Fiscal Policy under Balanced Budget and Indeterminacy:
A New Keynesian Perspective[*]

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Abstract. We investigate the effect of fiscal policy on equilibrium determinacy in a New Keynesian economy with rule-of-thumb (liquidity constrained) consumers and capital accumulation by focusing on the inter-action between monetary policy and taxation under the assumption of balanced budget. Our main finding is that taxation of firms' monopoly rents reduces the parameter range within which the Taylor principle is insufficient to guarantee equilibrium determinacy; hence it supports the determinacy of the rational expectation equilibrium.

Keywords: Rule-of-thumb consumers, equilibrium determinacy, fiscal and monetary policy inter-actions, tax distortions, balanced government budget.

JEL codes: E61, E63.

1. Introduction

There is a large literature on tax distortions, balanced budget rules and equilibrium indeterminacy suggesting that policy feedback rules linking monetary and fiscal instruments to the state of the economy can induce endogenous fluctuations and hence be destabilizing.[1] King *et al*. (1988), e.g., show that in a real business cycle model the amplitude of the business cycle increases when the government follows a balanced-budget rule and finances government spending with income taxes. Schmitt-Grohè and Uribe (1997a), in a central contribution, prove that expectations of future higher tax rates can be self-fulfilled when income taxation is endogenously determined in order to balance the budget whereas the growth rate of government expenditure is exogenously fixed.

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[1] See, among other, King *et al*. (1988), Leeper (1991), Woodford (1994), Sims (1994), Schmitt-Grohe and Uribe (1997a, 1997b, 2000), Leith and Wren-Lewis (2000), Gali *et al*. (2003), Guo and Harrison (2004).

Guo and Harrison (2004) illustrate that Schmitt-Grohé and Uribe's indeterminacy result in the real business cycle models depends crucially on a fiscal policy where the tax rate decreases with the household's taxable income, i.e. constant government expenditures financed by proportional taxation on income. Specifically, they modify Schmitt-Grohé and Uribe's analysis by allowing for endogenous public spending and transfers financed by separate fixed tax rates, a different balanced-budget rule that is commonly used in the real business cycle literature. Under their formulation, the economy does not display endogenous business cycles driven by agents' animal spirit.

Following the Guo and Harrison's formulation we aim to contrast the instability of the aggregate economy, by suggesting that in a New Keynesian (NEK) DSGE model with rule-of-thumb behavior, as introduced by Galì et al. (2003, 2004), a balanced budget rule may actually reduce the scope for indeterminacy.

More in details, Galì et al. (2003, 2004) show that the presence of a significant proportion of households that do not participate in the financial market affects the conditions under which a standard Taylor rule delivers uniqueness of the rational expectation equilibrium.[2] The Gali and coauthors' result can be explained as follows. In a canonical New Keynesian model with sticky prices, a coefficient larger than one in the Taylor rule implies a countercyclical response of monetary policy. Shocks that boost economic activity and inflation induce a monetary response that raises the real interest rate thus moderating consumption spending by financially unrestricted consumers and reducing private investment. The presence of rule-of-thumb consumers changes this in two ways. First the standard interest rate effect operates only through a small proportion of unrestricted consumers and, second, the increase in economic activity that leads to an increase in inflation also increases real wages and thus consumption of restricted consumers. In order to bring inflation under control and rule out sunspots the reaction of the real interest rate must be stronger rather than the canonical model.

We argue that the above result is not invariant to a public expenditure financed by different taxations and that, more precisely, once corporate income tax is introduced, fiscal policies based on budged balanced constraints may stabilize the economy differently from the common wisdom. The intuition behind our results is as follows. An

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expectation-driven increase in activity and inflation gives a rise in real wages and a decline in firms' markups due to price stickiness. Lower markups mean lower revenues from corporate taxation, because tax rates are constant. Hence, in order to balance the budget, government cuts expenditure which in itself reduces aggregate demand. This effect of fiscal policy runs completely opposite to the effect of rule-of-thumb consumption, since the latter generates a positive correlation between real wages and aggregate demand. The countercyclical behavior of markups, well-known in this class of models, is associated to a decrease in profits since dividends follow the same pattern of markups. A corporate taxation combined with the specific balanced budget arrangement can diminish tax revenues, government expenditures and aggregate demand and stabilize the economy. Furthermore labor and income taxation does not have this effect. In fact, only by counter-balancing the output expansion driven by animal spirits is possible to rule out sunspots. While profit taxation reduces tax revenues and, hence, aggregate demand, labor and income taxes go in the opposite direction because of the increase in output and employment.

