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Abstract

This paper studies the performance of monetary policy under alternative fiscal regimes in a dynamic New Keynesian optimizing general equilibrium model with wealth effects. The interactions between fiscal policy and interest rate rules are shown to have relevant implications for the existence of a unique rational expectations equilibrium. When calibrated to Euro Area quarterly data, the model simulation results show that the preferred monetary-fiscal regime for inflation stabilization consists of a generalized Taylor rule with a low degree of inertia coupled with a public debt-GDP ratio targeting rule.

Keywords: Fiscal Policy Rules; Monetary Policy; Wealth Effects; Simulations.

JEL classification: E52; E58; E63.

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1 Introduction

Stability in dynamic macroeconomic models and interest rate rules *à la* Taylor (1993) have recently become one of the most debated issue in the literature[1]. A well known result in New Keynesian models is the so-called 'Taylor principle': the long-run response of the short term interest rate to inflation must be more than proportional in order to achieve real determinacy (see Taylor, 1999; Woodford 2001a, 2003). It is also argued that interest-rate smoothing may improve the performance of monetary policy, since it positively influences private-sector inflationary expectations by introducing history-dependence (see McCallum and Nelson, 1999; Rotemberg and Woodford, 1997, 1999; Woodford, 1999).

The framework employed has typically been the infinite horizon representative agent setup. Hence, there is not relevance of alternative fiscal policies for monetary policy design. One way to explain the links between fiscal policy, monetary policy and price stability is provided by the so-called 'fiscal theory of the price level' (FTPL) (see Leeper, 1991; Woodford, 1994; 1995; 2001b; Sims, 1994). More recently, the FTPL has been extended to the Dynamic New Keynesian (DNK) framework by Woodford (2003) to study the conditions for equilibrium determinacy. Notably, the theoretical validity of this approach in explaining the influence of fiscal variables on price level dynamics applies only to the case of 'non-Ricardian' fiscal regimes[2], where the public sector is expected not to satisfy the solvency condition for all sequences of the price level.

The framework of analysis of the present paper permits to analyze the implications of both 'Ricardian' and 'non-Ricardian' fiscal regimes. The main aim is to evaluate the effects of different fiscal policy regimes on the performance of interest rate rules of the Taylor-type in a modified DNK macroeconomic model, incorporating wealth effects.

A number of recent papers have also sought to consider the interactions between monetary and fiscal rules, in the context of models with overlapping generations, sticky prices and wealth effects; important examples include Leith and Wren-Lewis (2000, 2002), and Bénassy, (2003). Our approach is different in several respects. First, we extend the issue of the interactions between fiscal and monetary policy in a stochastic discrete time version of the Yaari (1965)-Blanchard (1985) overlapping generations (OLG) model[3], allow-

[1]See, for example, McCallum (1999), Taylor (1999) and Woodford (2003).

[2]The distinction between 'Ricardian' and 'non-Ricardian' regimes follows the terminology introduced by Woodford (1995).

[3]We should make clear that a stochastic version of the OLG setup allows us to examine the effects of shocks and clarifies the difference with respect to the infinite horizon DNK

ing for nominal rigidities as modelled by Calvo (1983). Second, we calibrate a linearized version of the model to quarterly Euro Area data. Third, we show how the interactions between fiscal regimes and interest rate rules affect the conditions for the existence of a unique rational expectations equilibrium. Finally, we consider a number of combinations between fiscal regimes and interest rate rules in response to shocks to public expenditure, costs, productivity and monetary disturbances.

The main results of the paper are the following. A 'passive' monetary policy (i.e., that does not satisfy the 'Taylor principle') may ensure determinacy in rational expectations equilibrium under both 'Ricardian' and 'non-Ricardian' fiscal policy regimes. Simulation results show that the combination of a generalized Taylor rule with low inertia and a public debt-GDP ratio target is the most desirable fiscal-monetary policy mix to stabilize inflation. It is also shown that different 'Ricardian' fiscal rules generate similar outcomes only when monetary policy overreacts to inflation.

The negative consequences of high government debt and deficits on price stability and the potential interrelations between fiscal and monetary policy are a debated issue in the European Monetary Union. It is argued that the fiscal restrictions, defined in the Maastricht Treaty, are necessary for the European Central Bank to pursue the primary objective of price stability. The present paper illustrates how different fiscal regimes may influence the performance of monetary policy in terms of output and inflation stabilization. Our results give theoretical support to the view that sound debt policies are necessary for price stability and provide extra reasons to promote fiscal convergence in the Euro Area.

The paper is organized as follows. In Section 2 we present the DNK optimizing model with OLG. Equilibrium under both flexible and sticky prices is illustrated in Section 3. Section 4 describes alternative fiscal regimes. In Section 5 we calibrate the model. The implications of alternative fiscal regimes on the performance of interest rate rules are illustrated in Section 6. The main conclusions are summarized in Section 7.

2 A Sticky Price Model with Wealth Effects

This Section presents a 'New Keynesian' model extended to account for wealth effects. The economy is populated by four types of agents: consumers, firms, the monetary authority and the government. The demand side is based on an extended discrete-time version of the Yaari (1965)-Blanchard (1985)

models.

overlapping generations model[4], where both real money balances and labor supply decisions are explicitly included. According to Sidrauski (1965) and Brock (1985), money enters the utility function since it provides transaction services[5]. Private agents face uncertainty on their life length and on the future time paths of the economic variables. This kind of extension allows us to build a stochastic dynamic general equilibrium framework to evaluate monetary policy. The supply side is described by a monopolistically competitive goods market (see Dixit and Stiglitz, 1977) with staggered nominal price setting *à la* Calvo (1983)[6]. It is also assumed that individuals have some market power in the labor market[7], following Clarida, Galì and Gertler (2002) and Benigno and Woodford (2003).

2.1 Consumers optimization

Agents have identical preferences and face the same constant probability of death, $\vartheta \in (0,1)$, in each time period. Population is assumed to be constant over time and the total size is normalized to one. It follows that at each time period a new generation of size ϑ is born and a fraction of equal size of the population dies. Since there is no bequest motive and lifetime is uncertain, a life insurance market is assumed to be operative as in Blanchard (1985). In particular, at each time period competitive insurance companies collect financial assets from deceased members of the population and pay fair premia to survivors. Given the structure of the population, the zero profit condition in the insurance sector implies that the gross return on the insurance contract, incorporated in the individual flow budget constraint, is given by $(1-\vartheta)^{-1}$.

All agents face stochastic sequences of prices, interest rates, taxes and profit shares, and decide on consumption, real money holdings, labor supply and wealth accumulation. Total financial wealth is composed of real money balances and government bonds. For simplicity, labor income, profit shares and lump-sum taxes are age-independent, while newly born agents do not hold any financial assets.

[4]A discrete-time version of the Yaari-Blanchard model has been previously described by Frenkel and Razin (1987).

[5]A monetary version of the Blanchard Yaari framework was developed by Marini and van der Ploeg (1988). For a discrete-time version, see Cushing (1999).

[6]Smets and Wouters (2002) incorporate the Yaari-Blanchard framework into an open economy DNK model, to study the implications for optimal monetary policy of an imperfect pass-through in the Euro Area.

[7]This feature of the model provides an analytically tractable way to characterize a short run trade-off between output and inflation. The households market power is in fact assumed to change exogenously, giving rise to a 'cost-push shock' on inflation.

The representative agent j of the generation born at time $s \leq 0$ maximizes the following expected lifetime utility function:

$$E_0 \sum_{t=0}^{\infty} [\beta (1-\vartheta)]^t \left\{ \ln c_{s,t}(j) + \chi \ln \frac{m_{s,t}(j)}{P_t} + \kappa \ln [1 - l_{s,t}(j)] \right\}, \quad (1)$$

where all parameters are positive, $0 < \beta < 1$ is the subjective discount factor[8], $m_{s,t}(j)$ is the agent's j end of period money holdings, P_t is the price index and $l_{s,t}(j)$ denotes the agent's j fraction of time in employment. Labor is assumed to be supplied under monopolistic competition[9]; $c_{s,t}(j)$ is the consumption index of a continuum of non-durable differentiated goods defined as in Dixit and Stiglitz (1977)

$$c_{s,t}(j) = \left[\int_0^1 c_{s,t}(i,j)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \quad (2)$$

where $c_{s,t}(i,j)$ denote consumption of good i by the agent j of the generation born at time s and θ is the constant elasticity of substitution, $\theta > 1$. Each good is an imperfect substitute for all other goods. It follows that the price index P_t is the utility-based price of a consumption bundle of differentiated goods[10]:

$$P_t = \left[\int_0^1 P_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}. \quad (3)$$

In addition, the consumer j faces the following demand function for her labor services[11]:

$$l_{s,t}(j) = \left[\frac{w_{s,t}(j)}{W_t} \right]^{-\eta_t} L_t, \quad (4)$$

where L_t is total employment, $\eta_t > 1$ is the elasticity of substitution between differentiated labor inputs and W_t is the relative aggregate wage index[12]:

$$W_t = \left[\sum_{s=-\infty}^{t} \int_0^{\vartheta(1-\vartheta)^{t-s}} w_{s,t}(j)^{1-\eta_t} dj \right]^{\frac{1}{1-\eta_t}}, \quad (5)$$

[8]Given the positive probability of death, however, the effective discount factor of each individual is $\beta(1-\vartheta)$.

