT consumption and weakens the link between $\hat{w}_t$ and $\hat{y}_t$ and is quite effective in ensuring that determinacy obtains when monetary policy follows the Taylor principle. Fiscal control of nominal income growth therefore strengthens the complementarity between the monetary and the fiscal policy rules since both consumer groups now directly react to a contractionary policy stimulus whenever inflation increases.

2.3 Model Fit to Business Cycle Statistics

The combination of consumption habits and RT households is crucial for our theoretical results concerning determinacy. Are these two "frictions" also important to fit business cycle statistics? To answer this question one must close the model by choosing plausible parameters for the monetary and fiscal policy rules. Our model is calibrated to the U.S. economy (see Table 1), we therefore select policy parameters which are consistent with monetary and fiscal reaction functions estimated for this economy. The monetary policy feedback, $\phi_\pi = 1.5$, is in line with the estimates obtained in Clarida, Galí, and Gertler (1998). As for the fiscal rule, we focus on the rule that targets the current output deviation from steady state ($\alpha_1 = \alpha_2 = 0$) and set $\tau_s = 0.25$, in order to match the U.S. budgetary response to the output gap estimated in van den Noord (2000).

TABLE 2
MODEL'S FIT

	Data	$\theta = 0,\ \tau_s = 0$	$\theta = 0.4,\ \tau_s = 0$	$\theta = 0.4,\ \tau_s = 0.25$
$\Delta \hat{y}$	1.36	0.1890	5.0598	1.0179
π	0.72	0.3327	1.1615	0.6806
$\hat{h}$	3.11	0.5101	3.5135	1.3034
$\hat{R}$	0.72	0.4990	1.7422	1.0209

Note: Values represent percentage standard deviations.

As showed in Table 2, the representative agent model underestimates the second moments of inflation, hours, and nominal interest rate we found in the data.[15] By contrast, simulated volatility is too high when we include RT consumers and fiscal policy is switched off. Finally, model fit substantially improves when fiscal policy is activated.

3. OPTIMAL SIMPLE MONETARY AND FISCAL POLICY RULES

This paper now turns to the analysis of the optimal simple policy rules, subject to the determinacy constraints of the model. The first step in our analysis is the identification of the solution to the social planner problem.

3.1 The Social Planner Problem

The social planner problem can be characterized as:

$$\max_{C_t^o, C_t^{rt}, h_t^o, h_t^{rt}} E_t \sum_{t=0}^{\infty} \beta^t \left[\begin{array}{c} \theta \left(\log \left(C_t^{rt} - bC_{t-1}^{rt} \right) - \dfrac{\psi_l}{1+\phi_l} \left(h_t^{rt} \right)^{1+\phi_l} \right) \\ + \ (1-\theta) \left(\log \left(C_t^o - bC_{t-1}^o \right) - \dfrac{\psi_l}{1+\phi_l} \left(h_t^o \right)^{1+\phi_l} \right) \end{array} \right]$$

subject to

$$\theta C_t^{rt} + (1-\theta) C_t^o = C_t,$$

$$\theta h_t^{rt} + (1-\theta) h_t^o = h_t,$$

$$Y_t = C_t,$$

15. We take the values for detrended percentage standard deviations in the data from Galì and Rabanal (2004). The standard deviations we compute for our model are detrended (through HP filter) in order to make them comparable with the ones extracted from the time series.

$$Y_t = a_t h_t.$$

By assumption, the two household groups have symmetrical preferences, but RT consumers have no access to financial markets. As a result, from the social planner perspective both consumption and worked hours should be identical for the two groups. In addition, the social planner faces an intertemporal problem due to internal habit formation, which affects socially optimal dynamics in response to shocks. It is easy to demonstrate that the log-linear solutions to the social planner problem, that is, the socially optimal deviations from steady state, are $(\hat{c}_t^o)^* = (\hat{c}_t^{rt})^* = (\hat{c}_t)^* = (\hat{y}_t)^*$, $(\hat{h}_t^o)^* = (\hat{h}_t^{rt})^*$, $\hat{w}_t^* = \hat{a}_t$, and

$$\left(\phi_l + \frac{(1+\beta b^2)}{(1-\beta b)(1-b)}\right)\hat{y}_t^* = \frac{\beta b}{(1-\beta b)(1-b)}\hat{y}_{t+1}^* + \frac{b}{(1-\beta b)(1-b)}\hat{y}_{t-1}^* + (\phi_l + 1)\,\hat{a}_t. \quad (24)$$

Given (24), it would be straightforward to show that consumption habits cause an "hump-shaped" socially optimal output response to shocks.