We only partially confirm the Guo and Harrison's result in New Keynesian models. The existence of a time-varying government expenditures and income taxation are not a sufficient condition to deter equilibrium indeterminacy only the introduction of the *profit* taxation is necessary to obtain a stabilizing fiscal policy in a canonical New Keynesian model augmented with liquidity constrained consumers.

The rest paper is structured as follows. Next section describes the basic framework. Section 3 derives the model dynamics around the steady state. Section 4 investigates the model properties. A final section concludes.

2. The Model

We consider a *continuum* of households distributed in a unitary segment of mass one. Households can be of two different kinds: a fraction of them $(1-\lambda)$ can access to the capital markets,[3] whereas the remaining proportion (λ) cannot and thus has to consume

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[3] Spenders' behavior can be interpreted in various ways, e.g. different interpretations include myopia, limited participation to asset markets or fear of saving. See Mankiw (2000) and references therein. Some evidence of the quantitative importance of rule-of-thumb consumers is provided by Campbell and Mankiw (1989), Jappelli (1990), Shea (1995), Parker (1999), Souleles (1999), Fuhrer (2000), Fuhrer and Rudebusch (2003) and Ahmad (2005).

all the current disposable income. We refer to them as *rule-of-thumb* or *non-Ricardian* households and to the former as *optimizing* or *Ricardian* households.

Each optimizing consumer is assumed to maximize an inter-temporal utility function given by:

$$(1) \qquad E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{1-\sigma} \left(C_t^o L_t^{ov} \right)^{1-\sigma} \right]$$

subject to the sequence of budget constraints,

$$(2) \qquad P_t \left(C_t^o + I_t \right) + B_t = \left(W_t N_t^o + R_t^K K_{t-1} + D_t \right) \left(1 - \tau_t^Y \right) + B_{t-1} R_{t-1}$$

and the capital accumulation equation

$$(3) \qquad K_t = \left(1 - \delta \right) K_{t-1} + \phi \left(\frac{I_t}{K_{t-1}} \right) K_{t-1}$$

where C_t^o and L_t^o represent consumption and leisure for optimizing household (hence we use a "o" superscript) and β is the discount factor. The period utility take the Cobb-Douglas form inside a CRRA function, where $\sigma \geq 0$ is the inverse of the elasticity of inter-temporal substitution of an aggregate factor composed by consumption and leisure, while $v > 0$ denotes a cost of working. N_t^o is the level of employment, where $L_t^o = 1 - N_t^o$; W_t denotes the nominal wage, R_t^K the nominal return on capital, K_t the capital, I_t the investment, D_t the dividends from ownership of firms and B_t the quantity of nominally risk-less bonds purchased in period t, maturing in period $t+1$; each bond pays R_{t+1} of money at maturity (hence R_t is the nominal interest rate);[4] τ_t^Y denotes the income tax rate.

In equation (3), $\phi \left(\frac{I_t}{K_{t-1}} \right) K_{t-1}$ represents the capital adjustment costs, which determines the change in the capital stock (gross of depreciation) induced by investment spending I_t. We assume $\phi'(.) > 0$, $\phi''(.) \leq 0$, $\phi'(\delta) = 1$ and $\phi(\delta) = \delta$. The function of the adjustment costs is convex and the corresponding value of the equilibrium level of the ratio investment-to-capital stock is equal to the depreciation rate, i.e. in the steady state there are not adjustment costs.

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[4] In addition to the budget constraint, we assume that the Ricardian representative household is also subjected to a standard solvency constraint that prevents it from engaging in Ponzi-type schemes. Recall that non-Ricardian households do not save; thus they are not subject to the solvency condition.

The consumer choices consumption, leisure, investment and bonds by maximizing equation (1) subject to the constraints (2) and (3), in solving the inter-temporal optimization problem the tax rate and public expenditure are taken as exogenously given. By computing and rearranging the first-order conditions, one obtains the intra-temporal optimality condition setting the marginal rate of substitution between leisure and consumption equal to the real net wage; the Euler condition for the optimal inter-temporal allocation of consumption; the inter-temporal path of the Tobin's Q. Notice that leisure is present in the Euler condition given our assumption of the form of the period utility function (which is not separable).

(4)
$$\left(1-\tau_t^Y\right)\frac{W_t}{P_t} = v\frac{C_t^o}{L_t^o}$$

(5)
$$E_t\left[\frac{C_t^o}{C_{t+1}^o}\right]^{\sigma}\left[\frac{L_{t+1}^o}{L_t^o}\right]^{v(1-\sigma)} = \frac{1}{\beta R_t}E_t\left[\frac{P_{t+1}}{P_t}\right]$$

(6)
$$P_t Q_t = \frac{1}{R_t}\left\{\left(1-E_t\tau_{t+1}^Y\right)E_t R_{t+1}^K + E_t P_{t+1}Q_{t+1}\left[(1-\delta)+\phi_{t+1}-\left(\frac{I_{t+1}}{K_t}\right)\phi'_{t+1}\right]\right\}$$

where $Q_t = \partial I_t/\partial K_t = \left[\phi'\left(\partial I_t/\partial K_{t-1}\right)\right]^{-1}$ is the Tobin's Q or the real shadow value of capital.