[9]Each individual exhibits specific skills and professional abilities which confers her a certain monopoly power in the labor market. We implicitly assume that when she passes away, her place is taken by a newly born agent.

[10]The utility based price index P_t is defined as the minimum expenditure required to buy one unit of the composite good, $c_{s,t}$, given the prices of all differentiated varieties.

[11]The demand function is derived from a production function that uses labor input through a CES aggregate of individuals labor. See also Clarida, Galì and Gertler (2002).

[12]The wage index W_t is defined as the firm's minimum expenditure required to buy one unit of the composite labor input, given the wages of all the differentiated labor inputs.

where the term $\vartheta(1-\vartheta)^{t-s}$ indicates the dimension of the generation born at time s in the time period t. The elasticity of labor demand, η_t, is the same across workers, but is allowed to change over time.

The flow budget constraint of the representative agent born at time s is

$$m_{s,t}(j)+b_{s,t}(j) \leq \omega_{s,t-1}(j)+w_{s,t}(j)\, l_{s,t}(j)+z_{s,t}(j)-\tau_{s,t}(j)-P_t c_{s,t}(j), \quad (6)$$

where $b_{s,t}(j)$ denotes nominal government bonds at the end of period t, $w_{s,t}(j)$ is the nominal wage rate, $z_{s,t}(j)$ is the share in the profits of firms, $\tau_{s,t}(j)$ denote nominal lump-sum taxes and $\omega_{s,t-1}(j)$ is the total beginning of period financial wealth given by

$$\omega_{s,t-1}(j) = [m_{s,t-1}(j) + (1+i_{t-1})\, b_{s,t-1}(j)]\,(1-\vartheta)^{-1}, \quad (7)$$

where i_{t-1} is the nominal interest rate paid at beginning of period[13].

The representative consumer j of the generation born at time $s \leq 0$ chooses the set $\{c_{s,0}(j), m_{s,0}(j), w_{s,0}(j), b_{s,0}(j)\}$ and the sequences of contingency plans $\{c_{s,t}(j), m_{s,t}(j), w_{s,t}(j), b_{s,t}(j)\}_{t=1}^{\infty}$ in order to maximize (1) subject to (4) and (6), given the initial wealth $\omega_{s,t-1}(j)$ and the stochastic sequences $\{z_{s,t}(j),\ \tau_{s,t}(j),\ i_t,\ P_t,\ W_t, L_t\}_{t=0}^{\infty}$, whose exogenously given probability distributions are known by the consumers.

The solution to the consumer intertemporal maximizing problem yields the following first order necessary conditions:

$$\frac{1}{P_t c_{s,t}(j)} = \beta(1+i_t)\, E_t\left[\frac{1}{P_{t+1} c_{s,t+1}(j)}\right], \quad (8)$$

$$\frac{m_{s,t}(j)}{P_t} = \chi \frac{(1+i_t)}{i_t} c_{s,t}(j), \quad (9)$$

$$\frac{w_{s,t}(j)}{P_t} = \kappa(1+u_t^w)\,\frac{c_{s,t}(j)}{1-l_{s,t}(j)}, \quad (10)$$

where equation (8) is the stochastic Euler equation, equations (9) and (10) denote the efficiency conditions on real money balances and labor supply, respectively. Note that the optimal condition for labor supply reflects the agent's market power that is incorporated in the exogenous optimal wage markup $u_t^w = 1/(\eta_t - 1)$. Since the markup factor is allowed to vary over time, the model includes the possibility of a 'cost push shock' that affects the equilibrium price setting decision.

[13]It should be noted that the flow budget constraint incorporates the return on the insurance contract.

Define the stochastic discount factor[14] of the representative agent j of generation s as

$$Q_{t,t+1}(s,j) = \beta \frac{P_t}{P_{t+1}} \frac{c_{s,t}(j)}{c_{s,t+1}(j)}. \tag{11}$$

Combining (11) with (8) we obtain

$$E_t Q_{t,t+1}(s,j) = \frac{1}{1+i_t}\ , \tag{12}$$

for each $s \in (-\infty, t]$ and $j \in [0, \vartheta(1-\vartheta)^{t-s}]$. At the optimum the flow budget constraint (6) holds with equality in each time period and the transversality condition precluding Ponzi's game must hold:

$$\lim_{t\to\infty} E_0 Q_{0,t}(s,j)(1-\vartheta)^t \omega_{s,t}(j) = 0, \tag{13}$$

where $Q_{0,t}(s,j) = \prod_{k=1}^{t} Q_{k-1,k}(s,j)$. Solving equation (11) forward, using the budget constraint (6) and imposing the no-Ponzi-game condition (13), individual consumption can be written as a fraction of total wealth:

$$P_t c_{s,t}(j) = \Psi\left[\omega_{s,t-1}(j) + h_{s,t}(j)\right], \tag{14}$$

where $\Psi \equiv [1-\beta(1-\vartheta)]/(1+\chi)$ and $h_{s,t}(j)$ is human wealth, defined as

$$h_{s,t}(j) = E_t \sum_{v=t}^{\infty} Q_{t,v}(s,j)(1-\vartheta)^{v-t}\left[w_{s,v}(j) l_{s,t}(j) + z_{s,v}(j) - \tau_{s,v}(j)\right], \tag{15}$$

that is the expected present discounted value of future labor income and of profit shares net of taxes.

2.2 Aggregation

At time t the size of the generation born at time s is $\vartheta(1-\vartheta)^{t-s}$; it follows that the aggregate value of each economic variable can be obtained as a sum across cohorts:

$$X_t = \sum_{s=-\infty}^{t} \left[\int_0^{\vartheta(1-\vartheta)^{t-s}} x_{s,t}(j)\, dj\right], \tag{16}$$

where $x_{s,t}(j)$ indicates a generic economic variable for the agent j of generation s and X_t is the corresponding aggregate value.

[14] See for example Corsetti and Pesenti (2002) and Woodford (2003).

Aggregation of all generations alive at time t yields the following expressions for the aggregate financial wealth equation and for the transversality condition:

$$M_t + B_t = \Omega_{t-1} + W_t L_t + Z_t - T_t - P_t C_t, \tag{17}$$

$$\lim_{t\to\infty} E_0 Q_{0,t}(s,j)\,\Omega_t = 0, \tag{18}$$

where $\Omega_{t-1} = (1+i_{t-1})B_{t-1} + M_{t-1}$. The aggregate consumption function is defined as

$$P_t C_t = \Psi(\Omega_{t-1} + H_t), \tag{19}$$

where total human wealth at time t is

$$H_t = E_t \sum_{v=t}^{\infty} Q_{t,v}\,(1-\vartheta)^{v-t}\,(W_v L_v + Z_v - T_v)\,, \tag{20}$$

The aggregate money demand equation is

$$\frac{M_t}{P_t} = \chi \frac{(1+i_t)}{i_t} C_t, \tag{21}$$

and the labor supply is

$$\frac{W_t}{P_t} = \kappa\,(1+u_t^w)\,\frac{C_t}{1-L_t}, \tag{22}$$

Given equations (17) and (19) and using the definition of human wealth (20), the law of motion of total consumption can be derived as

$$E_t\,(Q_{t,t+1} P_{t+1} C_{t+1}) = \beta P_t C_t - \Phi E_t(Q_{t,t+1}\Omega_t), \tag{23}$$

where $\Phi \equiv [\vartheta/(1-\vartheta)]\Psi$. According to equation (23) the time path of total consumption is affected by the aggregate level of financial wealth.

2.3 The demand for goods

Standard individual optimization yields the demand for each brand i as a function of the relative price of i and of total consumption. After aggregation over all consumers, one obtains

$$C_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\theta} C_t. \tag{24}$$

Government spending, G_t, is assumed to be allocated amongst differentiated consumption goods in the same manner as individuals' consumption,

$$G_t = \left[\int_0^1 g_t(i)^{\frac{\theta-1}{\theta}}\,di\right]^{\frac{\theta}{\theta-1}}. \tag{25}$$

It follows that the demand for brand i is

$$Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\theta} Y_t, \tag{26}$$

where Y_t is the aggregate demand for goods, defined as

$$Y_t = C_t + G_t. \tag{27}$$

2.4 Firms optimization and price-setting decisions

The supply-side of the economy is described by a continuum of monopolistic firms, indexed by i, each producing a variety i of the differentiated product. Each firm i faces a production function that is linear in labor input,

$$Y_t(i) = A_t L_t(i), \tag{28}$$

where A_t is an exogenous technological parameter. The labor input used by each producer is defined as a CES composite of individual consumer labor input[15],

$$L_t(i) = \left[\sum_{s=-\infty}^{t} \int_0^{\vartheta(1-\vartheta)^{t-s}} l_{s,t}(j)^{\frac{\eta_t - 1}{\eta_t}} dj\right]^{\frac{\eta_t}{\eta_t - 1}}. \tag{29}$$

Aggregation across symmetric optimizing firms yields the market demand curve (4).