3.2 *The Policymaker's Welfare Function*

Following Bilbiie (2008) and Ascari, Colciago, and Rossi (2010), the policymaker's period objective function assigns weights θ, $(1-\theta)$ to utilities of the two households groups

$$W_t = \left\{\left[(1-\theta)\ln\left(C_t^o - bC_{t-1}^o\right) + \theta\ln\left(C_t^{rt} - bC_{t-1}^{rt}\right)\right] - \frac{\psi_l}{1+\phi_l}(h_t)^{1+\phi_l}\right\}. \quad (25)$$

We derive the second-order approximation[16] to (25) around the efficient steady state, and then re-express it as deviations from the solutions to the social planner problem, obtaining the discounted value of the central bank loss function: [17]

$$L_t \approx -\frac{1}{2}\frac{(1-\beta b)}{(1-b)}\sum_{s=0}^{\infty}\beta^s \left[\begin{array}{l} \frac{(1-b)}{(1-\beta b)}\left[\begin{array}{l}\theta\left(\hat{x}_{t+s}^{rt} - \hat{x}_{t+s}^*\right)^2 \\ \quad + (1-\theta)\left(\hat{x}_{t+s}^o - \hat{x}_{t+s}^*\right)^2\end{array}\right] \\ + \phi\left(\hat{y}_{t+s} - \hat{y}_{t+s}^*\right)^2 \\ + \frac{\alpha_w}{\kappa_w}\left(\hat{\pi}_{t+s}^w\right)^2 + \frac{\eta}{\kappa_p}\left(\hat{\pi}_{t+s}\right)^2 \end{array}\right] + tip + O(||\xi||^3), \quad (26)$$

16. Here we follow Benigno and Woodford (2003).

17. The derivation of (26) strictly follows Ascari, Colciago, and Rossi (2010) and Leith, Moldovan, and Rossi (2012). Detailed derivation is available upon request.

where $\hat{x}^{*}_{t+s} = \frac{1}{(1-b)}\hat{y}^{*}_{t+s} - \frac{b}{(1-b)}\hat{y}^{*}_{t+s-1}$, $\hat{x}^{i}_{t+s} = \frac{1}{(1-b)}\hat{c}^{i}_{t+s} - b(1-b)\hat{c}^{i}_{t+s-1}$, $\kappa_p = \frac{(1-\lambda_p)(1-\beta\lambda_p)}{\lambda_p}$, and $\kappa_w = \frac{(1-\lambda_w)(1-\beta\lambda_w)}{\lambda_w}$. Straightforward manipulations of (26) show that

$$\left[\theta\left(\hat{x}^{rt}_{t+s} - \hat{x}^{*}_{t+s}\right)^2 + (1-\theta)\left(\hat{x}^{o}_{t+s} - \hat{x}^{*}_{t+s}\right)^2\right]$$
$$= \left(\hat{x}^{o}_{t+s} - \hat{x}^{*}_{t+s}\right)^2 + \theta\left[\left(\hat{x}^{rt}_{t+s} - \hat{x}^{o}_{t+s}\right)^2 + \left(\hat{x}^{rt}_{t+s} - \hat{x}^{o}_{t+s}\right)\left(\hat{x}^{o}_{t+s} - \hat{x}^{*}_{t+s}\right)\right]. \qquad (27)$$

The policymaker is therefore concerned with the differences in consumption utility, $(\hat{x}^{rt}_{t+s} - \hat{x}^{o}_{t+s})$, between the two consumer groups. These are determined by firm profits and may arise only to the extent that marginal costs gaps are tolerated.