As said, a proportion λ of households follows a rule-of-thumb and thus these households do not borrow or save. We refer to them through the superscript "r." Each period rule-of-thumb consumers solve their maximization problem, i.e. to choose the labor and consumption path that maximize:

(7)
$$E_t\sum_{t=0}^{\infty}\beta^t\left[\frac{1}{1-\sigma}\left(C_t^r L_t^{rv}\right)^{1-\sigma}\right]$$

subject to the constraint that all their labor income is consumed

(8)
$$P_t C_t^r = W_t N_t^r\left(1-\tau_t^Y\right)$$

The associated first order condition is given by:

(9)
$$\left(1-\tau_t^Y\right)\frac{W_t}{P_t} = v\frac{C_t^r}{L_t^r}$$

which can be combined with the budget constraint, rewritten as:

(10)
$$C_t^r = \frac{W_t}{P_t}N_t^r\left(1-\tau_t^Y\right)$$

By remembering that $L_t^r = 1 - N_t^r$, we obtain a constant amount of labor for rule-of-thumb consumers

(11)
$$N_t^r = \frac{1}{1+v} = N^r$$

Thus, the consumption is a proportion of the real wage

(12)
$$C_t^r = \frac{W_t}{P_t} \frac{1}{1+v} \left(1 - \tau_t^Y\right)$$

Aggregate leisure can be rewritten in function of the employment $L_t = 1 - N_t$.

Then we can formally write the weighted average of the variables for each consumer type:

(13)
$$C_t = (1-\lambda) C_t^o + \lambda C_t^r$$

(14)
$$N_t = (1-\lambda) N_t^o + \lambda N_t^r$$

By substituting the constant employment for the rule-of-thumb households, we derive

(15)
$$N_t = (1-\lambda) N_t^o + \frac{\lambda}{1+v}$$

The aggregate first order condition is:

(16)
$$C_t = \frac{1}{v} \left(1 - \tau_t^Y\right) \frac{W_t}{P_t} \left(1 - N_t\right)$$

Regarding the supply side, we consider an economy vertically differentiated composed by two sectors. The final sector is perfectly competitive, while in the intermediate good sector producers are monopolistic competitors.

More precisely, we assume a continuum of intermediate firms, uniformly distributed over the unit interval. Each firm produces a differentiated intermediate good that is combined in a competitive final sector, which uses a Dixit and Stiglitz technology. The final goods technology displays constant returns of scale and does not require labor or capital to produce a unit of the final good, but only intermediate commodities $Y_{t,h}$. Formally,

(17)
$$Y_t = \left(\int_0^1 \left(Y_{t,h}\right)^{\frac{\varepsilon-1}{\varepsilon}} dh \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

Any final good firm will potentially make profits defined by

(18)
$$\pi = P_t Y_t - \int P_{t,h} Y_{t,h} dh$$

Each firm sets a price at each period to maximize its profits by considering its production

function. In formal terms, each firm maximizes equation (18) subject to (17). The assumption of free entry implies that profits will equal zero in equilibrium, the first order conditions for profit maximization lead to the following demand function:

$$(19) \qquad\qquad P_{t,h} = \left(\frac{Y_{t,h}}{Y_t} \right)^{-\frac{1}{\varepsilon}}$$

We capture the degree of monopoly power of each firm by the gross markup $(\varepsilon - 1)\varepsilon^{-1}$, where $\varepsilon > 1$.

The production function for a typical intermediate goods firm is given by:

$$(20) \qquad\qquad Y_{t,h} = K_{t-1,h}^{\alpha} N_{t,h}^{1-\alpha}$$

where $N_{t,h}$ and $K_{t,h}$ represent the labor services and the capital, and α the capital share.

Profit maximization, taking the wage and the rental cost as given, is

$$(21) \qquad \text{Max } \Pi_{t,h} = \left[P_{t,h} Y_{t,h} - \left(1 + \tau_t^N \right) W_t N_{t,h} - R_t^K K_{t-1,h} \right] \left(1 - \tau_t^\Pi \right)$$

subject to (19) and equation (20), where τ_t^N is the labor tax rate and τ_t^Π the corporate tax rate paid by firms and exogenously taken.