Following Calvo (1983), nominal price rigidity is modelled by allowing random intervals between price changes. Each period a firm adjusts its price with a constant probability $(1-\phi)$ and keeps its price fixed with probability ϕ. Firms that do not adjust prices adjust promptly output to meet demand. In either case, the cost minimization condition implies that

$$MC_t^n = \frac{W_t}{A_t}, \tag{30}$$

where MC_t^n denotes the nominal marginal cost. It should be noted that the nominal marginal cost is identical across firms, since the nominal wage and the technological parameter are not firm-specific.

The optimal pricing decision of a firm able to revise its price in period t is to choose the price $P_t(i)$ that maximizes the expected present discounted value of profits

$$E_t\left[\sum_{v=t}^{\infty} \phi^{v-t} Q_{t,v} Z_v(i)\right], \tag{31}$$

[15]It is straightforward to see that the aggregating factor (29) is homogenous of degree one.

where $Z_v(i)$ denotes nominal profits from the sale of good i and is defined as

$$Z_v(i) = P_t(i) Y_v(i) - W_v L_v(i). \tag{32}$$

Using (26) and (28) into (32) and (31) we obtain

$$E_t \left\{ \sum_{v=t}^{\infty} \phi^{v-t} Q_{t,v} Y_v P_v^{\theta} \left[P_t(i)^{1-\theta} - MC_v^n P_t(i)^{-\theta} \right] \right\}. \tag{33}$$

The first order condition for the optimal price is

$$E_t \left\{ \sum_{v=t}^{\infty} \phi^{v-t} Q_{t,v} Y_v P_v^{\theta} \left[(1-\theta) P_t(i)^{-\theta} + \theta MC_v^n P_t(i)^{-\theta-1} \right] \right\} = 0. \tag{34}$$

Dividing all terms by $(1-\theta)$ and rearranging,

$$E_t \left\{ \sum_{v=t}^{\infty} \phi^{v-t} Q_{t,v} Y_v P_v^{\theta} \left[P_t(i) - (1+\mu^p) MC_v^n \right] \right\} = 0, \tag{35}$$

where $\mu^p = 1/(\theta - 1)$ is the equilibrium net markup. Condition (35) implies that firms set their price equal to a markup over a weighted average of expected future nominal marginal costs. In symmetric equilibrium the price index follows a law of motion given by

$$P_t = \left[\phi (P_{t-1})^{1-\theta} + (1-\phi) P_t(i)^{1-\theta} \right]^{1/1-\theta}. \tag{36}$$

2.5 The Government

The government issues nominal debt in the form of interest-bearing bonds $B_{t.}$ The flow budget constraint of the government in nominal terms is given by

$$B_t + M_t = (1+i_{t-1}) B_{t-1} + P_t G_t - T_t + M_{t-1}, \tag{37}$$

where B_t is the nominal value of the end-of-period public debt. According to equation (37) public expenditures and interest payments can be financed by taxes, issuance of new bonds and seigniorage. The total amount of government liabilities at the beginning of period t is defined as $\Omega_{t-1} = (1+i_{t-1}) B_{t-1} + M_{t-1}$. The solvency condition requires that

$$\lim_{t \to \infty} E_0 Q_{0,t} \Omega_t = 0. \tag{38}$$

The flow budget constraint and the solvency condition imply that the current value of the government's liabilities is equal to the present discounted value of current and future budget surpluses.

We consider two types of fiscal policy rules which ensure sustainability of the government debt given any sequence of the endogenous variables of the model ('Ricardian' fiscal regimes) and one fiscal rule which implies a convergent path of the public debt in correspondence of only one sequence of the other endogenous variables of the model ('non-Ricardian' fiscal regime)[16].

3 General Equilibrium

In equilibrium demand and supply for goods, the labor input, the stock of nominal money balances and the stock of government bonds must be equalized. On the supply side, the aggregate production function is

$$Y_t = A_t L_t. \tag{39}$$

Combining the aggregate labor supply (22), the costs minimization condition (30), the goods market clearing condition (27) and the aggregate production function (39) yields the following expression for the real marginal cost:

$$MC_t = \frac{MC_t^n}{P_t} = \frac{\kappa \left(1 + u_t^w\right)\left(Y_t - G_t\right)}{A_t - Y_t}, \tag{40}$$

where MC_t is the real marginal cost. The solution depends on the behavior of prices and on the rules adopted by both monetary and fiscal authorities. We first characterize the global solution under flexible prices. The predicted evolution of real variables under complete price flexibility represents a useful benchmark and allows us to identify the 'natural' rate of output, that is the level of output that would occur in an equilibrium with flexible wages and prices. We then examine the case of nominal price rigidities, for which a log-linear approximation of the global system around a deterministic steady state is necessary.

3.1 Flexible price equilibrium

Under flexible prices ($\phi = 0$) all firms adjust prices in each period. Following Clarida, Galì and Gertler (2002), the wage markup characterizing the equilibrium under this benchmark case is assumed to be fixed at its steady state value, $1 + u^w$. The solution to the maximizing problem of a firm i implies that the optimal price for the variety i is a constant markup over marginal cost:

$$\frac{P_t(i)}{P_t} = \left(1 + \mu^p\right) MC_t. \tag{41}$$

[16] See Woodford (1995, 2003).

In symmetric equilibrium $P_t(i)/P_t = 1$; hence equation (41) implies that the flexible price equilibrium is characterized by a constant real marginal cost:

$$\overline{MC} = \frac{1}{1+\mu^p}. \tag{42}$$

Substitution of (42) into (40) allows us to define the 'natural level of output' as

$$Y_t^N = \frac{\kappa(1+u^w)G_t + \frac{1}{1+\mu^p}A_t}{\kappa(1+u^w) + \frac{1}{1+\mu^p}}. \tag{43}$$

As expected, under flexible prices, output does not depend on monetary factors.

3.2 Dynamics under sticky prices

Consider now the complete system describing the economy with sticky prices, as a log-linear approximation around a non-stochastic zero inflation steady state.

3.2.1 The demand side

The demand side of the economy is described by the aggregate demand, the LM and IS equations. In equilibrium the aggregate demand is equal to output; it follows that the resource constraint (27) in log-linear terms is

$$\widehat{Y}_t = \frac{C}{Y}\widehat{C}_t + \frac{G}{Y}\widehat{G}_t, \tag{44}$$

where all variables are expressed as percentage deviations from their steady state value. Government spending is assumed to follow a stationary autoregressive process,

$$\widehat{G}_t = \rho^G \widehat{G}_{t-1} + \varepsilon_t^G, \tag{45}$$

where $0 < \rho^G < 1$ and ε_t^G is a white noise.

The LM equation is the log-linear version of (21):

$$\widehat{M}_t - \widehat{P}_t = \frac{1}{C}(Y\widehat{Y}_t - G\widehat{G}_t) - \frac{1}{i(1+i)}\widetilde{i}_t, \tag{46}$$

where $\widetilde{i}_t$ is the deviation of the nominal interest rate from its long run level, that is that $\widetilde{i}_t = i_t - i$ and, $R \equiv 1 + i$ is the steady state interest factor.

The IS relation is obtained by combining the log-linearized version of (23) and (27):

$$\widehat{Y}_t = \frac{1}{(1+\delta)}\left[\frac{C}{Y}E_t\pi_{t+1} - \frac{C}{Y}(1+\frac{\gamma}{R-1})\widetilde{i}_t + E_t\widehat{Y}_{t+1} + \delta\frac{C}{Y}(\widehat{B}_t - \widehat{P}_t)\right] + \widehat{g}_t, \tag{47}$$

where $\delta \equiv \Phi\frac{RB}{PC}$, $\gamma \equiv \Phi\chi\frac{1+i}{i}$ and $\widehat{g}_t \equiv \frac{G}{Y(1+\delta)}[(1+\delta) - \rho^G]\widehat{G}_t$.

3.2.2 The supply side

The aggregate production function (39) in log-linear terms is

$$\widehat{Y}_t = \widehat{A}_t + \widehat{L}_t, \tag{48}$$

where $\widehat{A}_t$ is assumed to follow a stationary first-order process,

$$\widehat{A}_t = \rho^A\widehat{A}_{t-1} + \varepsilon_t^A, \tag{49}$$

where $0 < \rho^A < 1$ and ε_t^A is a white noise.

The log-linearized optimal price setting equation (35) combined with the log-linearized price index (36) yields

$$\pi_t = \frac{1}{R}E_t\pi_{t+1} + \frac{(1-\phi)\left(1-\frac{\phi}{R}\right)}{\phi}\widehat{MC}_t. \tag{50}$$

It can be shown that the real marginal cost can be expressed as

$$\widehat{MC}_t = \varrho(\widehat{Y}_t - \widehat{Y}_t^n) + \widehat{u}_t^w, \tag{51}$$

where $\varrho \equiv \frac{L}{1-L} + \frac{Y}{Y-G}$ and $\widehat{Y}_t^n = \varrho(\frac{1}{1-L}\widehat{A}_t + \frac{G}{C}\widehat{G}_t)$.