3.3 Monetary Policy without Fiscal Stabilization

The optimization problem consists in deriving the strength of the policy parameter ϕ_π, which minimizes (26) subject to the behavior of households, wage setters and firms in response to a technology shock. As in Schmitt-Grohé and Uribe (2004, 2007) who arbitrarily limit the attention to policy coefficients in the interval [−3,3],[18] we restrict the admissible range of ϕ_π, but we allow for the interval [−10,10] in order to enhance the differences of our results with theirs. Our results are obtained using the parameter values presented in Table 1.[19]

Consider first a situation where all agents are Ricardians, wages are flexible, and there are no consumption habits. In this case the policymaker is only concerned with stabilization of profit margins at the efficient steady state value and monetary policy is aggressive, $(\phi^{*}_{\pi}(\theta = b = \lambda_w = 0) = 10)$. When wages are sticky the strength of the inflation coefficient in (18) falls dramatically, $\phi^{*}_{\pi}(\theta = b = 0, \lambda_w = 0.64) = 2.4$. This happens because optimal policy now tolerates inflation in order to limit wage adjustment costs (see Erceg, Guerrieri, and Gust 2006). At this stage, introducing RT consumers has a minor impact on the optimal rule: $2.4 < \phi^{*}_{\pi}(\lambda_w = 0.64, 0 < \theta < 0.42, b = 0) \leq 2.8$. Similarly, the policy rule does not change much when habit frictions are introduced but RT consumers are absent, $\phi^{*}_{\pi}(\lambda_w = 0.64, \theta = 0, b = 0.7) = 3.9$. By contrast, the combination of habits and RT consumers requires a larger ϕ^{*}_{π}, which rapidly grows with θ (Figure 3). In fact, habits increase the sensitivity of real wages to current employment levels (see (22)) and an increasing share or RT households strengthens the redistributive effects of wage changes between the two consumer groups ($\hat{c}^{o}_{t+s} - \hat{c}^{rt}_{t+s} = \frac{\hat{d}_{t+s}}{1-\theta} = -\frac{\hat{w}_{t+s}}{1-\theta}$). Given (27), the policymaker's concern with such differences also increases with θ. As a result, the anti-inflation

18. This choice is justified by the idea that rules characterized by stronger interest rate reaction to changes in inflation are difficult to communicate to the public and therefore unlikely to be implemented in practice (Schmitt-Grohe and Uribe 2007).

19. Optimal policy coefficients are obtained numerically, following Soderlind (1999). Optimal coefficients in the monetary rule are the result of a grid search in the interval [−10,10] with step 0.1. Optimal fiscal coefficients are searched in the interval (0,1) with step 0.01.

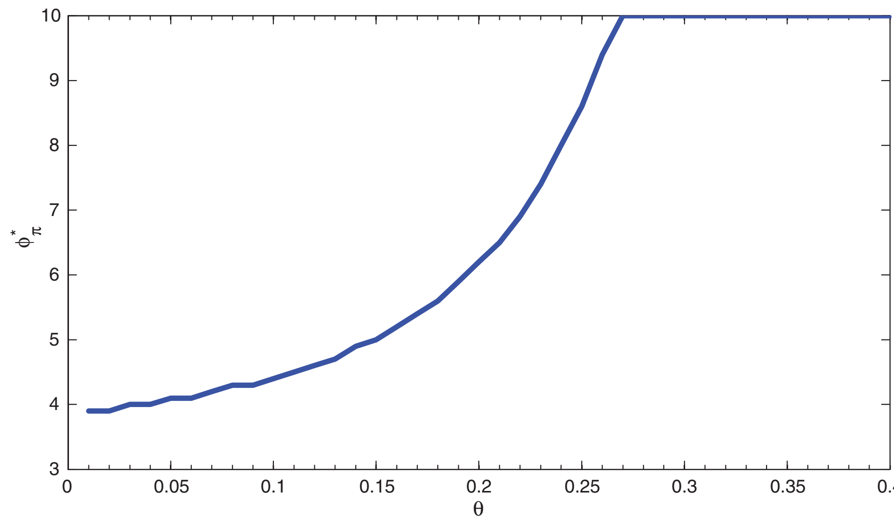

FIG. 3. Optimal Interest Rate Response to Inflation as Function of the Share of RT Households.