The solution of the above problem implies the following first order conditions:

$$(22) \qquad\qquad \frac{R_t^K}{P_{t,h}} = \frac{\varepsilon - 1}{\varepsilon} \alpha \frac{Y_{t,h}}{K_{t-1,h}}$$

$$(23) \qquad\qquad \left(1 + \tau_t^N \right) \frac{W_t}{P_{t,h}} = \frac{\varepsilon - 1}{\varepsilon} (1 - \alpha) \frac{Y_{t,h}}{N_{t,h}}$$

The firm's first order conditions represent the input demand schedules.

For the sake of simplicity, we assume a symmetric equilibrium. We then impose $Y_{t,h} = Y_{t,k} = Y_t$, $C_{t,h} = C_{t,k} = C_t$, $I_{t,h} = I_{t,k} = I_t$, $N_{t,h} = N_{t,k} = N_t$ for all j and $k \in [0,1]$.

Intermediate firms set nominal prices as in Calvo (1983). Each firm resets its price with probability $(1 - \omega)$ each period, while the remaining fraction ω of producers keep their prices unchanged.

A firm resetting its price in period t will seek to maximize

$$(24) \qquad\qquad \underset{\{P_t^*\}}{\text{Max }} E_t \sum_{k=0}^{\infty} \omega^k \left[\Lambda_{t+k} Y_{t+k,h} \left(P_t^* - P_{t+k} MC_{t+k} \right) \right]$$

subject to $Y_{t+k,h} = \left(P_t^*\right)^{-\varepsilon} P_{t,h}^{\varepsilon} Y_{t+k}$, where $\Lambda_{t+k} = R_t^{-1} E_t \left[P_{t+1}/P_t\right]$ is the discount factor, P_t^* represents the price chosen by firms resetting prices at time t and MC_t the marginal cost at time t.

The first order condition for this problem is:

(25)
$$\sum_{k=0}^{\infty} \omega^k E_t \left[\Lambda_{t+k} Y_{t+k,h} \left(P_t^* - \frac{\varepsilon}{\varepsilon-1} P_{t+k} MC_{t+k} \right) \right] = 0$$

Finally, the equation describing the dynamics for the aggregate price level is given by:

(26)
$$P_t = \left[\omega P_{t-1}^{1-\varepsilon} + \left(1-\omega\right)\left(P_t^*\right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}$$

where P_t^* is the optimal price chosen by firms resetting at time t.

We assume that a central bank set the growth of interest rate according to a standard Taylor rule (Taylor (1993)), which satisfies the Taylor principle, i.e. the nominal interest rate reacts more than one to the expected inflation.[5] Formally,

(27)
$$R_t = \left(\frac{P_{t+1}}{P_t}\right)^{\theta_\pi} + Y_t^{\theta_y}$$

where $\theta_\pi > 1$.

The Government spending is endogenously determined every period by balancing, in expected term, the following budget constraint:

(28)
$$P_t G_t + B_{t-1} R_t = \tau_t^Y \left(W_t N_t + R_t^K K_{t-1} + D_t \right) + \frac{\tau_t^\Pi}{1-\tau_t^\Pi} D_t + \tau_t^N W_t N_{t,h} + B_t$$

where G_t is the government purchases.

The following standard aggregate resource constraint must also holds:

(29)
$$Y_t = C_t + I_t + G_t$$

that, of course, also includes investments and public expenditure.

3. Dynamics around the Steady State

In the long run our economy progresses to a zero-debt and a zero-inflation steady state, where, for the sake of simplicity, we also assume $P = 1$. The budget constraint for the optimizers becomes $C^o + I = \left(WN^o + R^K K + D\right)\left(1-\tau^Y\right)$. The steady state for investment,

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discount factor, marginal utility of wealth, Tobin's Q are respectively: $\delta K = I$, $\beta R = 1$,

$$\left[C^o \left(L^o \right)^v \right]^{-\sigma} L^{ov} = \Lambda \text{ and } Q = 1.$$

By using the optimality conditions, we can derive the unique steady state of consumption for Ricardian households and capital rental cost in function of the coefficient of time preference ρ, equal to r in the long run:

$$(30) \qquad \left(1 - \tau^Y \right) W = v \frac{C^o}{1 - N^o}$$

$$(31) \qquad \left(1 - \tau^Y \right) R^K = \frac{1}{\beta} - \left(1 - \delta \right) = \rho + \delta$$

The same is for the rule-of-thumb consumers:

$$(32) \qquad C^r = WN^r \left(1 - \tau^Y \right) = \frac{W}{1 + v} \left(1 - \tau^Y \right)$$