The forward looking Phillips curve can then be re-written as

$$\pi_t = \frac{1}{R}E_t\pi_{t+1} + \lambda x_t + u_t, \tag{52}$$

where $\lambda \equiv \varrho\frac{(1-\phi)\left(1-\frac{\phi}{R}\right)}{\phi}$, $u_t \equiv \frac{(1-\phi)\left(1-\frac{\phi}{R}\right)}{\phi}\widehat{u}_t^w$ and x_t is the output gap, defined as $x_t = \widehat{Y}_t - \widehat{Y}_t^n$.

The term u_t is the cost-push shock, assumed to follow a first order autoregressive process,

$$u_t = \rho^u u_{t-1} + \varepsilon_t^u, \tag{53}$$

where $0 < \rho^u < 1$ and ε_t^u is a white noise.

4 Fiscal policy regimes

In the present model with wealth effects, the IS equation (47) depends on the time path of public debt, which is specified by the fiscal policy regime. We now consider two 'Ricardian' and a 'non-Ricardian' fiscal rules.

4.1 'Ricardian' fiscal regimes

The two 'Ricardian' rules imply that, when substituted into the flow budget constraint (37), the government debt remains into a neighborhood of its steady state level, for all small deviations of the other endogenous variables of the model from their steady state levels and for small enough exogenous disturbances. We consider two fiscal rules: a stock rule and a tax rule.

Definition 1 *A stock rule is a fiscal regime where the nominal stock of public debt is proportional to nominal output:* $B_t = \mu P_t Y_t$, *given an exogenous sequence* $\{G_t\}$ *and* $\mu > 0$.

In other words this rule can be interpreted as a public debt-GDP ratio stabilization criterion. It follows that taxes are set accordingly given the exogenous sequence of public expenditure. By substituting the rule into the flow budget constraint (37), it emerges that total taxation depends on the present and on the past level of public debt. Under a stock rule the log-linear public debt evolves as follows

$$\widehat{B}_t - \widehat{P}_t = \widehat{Y}_t. \tag{54}$$

Definition 2 *A tax rule is a fiscal regime where total taxation evolves as:* $T_t = \alpha(1 + i_{t-1})B_{t-1} + M_{t-1} - M_t$, *given an exogenous sequence* $\{G_t\}$ *and* $0 < \alpha < 1$.

The parameter α is chosen in order to ensure a non-explosive path for the public debt. Substituting the tax rule into the flow budget constraint (37) yields the time path of public debt under the specified fiscal rule, given an exogenous sequence of public expenditure.

Under a tax rule the log-linearized equation describing the path of public debt is

$$\widehat{B}_t - \widehat{P}_t = (1-\alpha)(1+i)(\widetilde{i}_{t-1} - \pi_t) + (1-\alpha)(1+i)(\widehat{B}_{t-1} - \widehat{P}_{t-1}) + \frac{PG}{B}\widehat{G}_t. \tag{55}$$

4.2 'Non-Ricardian' fiscal regime

The 'non-Ricardian' regime is described by a tax rule which does not ensure a convergent path for the government debt for any sequence of all the other endogenous variables. We simply set the parameter α equal to zero. It follows that the process describing the time path of public debt in log-linear terms is

$$\widehat{B}_t - \widehat{P}_t = (1+i)(\widetilde{i}_{t-1} - \pi_t) + (1+i)(\widehat{B}_{t-1} - \widehat{P}_{t-1}) + \frac{PG}{B}\widehat{G}_t. \qquad (56)$$

Under this policy regime there is only one sequence of endogenous variables that guarantees the respect of the intertemporal budget constraint of the government.

5 Calibration

The model is calibrated in order to evaluate the performance of different interest rate rules under alternative fiscal regimes. We assume that each period corresponds to a quarter of year.

We observe that private consumption is four time larger than government expenditure on average on the basis of the quarterly Euro Area aggregate series derived by Fagan et al. (2001) for the period 1970-1998. We assume in our structural model that $C/Y = 0.8$ and $G/Y = 0.2$. The average annual ratio of GDP and of the monetary aggregate M2 for the period 1997-2001 is 1.52[17]. The real interest rate is set equal to 4% per annum, as in Smets and Wouters (2002b). We calibrate the probability of death between two consecutive periods to be 0.015. Furthermore we assume an annual steady-state public debt to GDP ratio equal to 0.6, that is the Maastricht criterion. Under the tax rule the parameter α is set in order to support a debt-GDP ratio of 60% in steady state.

The steady state fraction of labor supply is set equal to 1/3, corresponding to the standard eight hours working day. We set the probability of keeping the price fixed between two consecutive quarters at $\phi = 0.75$, which is consistent with the estimates by Galì, Gertler and Salido (2001) for the Euro Area.

Finally, the baseline parameters related to shocks are set in line with the related literature. Real shocks are characterized by higher persistence than monetary policy and cost push shocks. The persistence and the variance of

[17]The Euro Area Data Source is the ECB Statistical DataBank. Table 2.04 of the Euro Area Statistics has been used.

the technological shock, the monetary shock and the cost push shock are calibrated[18]. The persistence and variance of the public expenditure shock are estimated over the period 1970-1997[19].

Table 1 summarizes the underlying parameter values, long run properties of the economy under the different fiscal regimes and the implied values for the rate of time preference β and for the parameters χ and α[20].

6 Interest Rate Rules and Fiscal Regimes

In the present Section we use the model to compare the performance of a variety of interest rate rules under different fiscal regimes. Our baseline specification of monetary policy is given by the standard contemporaneous Taylor (1993) rule

$$\widetilde{i}_t = \mu_\pi \pi_t + \mu_x x_t + v_t, \tag{57}$$

where the nominal interest rate depends on the current value of inflation and output gap, $\mu_\pi, \mu_x \geq 0$ and v_t follows an AR(1) process

$$v_t = \rho^v v_{t-1} + \varepsilon_t^v, \tag{58}$$

where $0 < \rho^v < 1$ and ε_t^v is a white noise. We also consider other variants of the Taylor type interest rate rules: a generalized Taylor rule which includes the lagged interest rate

$$\widetilde{i}_t = \mu_\pi \pi_t + \mu_x x_t + \mu_i \widetilde{i}_{t-1} + v_t, \tag{59}$$

where $\mu_i > 0$[21]; a backward looking Taylor rule in which the nominal interest rate responds to inflation and output gap lagged of one period[22]

$$\widetilde{i}_t = \mu_\pi \pi_{t-1} + \mu_x x_{t-1} + \mu_i \widetilde{i}_{t-1} + v_t; \tag{60}$$

a forward looking Taylor rule where the nominal interest rate responds to variation in the expected levels of inflation and of the output gap[23]:

$$\widetilde{i}_t = \mu_\pi E_t \pi_{t+1} + \mu_x E_t x_{t+1} + v_t. \tag{61}$$

[18]See Smets and Wouters (2002, 2003) and Giammarioli and Valla (2003).

[19]The public expenditure shock is the percentage deviation of actual public expenditure from trend public expenditure. The calibrated degree of persistence is obtained from estimation of the first order autoregressive model (45).

[20]Full derivation of the implied parameter values is reported in the Appendix.

[21]See McCallum (1999) and Rotemberg and Woodford (1999) for discussion of the benefits deriving from a certain degree of monetary policy inertia.

[22]McCallum (1999) suggests this kind of rule since it is much more realistic to assume that central banks react to the last quarter's observations on inflation and output gap.

[23]For a discussion on the class of forecast-based rules, see Batini and Haldane (1999).

The log-linearized model is solved in its state-space representation by applying the Klein (2000) algorithm.

6.1 Real determinacy

We now analyze the range of parameters values that rule out real indeterminacy and instability of the system for the different interest rate rules.

Definition 3 *An equilibrium is locally determined if and only if there are bounded and unique sequences for all endogenous variables of the model* $\{\pi_t, \widetilde{i}_t, x_t\}$ *for small enough process for the exogenous shocks.*

We illustrate regions of determinacy and indeterminacy in the space μ_π and μ_x under 'Ricardian' and 'non-Ricardian' fiscal regimes. All the other parameters are kept at their baseline values.

6.1.1 Real determinacy under 'Ricardian' fiscal regime

The regions of determinacy and indeterminacy in the space (μ_π, μ_x) are virtually identical under the two different 'Ricardian' fiscal rules. Hence, for convenience we analyze only one fiscal regime. Figure 1 reports 4 panels corresponding to the cases in which fiscal policy is conducted according to a stock fiscal rule under various interest rate rules.

The first two panels refer to a contemporaneous and to a forward interest rate rules, respectively. In both cases there is no policy inertia, as $\mu_i = 0$. The dark region indicates the parameters combinations (μ_π, μ_x) that guarantee determinacy. Conversely, the blank region reports the parameters combinations associated to real indeterminacy and instability. It clearly emerges that the so-called 'Taylor principle' is not necessary to achieve real determinacy of the model, since real determinacy is verified for values of the critical coefficient $\mu_\pi < 1$ in correspondence of $\mu_x = 0$[24]. In a framework with wealth effects monetary policy needs not to be aggressive to rule out real indeterminacy when there is small or no reaction to the output gap.