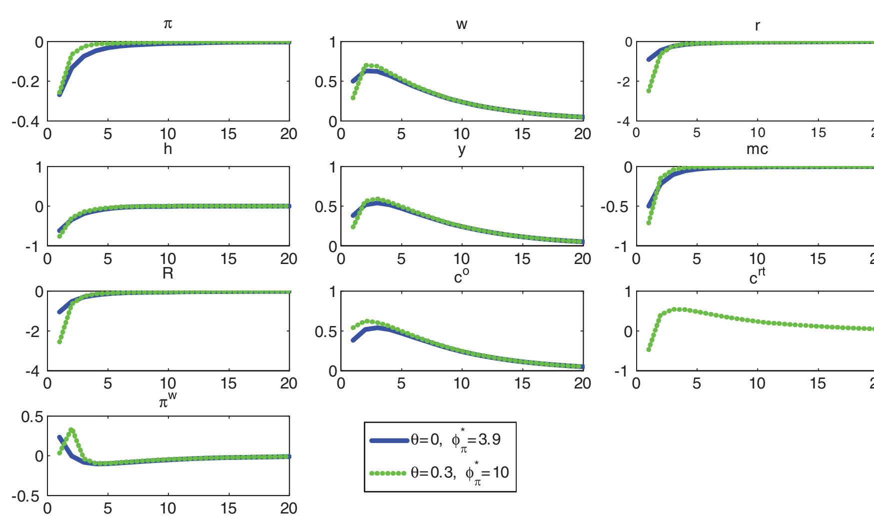

FIG. 4. Impulse Responses to a 1% Positive Productivity Shock (Percentage Deviations from Steady State).

policy is more aggressive because stabilizing profit margins becomes relatively more important that limiting nominal wage adjustment costs.

Figure 4 displays impulse response functions (IRFs henceforth) to a positive technology shock that obtain under $\phi^*_\pi(\lambda_w = 0.64, \theta = 0, b = 0.7) = 3.9$ (blue lines) and $\phi^*_\pi(\lambda_w = 0.64, \theta = 0.3, b = 0.7) = 10$ (green dotted lines). Due to the sluggish price

TABLE 3

PERCENTAGE STANDARD DEVIATIONS UNDER THE OPTIMAL MONETARY POLICY

	$\hat{y}$	π	$\hat{h}$	$\hat{R}$	$\hat{w}$	$\hat{r}$	$\hat{c}^{o}$	$\hat{c}^{rt}$	π^{w}	$\hat{d}$
$\theta = 0$	0.49	0.173	0.417	0.677	0.5740	0.589	0.49	–	0.188	0.321
$\theta = 0.3$	0.519	0.157	0.486	1.574	0.6017	1.535	0.573	0.638	0.25	0.438

Note: Values represent percentage standard deviations.

TABLE 4

OPTIMAL POLICY PARAMETERS

	$\theta = 0.25$			$\theta = 0.3$			$\theta = 0.4$		
	τ_s^*	ϕ_π^*	G^*	τ_s^*	ϕ_π^*	G^*	τ_s^*	ϕ_π^*	G^*
Rule 1	0.45	5.7	0.16	0.57	6	0.4	0.74	6.7	0.97
Rule 2	0.99	10	0.09	0.99	10	0.20	0.99	10	0.94
Rule 3	0.99	8.8	0.10	0.99	10	0.29	0.99	10	0.95

Note: G^* represents the percentage welfare gain with respect to the case of no fiscal stabilization

adjustment mechanism, output initially increases and worked hours fall irrespective of the value imposed on θ. This is in line with the empirical findings of Galì (1999), Basu, Fernald, and Kimballet (2006), and Canova, López-Salido, and Michelacci (2010). Monetary policy cannot avoid substantial consumption differences between the two consumer groups when $\theta = 0.3$. Optimizing consumers increase demand because expected future consumption grows and because the real interest rate falls. In contrast, RT consumer demand is constrained by current labor income. However, for both groups actual consumption is equal to current income because there is no capital in the model. The surge in profits therefore explains why optimizing households can increase their consumption. Table 3 shows that when $\theta = 0.3$ the strong policy feedback manages to limit inflation volatility but cannot avoid an increase in volatility for all the remaining variables, and mainly for nominal wage inflation, $\hat{\pi}^{w}$, and profits.