The steady-state analysis for the intermediate firms yields the following results $Y = K^\alpha N^{1-\alpha}$, $R^K = MC\alpha YK^{-1}$, $\left(1 + \tau^N \right) W = MC \left(1 - \alpha \right) YN^{-1}$ and $P = P^* = 1 = \mu MC$, where $MC = \left(\varepsilon - 1 \right) \varepsilon^{-1}$ stands for marginal cost and $\mu = \varepsilon \left(\varepsilon - 1 \right)^{-1}$ is the mark-up. It follows that:

$$(33) \qquad \frac{R^K K}{Y} = MC\alpha = \frac{\alpha}{\mu}$$

$$(34) \qquad \frac{WN}{Y} = MC \frac{1 - \alpha}{1 + \tau^N} = \frac{1 - \alpha}{\mu \left(1 + \tau^N \right)}$$

Government and aggregate resource constraints are in the long run equal to:

$$(35) \qquad G = \tau^Y \left(WN + R^K K + D \right) + \frac{\tau^\Pi}{1 - \tau^\Pi} D + \tau^N WN$$

$$(36) \qquad Y = C + I + G = \left(1 + \tau^N \right) WN + R^K K + \frac{1}{1 - \tau^\Pi} D = \left(MC \right) Y + \left(1 - MC \right) Y$$

From equation (36) dividends are $D = \left[Y - \left(1 + \tau^N \right) WN - R^K K \right] \left(1 - \tau^\Pi \right) = \left(1 - \tau^\Pi \right) \varepsilon^{-1} Y$, thus:

$$(37) \qquad \frac{D}{Y} = \frac{1 - \tau^\Pi}{\varepsilon}$$

The share of public expenditure is

(38)
$$s_g = \frac{1-\alpha}{\mu} \frac{\tau^Y + \tau^N}{1+\tau^N} + \frac{\tau^\Pi(1-\tau^Y) + \tau^Y[1+(\varepsilon-1)\alpha]}{\varepsilon}$$

By combining equations (31) and (33), we obtain the share of investment:

(39)
$$s_i = \frac{\alpha\delta(1-\tau^Y)}{(\rho+\delta)} \frac{\varepsilon-1}{\varepsilon}$$

The share of consumption is easily determined from $s_c = 1 - s_i - s_g$:

(40)
$$s_c = 1 - s_g - \frac{\alpha\delta(1-\tau^Y)}{\mu(\rho+\delta)}$$

After some tedious algebra, we obtain the steady state level of aggregate employment:[6]

(41)
$$N = \frac{(1-\alpha)(\rho+\delta)(1-\tau^Y)}{v[(\rho+\delta)(1-s_g)(1+\tau^N)\mu - \alpha\delta(1-\tau^Y)(1+\tau^N)] + (1-\alpha)(\rho+\delta)(1-\tau^Y)}$$

We can rewrite the level of employment, consumption, and Ricardian consumption as: $N = (1-\lambda)N^o + \lambda(1+v)^{-1}$, $C = v^{-1}W(1-N)(1-\tau^Y)$, $C^o = W(1+v)^{-1}(1-\tau^Y)$ and, by combining these aggregate equations, it is possible to obtain the consumption steady state ratios; by using $1 = (1-\lambda)\gamma_o + \lambda\gamma_r$, it follows that $\gamma_o = \frac{C^o}{C} = \frac{1-\lambda\gamma_r}{1-\lambda}$ and $\gamma_r = \frac{C^r}{C} = \frac{v}{1+v}\frac{1}{1-N}$.

Disregarding on tax rate, the resulting linear equations of the firm's optimality conditions are:

(42)
$$y_t = \alpha k_{t-1} + (1-\alpha)n_t$$

(43)
$$r_t^K - p_t = -\hat{\mu}_t + y_t - k_{t-1}$$

(44)
$$w_t - p_t = -\hat{\mu}_t + y_t - n_t$$

(45)
$$\pi_t = \beta E_t \pi_{t+1} - \frac{(1-\beta\omega)(1-\omega)}{\omega}\hat{\mu}_t$$

where $\hat{\mu}_t$ represents the (log)deviations of the gross markup from its steady-state level, which is equal to the inverse of the marginal cost, i.e. $\widehat{(MC)}_t = -\hat{\mu}_t$ in logs.