The third and fourth panels correspond to the cases of Taylor-type rules an with inertial component (μ_i is increased from 0 to 0.5). Real determinacy is verified for a larger set of parameter values. Hence monetary policy inertia improves the prospects for determinacy.

[24]When wealth effects are not operative, a 'Ricardian' fiscal regime does not affect the dynamic properties of the system. In this case the model displays real indeterminacy for a larger set of the parameters (μ_π, μ_x) and in correspondence of low level of the parameter μ_x, μ_π must be strictly large than one to rule out multiple equilibria. See Rotemberg and Woodford (1999).

6.1.2 Real determinacy under a 'non-Ricardian' fiscal regime

Under a 'non-Ricardian' fiscal regime, as shown by Woodford (2003), equilibrium determinacy is obtained if and only if the contemporaneous interest rate rule violates the 'Taylor principle'. This result has been derived in a standard DNK model without wealth effects.

From Figure 2 it emerges that in our setup the parameters space ensuring determinacy in the 'non-Ricardian' case is just the mirror image of the parameters space where there is indeterminacy in the 'Ricardian' regime. The model is unstable for all other parameters combinations.

6.2 Simulation results

In order to evaluate the stochastic properties of alternative monetary rules under different fiscal regimes we perform some Monte Carlo experiments. We draw from a random generator a finite set of innovation sequences $\{\varepsilon_t^g, \varepsilon_t^a, \varepsilon_t^u, \varepsilon_t^v\}$ for a sample period of 300 quarters. The values reported in Tables 2-6 are mean values over 1000 replications of the simulation experiment[25].

Tables 2-5 refer to the case of 'Ricardian' fiscal regime, while Table 6 summarizes simulation results under a 'non-Ricardian' regime.

In the first simulation exercise we analyze the performance of a contemporaneous Taylor rule of the form (57) under 'Ricardian' fiscal regimes. Table 2 includes results for values of the policy parameters μ_π and μ_x under a stock rule and a tax rule regime, respectively. The results show that higher values of μ_π and μ_x lead in most cases to lower standard deviations for both the inflation rate and the output gap. These results suggest that the monetary authorities can stabilize the economy by responding strongly to current variations in inflation and in the output gap. In addition, simulation results reported in Table 2 indicate that when monetary policy is sufficiently 'passive' a public debt-GDP ratio targeting rule performs better in stabilizing the economy. An 'active' enough interest rate rule produces very similar results under both 'Ricardian' fiscal rules.

Table 3 reports simulation results under the assumption that monetary policy is conducted according to a generalized Taylor rule. For a low inertial component ($\mu_i = 0.5$) results improve only for inflation and for the nominal interest rate. A larger smoothing parameter ($\mu_i = 1$) combined with a sufficiently aggressive monetary policy, ($\mu_\pi = 1.5; 2$) does not improve the results for inflation. Standard deviations of the output gap are larger for all combinations of policy parameters in the presence of an inertial component.

[25] In each experiment we consider a sample period of 350 quarters, whereas in the computations of the mean values over the 1000 replications we ignore the initial 50 quarters.

In correspondence of this interest rate rule, the choice of the fiscal rule seems to be irrelevant for the results.

Table 4 illustrates simulation results for our macroeconomic model under a backward looking Taylor rule. It emerges that a backward monetary rule performs better than the contemporaneous Taylor rule in terms of inflation, but not in terms of output gap deviations. The presence of a smoothing parameter for the interest rate deteriorates the performance of this rule with respect to the generalized Taylor rule.

Table 5 reports simulation results under a forward looking Taylor rule. In this case under a 'passive' interest rate rule simulation results for inflation and interest rate deviations are quite high. A 'passive' monetary policy generates different outcomes for the two fiscal rules, with the stock rule performing better than the tax rule.

Table 6 summarizes simulation results for different interest rate rules under a 'non-Ricardian' regime in correspondence of policy parameters which guarantee the determinacy of the equilibrium. The combination of Taylor type rules with this kind of fiscal regime is not sufficient to stabilize inflation and output gap. An interest rate peg performs relatively better in reducing the variability of the inflation rate.

From the simulation exercises the monetary-fiscal policy combination which produces better results for inflation stabilization combines a generalized Taylor rule with a low enough smoothing component together with a stock rule as a fiscal policy commitment. On the other hand, the preferable monetary policy for output gap stabilization is given by a contemporaneous Taylor rule.

The results give support to the view that a Taylor type rule for monetary policy should be combined with fiscal rules which ensure public sector solvency for any sequence of all the other variables.

6.3 The Impulse Response Functions

In this section we derive impulse response functions for the main endogenous variables $\{\widehat{Y}_t, x_t, \pi_t, i_t\}$ in response to unit shocks to $\{\varepsilon_t^g, \varepsilon_t^a, \varepsilon_t^u, \varepsilon_t^v\}$.

In particular, we examine the properties of a contemporaneous and of a generalized Taylor rule when fiscal policy is conducted according to 'Ricardian' rules (Figures 3-10). We derive impulse response functions when the nominal interest rate is pegged and the fiscal regime is 'non-Ricardian' (Figures 11-14).

Figures 3-7 show responses to unit shocks to public expenditure, productivity, costs and to the policy rule, respectively, under the assumption that monetary policy is conducted according to a contemporaneous Taylor rule

with $\mu_\pi = .9$ and $\mu_x = .06$. A unit shock to public expenditure generates different responses depending on whether fiscal policy commits to a stock or to a tax rule (Figure 3). In particular, the public debt-GDP targeting rule seems to be more stabilizing than a tax rule, consistently with simulation results. Conversely, the choice of the rule does not affect the response of the economy to productivity and to cost push shocks (Figures 4-5). Figure 6 shows responses of the main variables to a unit shock in the monetary policy rule. Inflation response is slightly larger under a stock rule.

Figures 8-11 report impulse response functions when monetary policy follows a generalized Taylor rule, with $\mu_\pi = 1.5$, $\mu_x = .06$ and $\mu_i = .5$. In this case the economy appears to respond to shocks independently of the fiscal rules, with the exception of the response of the inflation rate to a unit shock to public expenditure.

Finally, Figures 12-14 give the impulse responses of the model under a 'non-Ricardian' rule and interest rate peg. The impact of the shocks on all variables is rather large, as expected.

7 Conclusions

The present paper investigates the interrelations between monetary and fiscal policy within a microfounded dynamic New Keynesian model with wealth effects. The model is derived analytically and calibrated to quarterly data for the Euro Area. Several combinations of Taylor rules and fiscal regimes are considered and evaluated numerically. From our analysis it clearly emerges that the explicit consideration of wealth effects leads to some significant deviations from the policy prescriptions derived within standard models based on the representative agent framework. In particular, the main findings of the paper can be summarized as follows:

(i) determinacy of equilibrium can be achieved under a 'passive' monetary rule in Taylor's sense, irrespectively of the fiscal regime adopted;

(ii) the choice of 'Ricardian' fiscal rules is not relevant, in terms of inflation and output stabilization, only when the monetary authorities systematically overreact to inflation; on the other hand, when the monetary rule is not too aggressive a fiscal stock rule is to be preferred to a tax rule;

(iii) a contemporaneous Taylor rule, combined with a public debt-GDP targeting, is preferable to reducing output gap variability;

(iv) the desirable monetary and fiscal policy mix for inflation stabilization is a combination of public debt-GDP ratio targeting, coupled with a Taylor rule with a low degree of inertia.

In conclusion, the framework of analysis proposed in this paper offers

some additional perspectives to discuss the possible interrelations between monetary and fiscal policy and provides supplementary reasons to enforce fiscal convergence within the Euro Area.

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Table 1- Baseline Parameters Values

Average Ratios	$C/Y = .80$ $G/Y = .20$ $M/PY = 2.63$ $B/Y = 2.40$ $L = 1/3$
Baseline parameter values	$\vartheta = .015$ $\phi = .75$ $i = r = .01$
Implied parameter values	$\chi = .03$ $\beta = .99$ $\varrho = .57$ $\lambda = .15$ $\alpha = .09$
Shocks	$\rho^A = .88;\ \sigma_{\varepsilon}^A = .421$ $\rho^G = .96;\ \sigma_{\varepsilon}^G = .008$ $\rho^u = 0;\ \sigma_{\varepsilon}^u = .122$ $\rho^v = 0;\ \sigma_{\varepsilon}^v = .152$

Table 2- Performance of a Contemporaneous Taylor Rule under 'Ricardian' Fiscal Regimes

μ_π, μ_x	$sd(\pi_t)$	$sd(\widetilde{i_t})$	$sd(x_t)$
$0.90, 0.06$	2.92	3.34	2.43
	3.66	3.90	2.50
$1.10, 0.06$	1.31	2.40	1.98
	1.39	2.46	1.98
$1.50, 0.06$	0.82	2.18	1.81
	0.83	2.19	1.81
$2.00, 0.06$	0.65	2.11	1.77
	0.66	2.12	1.77
$0.90, 0.50$	1.20	1.97	1.50
	1.41	2.11	1.51
$1.10, 0.50$	0.89	1.80	1.42
	0.95	1.84	1.42
$1.50, 0.50$	0.70	1.70	1.37
	0.72	1.72	1.37

Note: Table reports standard deviations of the variables of interest under a stock rule and a tax rule regime, respectively.