3.4 Optimal Monetary and Fiscal Rules

In this case coefficients ϕ_π^* and τ_s^* are chosen to minimize (26) conditional to the fact that the fiscal rule alternatively controls nominal income growth (rule 1, $\alpha_1 = \alpha_2 = 1$), real income growth (rule 2, $\alpha_1 = 1, \alpha_2 = 0$), and the current output gap (rule 3, $\alpha_1 = \alpha_2 = 0$). All the fiscal rules reduce welfare losses relative to the benchmark regime where $\tau_s = 0$, the obtained welfare gains increase in θ, and $L(\alpha_1 = \alpha_2 = 1) < L(\alpha_1 = \alpha_2 = 0) < L(\alpha_1 = 1, \alpha_2 = 0)$ (Table 4). Under rules 2 and 3 coefficients ϕ_π^* and τ_s^* reach the maximum admissible values, whereas

TABLE 5

Percentage Standard Deviations under the Optimal Policy

	No fiscal policy	Fiscal rule 3	Fiscal rule 2	Fiscal rule 1
$\hat{y}$	0.5189	0.5042	0.4867	0.4957
π	0.1574	0.1619	0.1910	0.1651
$\hat{h}$	0.4862	0.4600	0.5226	0.4427
$\hat{R}$	1.5741	1.6188	1.9097	0.9905
$\hat{w}$	0.6017	0.5847	0.5598	0.5758
$\hat{r}$	1.5347	1.5623	1.8454	0.9223
$\hat{c}^{o}$	0.5726	0.7840	0.6034	0.5175
$\hat{c}^{rt}$	0.6377	0.4066	0.7574	0.4927
π^{w}	0.2498	0.1830	0.1644	0.1604
$\hat{s}$	–	0.5133	0.2250	0.1858
$\hat{d}$	0.4381	0.3922	0.4707	0.3608

Note: Values represent percentage standard deviations under benchmark calibration and $\theta = 0.3$

control of nominal income growth is associated to lower policy parameters for both monetary and fiscal policy. The lower values observed for ϕ_{π}^{*} and τ_{s}^{*} under rule 1 are easily understood taking into account the complementarity between monetary and fiscal policy that obtains when this rule is implemented (see (23)). Table 5 shows that control of nominal income growth obtains a substantial reduction in the volatility of profits, wage inflation, and Ricardian households consumption. This comes at the cost of a minor increase in inflation volatility. In addition, under this rule we observe a dramatic fall of RT consumption volatility, which is now identical to the one observed for Ricardian agents. Rule 3 has similar effects with the notable exception of Ricardian agents' consumption volatility, that increases dramatically. Rule 2 dampens the volatility of output and the real wage, but has adverse effects on the remaining variables. In Figure 5(a) we plot the IRFs under different the fiscal rules. It is interesting to note that the three fiscal rules have different effects on consumption dynamics of the two consumers groups. Under rules 2 and 3 the tax burden increases, inducing a fall in RT consumption relative to the case of no fiscal policy action.[20] This, in turn, limits wage dynamics and dampens marginal costs. The beneficial effect of taxes on profits strengthens the initial increase in the consumption of optimizing households. The reduction in aggregate consumption volatility associated to these rules is therefore due to a composition effect. Rule 1, which reacts to the inflation fall, works quite differently. In fact the fiscal feedback on nominal income growth delivers the tax reduction necessary to raise consumption of RT agents in response to the productivity increase. The relative merits of rule 1 are apparent from the analysis of Figure 5(b), where variables are defined as gaps from socially optimal deviations from steady state.