The log-linearization of the production function (17) and of the first order conditions ((22) and (23)) gives us the transition dynamic of the output (42) and the input demand schedules ((43) and (44)). The labor demand curve is downward sloping and depends negatively upon the labor taxation. The New Keynesian Phillips Curve is derived by

solving the firm's maximization problem (24) in a standard manner.[7]

Regarding, the log-linearized version of the household's optimality conditions, the log-linearized version of the capital accumulation equation is:

$$(46) \qquad k_t = (1-\delta)k_{t-1} + \delta i_t$$

By rewriting the Ricardian leisure as a function of the aggregate employment (notice that $n_t = (1-\lambda)\gamma_o n_t^o$, then $l_t^o = -\frac{N}{(1-\gamma_o N)}\frac{1}{(1-\lambda)}n_t$ and $l_t = -\varphi n_t$, where $\varphi = \frac{N}{1-N}$ is the steady-state inverse Frisch labor supply elasticity), the optimal conditions for Ricardian and Non Ricardian consumers can be rewritten as $w_t - p_t = c_t^r$, $w_t - p_t = c_t^o - \frac{N}{(1-\gamma_o N)(1-\lambda)}n_t$ and $c_t^o = E_t c_{t+1}^o - \frac{1}{\sigma}(r_t - E_t \pi_{t+1}) + \frac{(1-\sigma)\nu}{\sigma(1-\gamma_o N)(1-\lambda)}\Delta n_{t+1}$.

Ricardian consumers take account of the employment and the income tax rate, while the level of the employment of the rule of thumb is constant. The Euler equation is standard except for the presence of the deviations in employment. The presence of the deviations in employment is justified by the fact that the marginal utility of consumption in each period depends upon the leisure. If $\sigma < 1$, the marginal utility of consumption and leisure are positively related. An increase in current labor decreases the marginal utility of consumption and, ceteris paribus, current consumption must decrease.

The log-linearized version of the aggregate labor supply is:

$$(47) \qquad w_t - p_t = c_t + \varphi n_t$$

and log-linearized consumption is $c_t = (1-\lambda)\gamma_o c_t^o + \lambda \gamma_r c_t^r$. After some algebra we also obtain $c_t^r = c_t + \varphi n_t$ and $c_t^o = c_t - \frac{\nu(1+\nu)^{-1}\lambda\varphi(1+\varphi)}{1-\nu(1+\nu)^{-1}\lambda(1+\varphi)}n_t.$, the aggregate Euler Equation is thus:

$$(48) \qquad c_t = E_t c_{t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1}) - \nu\left[\frac{(\sigma-1)N}{\sigma(1-\gamma_o N)(1-\lambda)} + \frac{\lambda\varphi\gamma_r}{1-\lambda\gamma_r}\right]\Delta n_{t+1}$$

The log-linear equations describing the dynamics of Tobin's Q and its relationship with investments are:

$$(49) \qquad q_t = -\phi''(\delta)\delta(i_t - k_{t-1}) = \frac{1}{\eta}(i_t - k_{t-1})$$

$$(50) \qquad q_t = \beta E_t q_{t+1} + [1 - \beta(1-\delta)](r_{t+1}^k - p_{t+1}) - (r_t - E_t \pi_{t+1})$$

where η represents the elasticity of the investment-capital ratio with respect to Q.

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[6] See the appendix A for details.

The log-linear equations describing the dynamics of government purchases, dividends and aggregate resources around zero-debt steady state are given by:

(51) $\quad s_g g_t = \dfrac{\tau^Y \alpha}{\mu}\left(r_t^k - p_t + k_{t-1}\right) + \dfrac{\tau^Y + \dfrac{\tau^\Pi}{\left(1-\tau^\Pi\right)}}{\varepsilon}\left(d_t - p_t\right) + \dfrac{(1-\alpha)\left(\tau^Y + \tau^N\right)\left(w_t - p_t + n_t\right)}{\mu}$

where s_g is given by equation (38).

(52) $\hspace{4cm} d_t - p_t = y_t + \left(\varepsilon - 1\right)\hat{\mu}_t$

(53) $\hspace{4cm} y_t = s_c c_t + s_i i_t + s_g g_t$

The central bank sets the level of interest rate in such a way that a standard Taylor rule is followed:

(54) $\hspace{4cm} r_t = \theta_\pi \pi_t + \theta_y y_t$

It is worth noticing that the targets of the above rule are consistent with the steady-state properties of the model.

We can now combine equilibrium conditions (42)-(54) to obtain a system of difference equations describing the log-linearized equilibrium dynamics of our economy. The system is composed of 13 equations and in 13 unknowns variables (y_t, k_t, n_t, $r_t^K - p_t$, $\hat{\mu}_t$, π_t, i_t, $w_t - p_t$, c_t, n_t, r_t, g_t, $d_t - p_t$).

4. Calibration and Analysis of Equilibrium Dynamics

We use numerical methods for studying the uniqueness of the equilibrium and to provide a theoretical reason to the conditions that guarantee the uniqueness of equilibrium. More precisely, we will focus on the difference between our conditions and those stressed by Galì *et al.* (2004) for the case of lump-sum taxation in order to check if the latter can be generalized.