Table 3- Performance of a Generalized Taylor Rule under 'Ricardian' Fiscal Regimes

	$\mu_i = 0.50$			$\mu_i = 1.00$		
μ_π, μ_x	$sd(\pi_t)$	$sd(\widetilde{i}_t)$	$sd(x_t)$	$sd(\pi_t)$	$sd(\widetilde{i}_t)$	$sd(x_t)$
$0.90, 0.06$	0.86	1.90	2.77	1.24	1.51	3.85
	0.87	1.93	2.77	1.23	1.52	3.82
$1.10, 0.06$	0.78	1.85	2.62	1.08	1.47	3.46
	0.78	1.86	2.61	1.08	1.47	3.45
$1.50, 0.06$	0.68	1.76	2.40	0.87	1.41	2.97
	0.68	1.78	2.40	0.88	1.42	2.97
$2.00, 0.06$	0.60	1.72	2.24	0.72	1.38	2.63
	0.60	1.73	2.24	0.72	1.38	2.62
$0.90, 0.50$	0.67	1.44	1.70	0.72	1.18	2.05
	0.68	1.46	1.69	0.71	1.19	2.05
$1.10, 0.50$	0.64	1.42	1.65	0.68	1.17	1.97
	0.64	1.43	1.66	0.68	1.18	1.97
$1.50, 0.50$	0.59	1.39	1.60	0.62	1.16	1.85
	0.59	1.40	1.61	0.62	1.16	1.85

Note: Table reports standard deviations of the variables of interest under a stock rule and a tax rule regime, respectively.

Table 4- Performance of a Lagged Taylor Rule under 'Ricardian' Fiscal Regimes

	$\mu_i = 0.00$			$\mu_i = 1.00$		
μ_π, μ_x	$sd(\pi_t)$	$sd(\widetilde{i}_t)$	$sd(x_t)$	$sd(\pi_t)$	$sd(\widetilde{i}_t)$	$sd(x_t)$
$0.90, 0.06$	2.01	2.98	2.36	1.34	2.59	4.91
	2.46	3.26	2.40	1.33	2.60	4.90
$1.10, 0.06$	1.08	2.62	2.07	1.18	2.57	4.52
	1.16	2.66	2.06	1.18	2.57	4.51
$1.50, 0.06$	0.72	2.56	1.96	0.97	2.54	4.00
	0.74	2.57	1.96	0.96	2.53	3.98
$0.90, 0.50$	1.02	2.74	1.75	0.72	2.40	2.81
	1.19	2.81	1.76	0.72	2.40	2.81
$1.10, 0.50$	0.80	2.69	1.71	0.69	2.40	2.75
	0.86	2.71	1.70	0.69	2.40	2.74
$1.50, 0.50$	0.65	2.69	1.69	0.64	2.40	2.64
	0.67	2.71	1.69	0.64	2.40	2.64

Note: Table reports standard deviations of the variables of interest under a stock rule and a tax rule regime, respectively.

Table 5- Performance of a Forward Taylor Rule under 'Ricardian' Fiscal Regimes

μ_π, μ_x	$sd(\pi_t)$	$sd(\widetilde{i_t})$	$sd(x_t)$
$0.90, 0.06$	5.74	5.47	3.63
	7.21	6.70	3.79
$1.10, 0.06$	1.74	2.82	2.39
	1.81	2.90	2.39
$1.50, 0.06$	1.00	2.52	2.13
	1.02	2.54	2.12
$0.90, 0.50$	1.51	2.73	2.23
	1.74	2.88	2.23
$1.10, 0.50$	1.08	2.55	2.14
	1.14	2.60	2.14
$1.50, 0.50$	0.85	2.46	2.08
	0.86	2.47	2.08

Note: Table reports standard deviations of the variables of interest under a stock rule and a tax rule regime, respectively.

Table 6- Performance of Various 'Passive' Interest Rate Rules under a 'Non-Ricardian' Fiscal Regime

	μ_π, μ_x, μ_i	$sd(\pi_t)$	$sd(\widetilde{i}_t)$	$sd(x_t)$
Interest rate peg	$0, 0, 0$	12.54	2.30	24.80
Contemporaneous Taylor Rule	$0.3, 0.06, 0$	16.76	6.90	23.99
	$0.8, 0.06, 0$	30.44	25.29	13.45
Generalized Taylor Rule	$0.3, 0.06, 0.5$	21.78	14.34	17.95
Lagged Taylor Rule	$0.3, 0.06, 0$	19.52	12.86	16.73
	$0.3, 0.06, 0.5$	19.40	12.76	16.67
Forward Taylor Rule	$0.3, 0.06$	15.63	5.40	24.38
	$0.8, 0.06$	27.86	21.55	17.75

Figure 1: Determinacy Space under Ricardian Regime

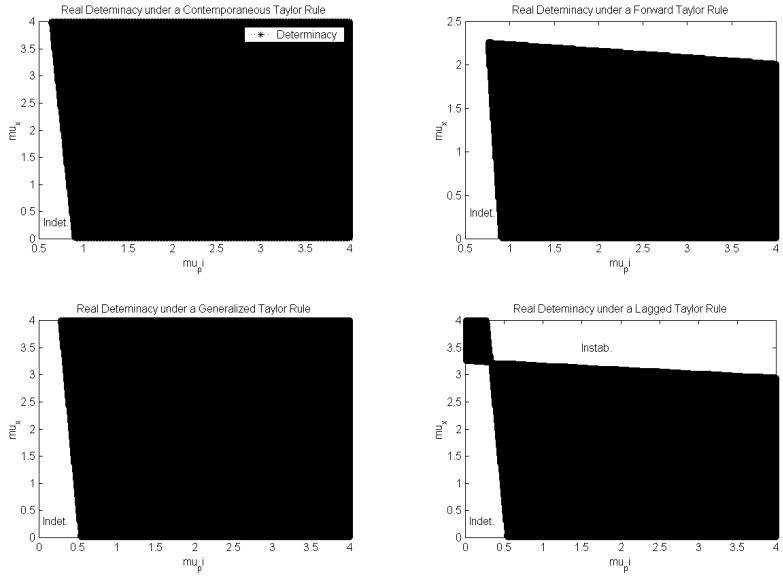

Figure 2: Determinacy Space under Non-Ricardian Regime

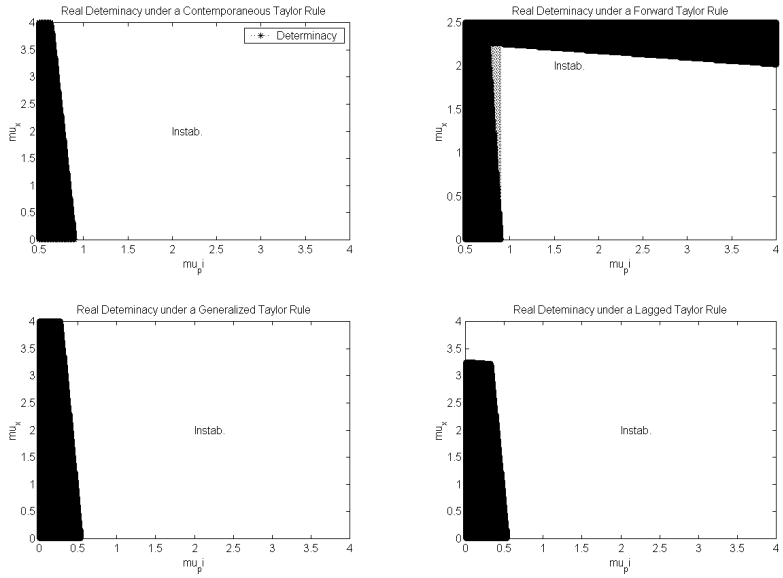

Figure 3: Responses to Unit Shock to Public Expenditure under Contemporaneous Taylor Rule