20. In this regard, rule based on feedback on $\hat{y}_t$ is particularly penalizing for RT consumers.

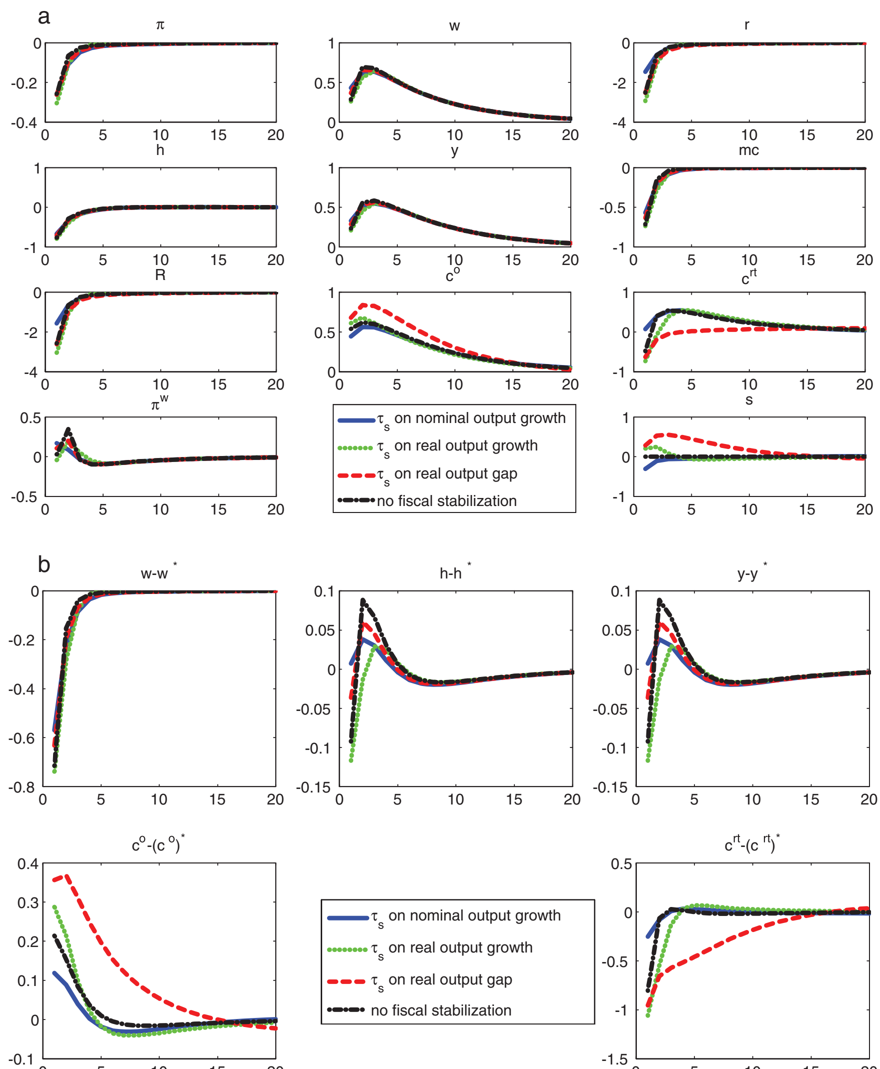

FIG. 5. (a) Impulse Responses to a 1% Positive Productivity Shock (percentage deviation from the steady state); (b) Impulse Responses to a 1% Positive Productivity Shock (gaps from socially optimal deviation from steady state).

4. CONCLUSION

The key message is that limited asset market participation has potentially strong policy implications when the central bank is the sole policymaker, but a well-crafted system of automatic fiscal stabilizers dampens the undesirable effects of limited asset market participation.

The fiscal rules we consider are akin to the so-called automatic stabilizers, that is, those elements of fiscal policy that react to the business cycle without requiring discretionary fiscal policy action. Automatic stabilizers characterize modern market economies and their working is typically associated to a reduction in the volatility of output and consumption (Fatas and Mihov 2001, 2010, Dolls, Fuest, and Peichl 2010, Debrun, Pisani-Ferry, and Sapir 2008, Debrun and Kapoor 2010). Our contribution provides a theoretical background to the policy-oriented literature that sees automatic stabilizers as an important component of the future macroeconomic policy framework (Baunsgaard and Symansky 2009, Blanchard et al. 2010).

Our results also sound a note of caution, suggesting that fiscal rules should be carefully designed. We emphasize the desirability of linking taxes to inflation and to income growth in order to restore the Taylor principle and to limit differences in consumption gaps between the two households groups. This conclusion supports Auerbach's (2009) statement that the U.S. policy of introducing full inflation indexation of the individual income tax—as well as the reduction in marginal tax rates—is likely to have complicated the task of monetary policy in the aftermath of the 2008 financial crisis, eventually forcing the government to implement a strongly discretionary fiscal action.

Further research should investigate the optimal design of automatic stabilizers in medium-scale models, accounting for both a richer set of tax instruments and counter-cyclical public consumption expenditure.

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