We calibrate our model following Galì *et al.* (2003), to compare the stabilization properties of a Taylor rule to their results. The labor disutility is set to obtain a steady state employment equal to $1/2$ without tax distortions as in Galì *et al.* (2003). For the tax rates we use the values estimated by Busato *et al.* (2005),[8] whereas monetary policy follows a

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[7] See e.g. in Walsh (2003: Appendix 5.7.3).
[8] Calibration of the tax rates however does not matter for our results. We present in the appendix a sensitivity analysis in order to evaluate the robustness of our main results.

standard Taylor rule. The table below summarizes the value assumed for the parameters.

Table 1 – Model calibration

Deep parameters	$\beta = 0.99$	$\varphi = 1$	$\sigma = 1$	$\eta = 1$
	$\alpha = 0.33$	$\varepsilon = 6$	$\delta = 0.025$	$v = 0.7$
Calvo's parameter	$\omega = 0.75$	$\lambda = 0.8$		
Monetary policy	$\theta_\pi = 1.5$	$\theta_y = 0.5$		
Tax rates	$\overline{\tau}^\Pi = 0.35$	$\overline{\tau}^N = 0.15$	$\overline{\tau}^Y = 0.12$	

The share of government expenditures (s_g) is endogenously determined taking account of the balanced budget policy rule.

Before stressing our results, it is useful to briefly discuss those of Galì *et al.* (2003, 2004) since we generalize their approach, as Galì *et al.* (2003) emerges as a particular case of our model (i.e. by assuming all the tax rates equal to zero).

Galì and coauthors show that the presence of rule-of-thumb consumers can dramatically change the properties of the interest rate set accordingly a Taylor rule. In particular, the combination between a high degree of price stickiness and a large share of rule-of-thumb consumers rules out the existence of a unique equilibrium converging to the steady state. Both frictions are necessary for having indeterminacy.[9] This result is driven by two imperfections: the presence of rule-of-thumb and counter-cyclical markups.[10] A decline in markups, associated to an increase in the economic activity, allows real wages to increase (see equation (44) disregarding taxes). Then the increase in real wages generates inflation and a boom in consumption among non Ricardian consumers. If the weight of the rule-of-thumb is sufficiently large, the rise in their consumption will more than offset the effect of the rise in interest rate on Ricardian consumption. In other words, the high share of rule-of-thumb can invert the mechanism of the Taylor principle. A shock in economic activity and inflation can be self-fulfilled, and fluctuations are induced by indeterminacy in the equilibrium path. That possibility is facilitated by a high relative risk aversion, since it dampens the response of the consumption of Ricardian households (as

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[9] Once that the Blanchard and Kahn's (1980) conditions are not satisfied, the equilibrium may be indeterminate and thus displaying sunspot fluctuations even when the interest rate rule satisfies the Taylor principle.

[10] That characterizes this kind of models.

we can see in equation (48)).

In our model the indeterminacy might be contrasted by fiscal policy. In Figure 1 we show the dynamic response of the aggregate variables when a positive shock hits the economic activity and fiscal policy is explicitly considered according to the baseline calibration. There the output expansion is ruled out jointly by the increase of the real interest rate and the reduction of the aggregate demand. In fact real interest rate moderates consumption spending by financially unrestricted consumers and reduces private investment; taxation on profits reduces tax revenues and government expenditures.

<center>About here figure 1</center>

In our model the sunspot mechanism stressed by Galì *et al.* (2003) can thus be ruled out by corporate taxes. Since the corporate tax rate burdens dividends, a decline in markups is now associated to a reduction in government expenditure. The positive effect on dividends driven by the increase in output is more than offset by a negative effect leaded by a decrease in markups, since the variation of profits share affects dividends stronger than the variation of the output level. Because of the consequent reduction of aggregate demand the expansionary mechanism is hindered; therefore, the increase in non-Ricardian consumption can be more than offset by the decrease of public expenditure. Corporate tax rate, by burdening markups, is able to stabilize the economy when the Taylor rule is unable to do it.

Table 2 shows that when the share of rule of thumb consumers is high enough, only a small threshold rate on profits could guarantee the uniqueness of the equilibrium, given that the Taylor rule needs a very high threshold inflation coefficient.

Table 2 - Rule of thumb consumers, threshold inflation coefficient and threshold profit tax rate

λ	θ_π	τ_π
0.1-0.6	0.94	0
0.7	3.7	0.07
0.8	12.2	0.26
0.9	24.4	0.44

In our calibration, taxation on profits affects conditions for indeterminacy: sunspots are less likely to be observed under fiscal distortions (see figure 2 below). As point out by Galì *et al.* (2003), results are strongly affected by the relative risk aversion and degree of stickiness. In our framework these effects are depicted in figure 2.