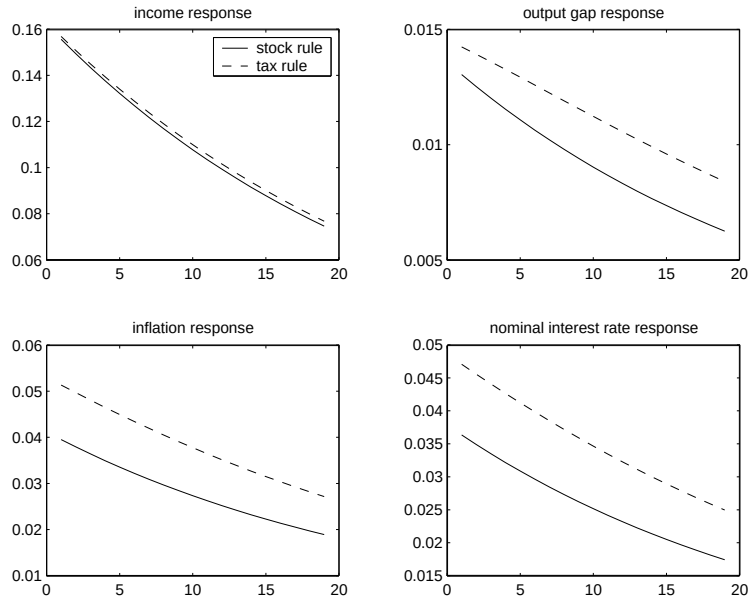

Figure 4: Responses to Unit Shock to Productivity under Contemporaneous Taylor Rule

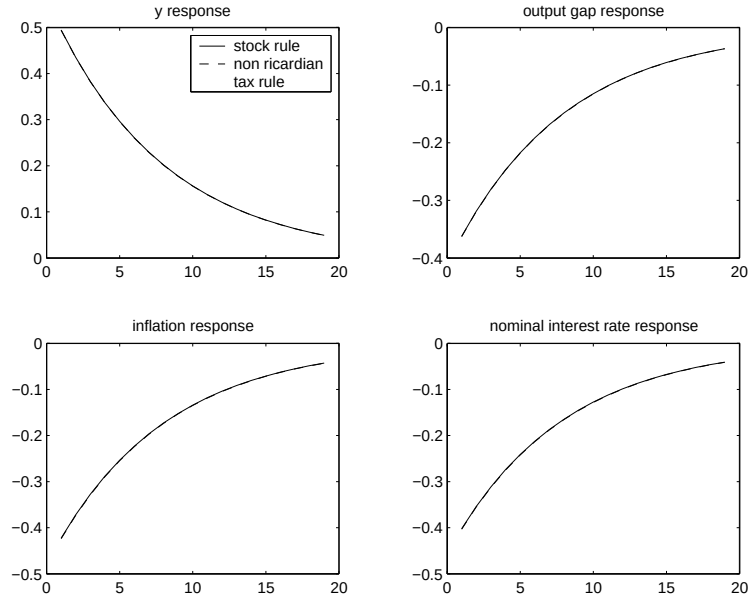

Figure 5: Responses to Unit Cost Push Shock under Contemporaneous Taylor Rule

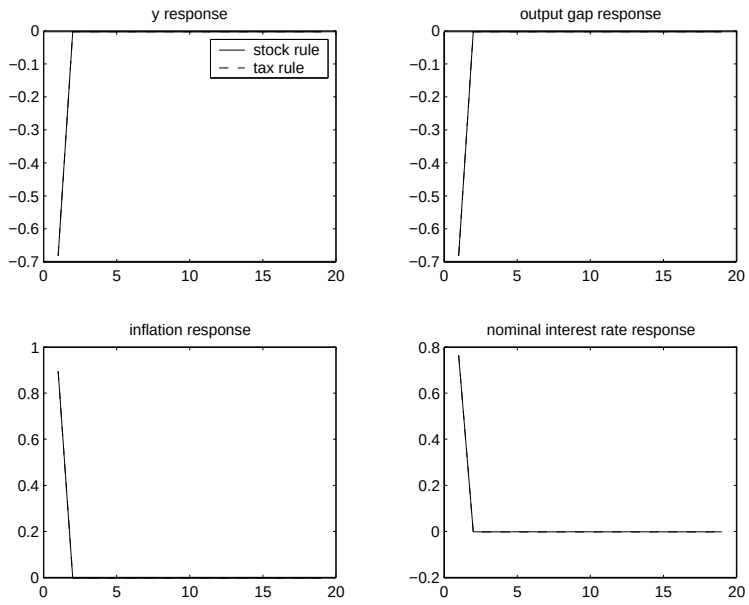

Figure 6: Responses to Unit Policy Shock under Contemporaneous Taylor Rule

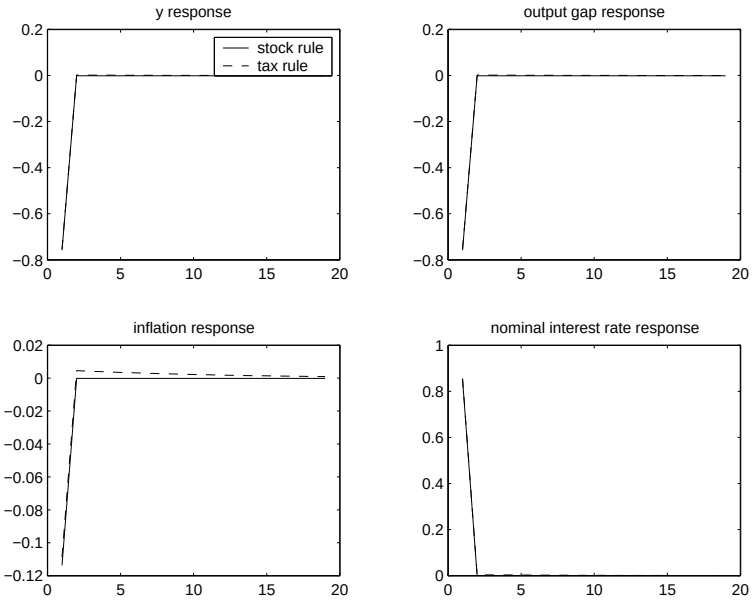

Figure 7: Responses to Unit Shock to Public Expenditure under Generalized Taylor Rule

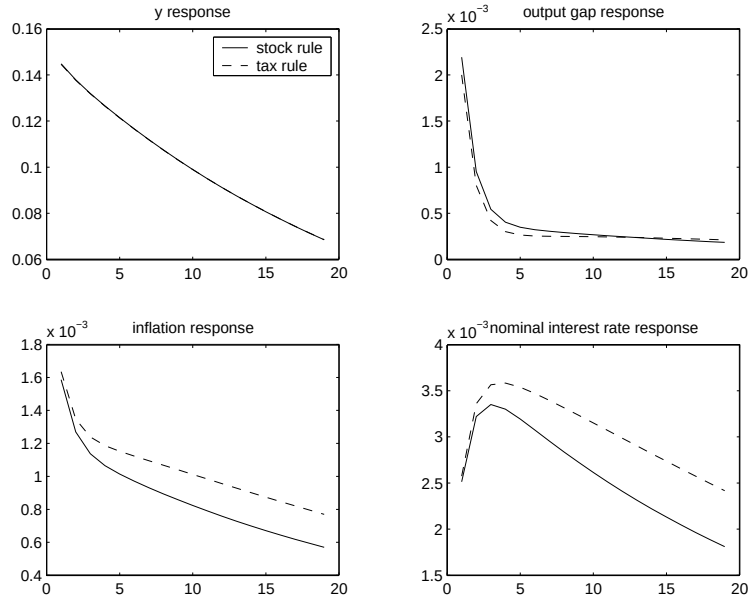

Figure 8: Responses to Unit Shock to Productivity under Generalized Taylor Rule

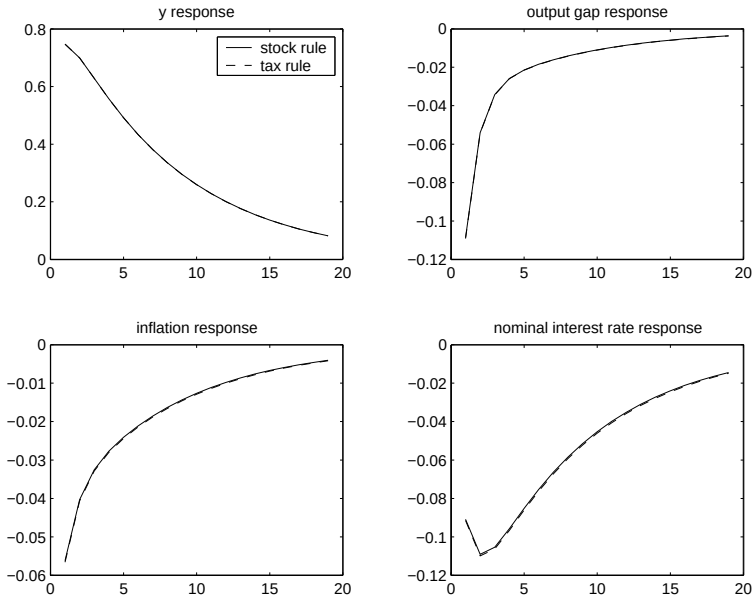

Figure 9: Responses to Unit Cost Push Shock under Generalized Taylor Rule

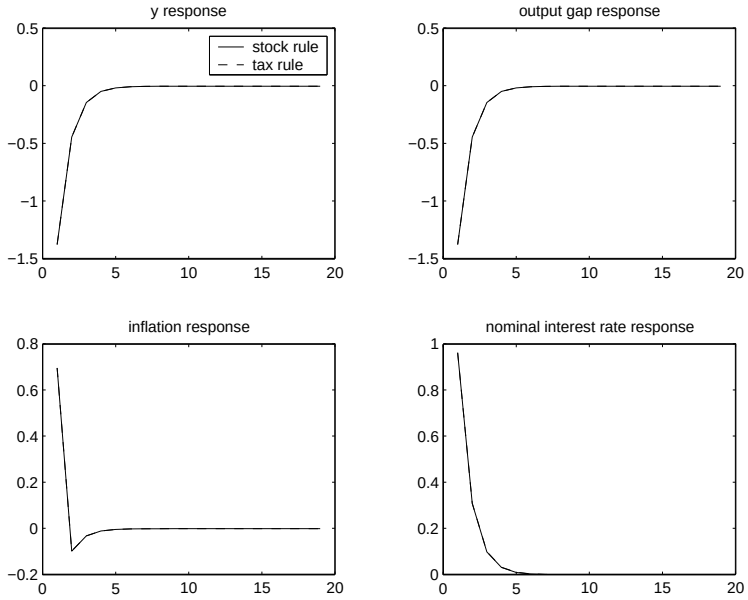

Figure 10: Responses to Unit Policy Shock under Generalized Taylor Rule

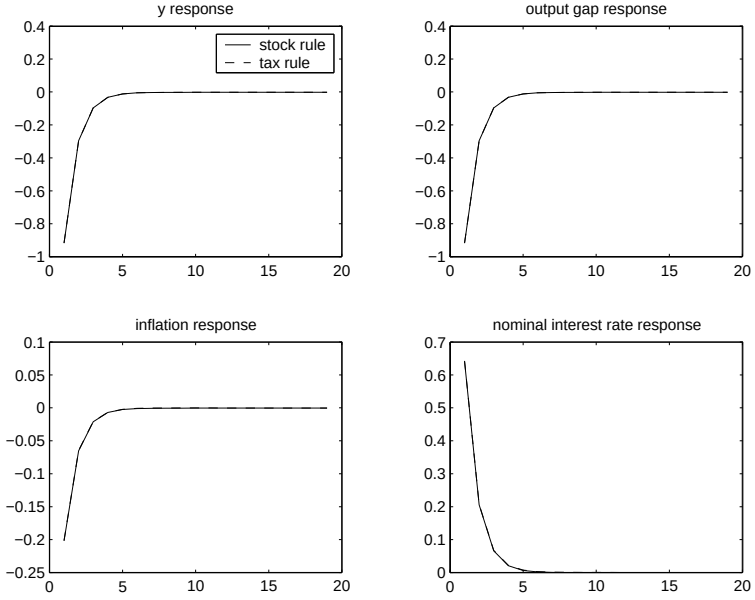

Figure 11: Responses to Unit Shock to Public Expenditure under Interest Rate Peg and 'Non-Ricardian' Regime

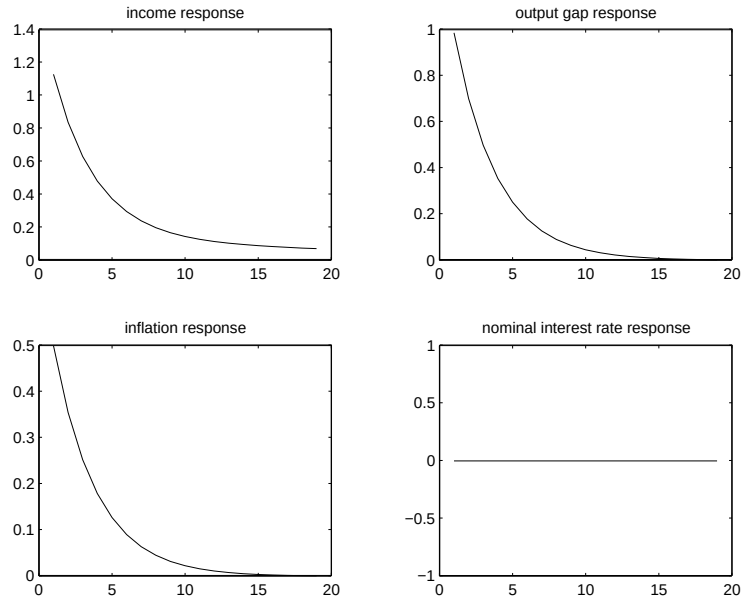

Figure 12: Responses to Unit Shock to Productivity under Interest Rate Peg and 'Non-Ricardian' Regime

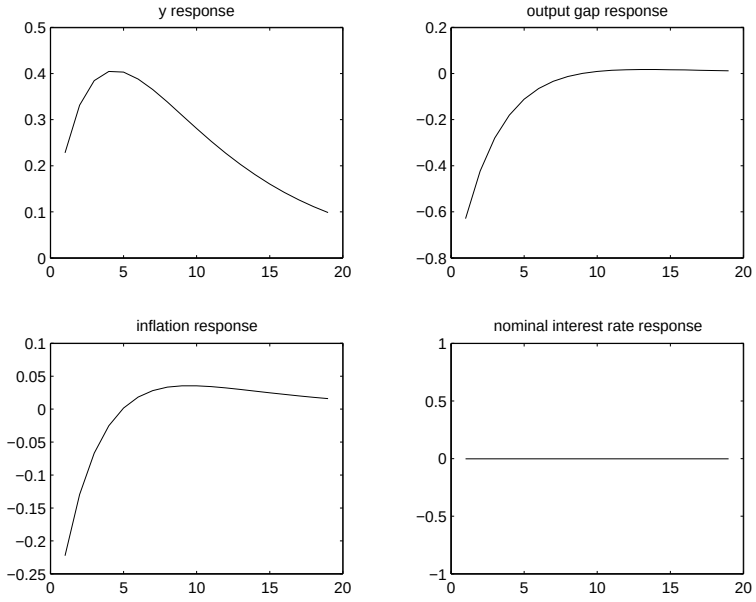

Figure 13: Responses to Unit Cost Push Shock under Interest Rate Peg and 'Non-Ricardian' Regime

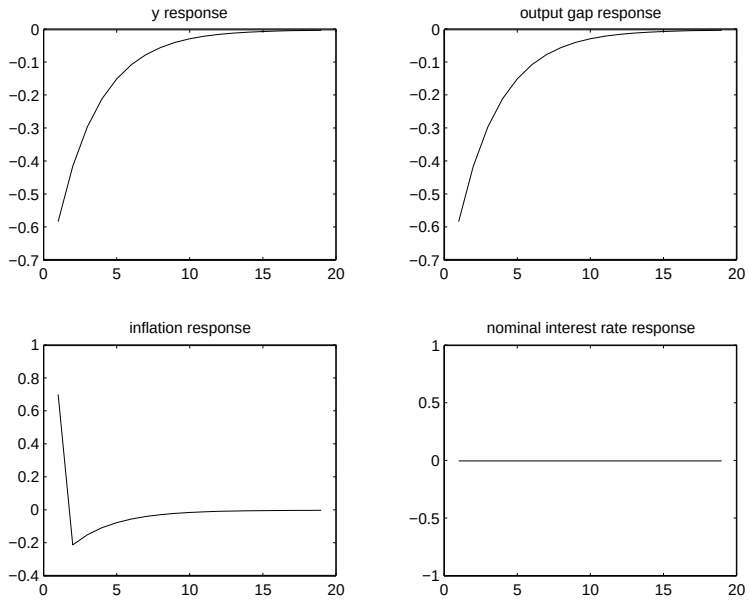
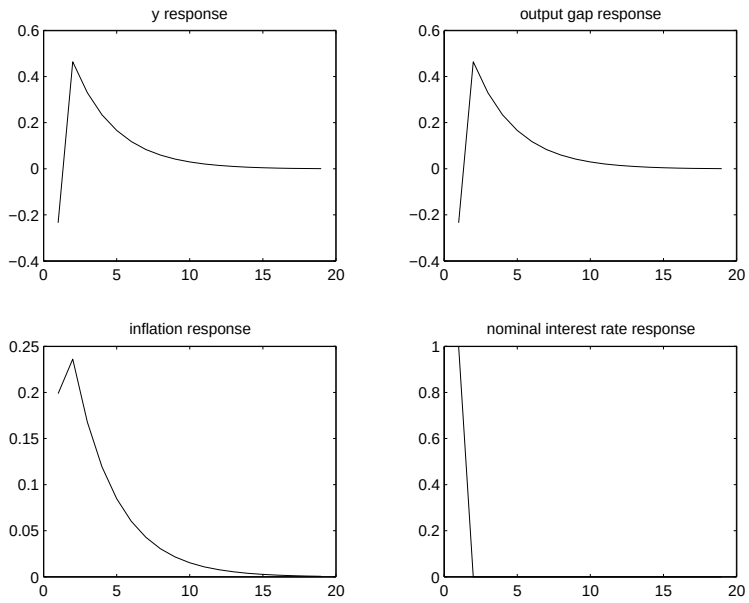
Figure 14: Responses to Unit Policy Shock under Interest Rate Peg and 'Non-Ricardian' Regime