About here figure 2

The relative risk aversions may have strong effects on determinacy properties of a Taylor rule. Figure 2 shows the change of the regions of indeterminacy for the case of $\sigma = 1$ (panel (a)) and $\sigma = 5$ (panel (b)). When $\sigma = 1$ the weight of the Ricardian-consumption reduction induced by monetary restriction is more important, indeterminacy requires a larger size of rule-of-thumb consumers relative to the case of $\sigma = 5$.[11]

Regarding the Calvo's parameter, in New Keynesian models, the impact of the current output (via markup) on current inflation by the Phillips curve is larger for low values of the Calvo's parameter. Then the Taylor principle does not hold and multiple solutions become possible.[12]

By considering steady state value of employment smaller than 1/2, which is a smaller value than those commonly used in the literature, the share of rule of thumb consumers necessary to modify the regime of determinacy becomes higher than values presented in the case of Galì *et al* (2004). In fact, an equilibrium value of employment of 1/3 rises the share of rule-of-thumb consumers necessary for an indeterminacy regime to about 0.8, a value very similar to our result in presence of fiscal distortions, despite the *ceteris paribus* calibration used by Galì *et al* (2003, 2004), i.e. employment equal to 1/2. Therefore, the lack of robustness of their findings is emphasized by a lower employment steady state value since a very small corporate tax structure is more likely to remove regions of indeterminacy in presence of a monetary Taylor rule.

Figure 3 depicts the impulse responses when a negative cost push shock is considered; counter-cyclical wage markups are easily observable. Despite of the increase in output, dividends follows the same pattern of markups, as previously highlighted. Nonetheless in Figure 3b we verify that the effect of a decrease in markups dominates the effect of an increase in output. Government expenditure diminishes, but aggregate demand rises because of the increase in real wages and non Ricardian consumption (and in private investment). However, if tax revenues did not reduce then it would be more probably associated to a presence of multiple equilibria. Again, taxation on profits plays a central role in avoiding sunspots. By contrast, an increase in labor or income tax rate implies an increase in government expenditure even if markups decline, and therefore, the regions of

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[11] Robustness of our results is also shortly discussed below and sensitivity analysis provided by appendix B.
[12] The indeterminacy caused by the excessive response of monetary policy has been emphasized by Bernanke and Woodford (1997). See also Clarida *et al.* (1998, 1999) and Woodford (2004).

indeterminacy are not restricted.

About here figure 3

Figure 4 shows how government expenditures increase after a negative cost push shock if only income taxation is considered. This is due to an increase in output. In this case if the share of rule-of-thumb consumers is equal to 0.67, as in the previous simulations, it is not possible to rule out sunspot equilibria through the intervention of fiscal policy and, hence, we have re-calibrated the share of rule-of-thumb consumers to 0.66.

About here figure 4

Figure 5 describes the impulse responses in presence of the taxation on labor. In this case it becomes more difficult to observe equilibrium determinacy. In fact, labor taxation is strongly pro-cyclical and destabilizing, thus in Figure 5 we have to diminish the share of rule of thumb consumers to 0.6, in order to depict the impulse response functions to a negative cost push shock. Again, it results that government expenditures are strongly very positively correlated with output.

About here figure 5

Summarizing, we show that Galì *et al.* (2004) is not indifferent to fiscal policy structure. Our general result is that balanced budget rule and corporate tax distortions[13] facilitate the Taylor criterion since, in such a case, sunspot-driven fluctuations in the business cycle are less likely to be observed. This occurs because when a sunspot mechanism driven by a decline in markups could act, the taxation on profits dampens the aggregate demand, through the reduction of government expenditure. Hence it breaks the movement leaded by the animal spirit hypothesis at the heart of the sunspot mechanism, i.e., the self-fulfilling prophecy of an expansion of the economic activity.

6. Concluding Remarks

Following the recent developments of literature on rule-of-thumb consumers in New Keynesian monetary model, we analyze the support of monetary and fiscal policies to saddle-path solutions by studying the determinacy of the rational expectation equilibrium.

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[13] In our model, dividend taxation is distortionary. There is a strong debate about the neutrality of dividend taxation (e.g. old and new view of dividend taxation, see Sinn, 1991). More precisely, in our context tax non-neutrality arises by introducing a non-separable utility function. In such a way the steady state value of employment changes the optimal condition in labor supply, since steady state empliyement is entailed by dividend taxation through government expenditures (see equation (47)).

We show that the properties of standard models augmented with rule-of-thumb consumers and fiscal policies are not indifferent to the taxation structure.

We find that corporate taxation implies a new conjoint fiscal and monetary stabilization. Although the Taylor principle is in fact generally known as a compelling criterion of policy stabilization, we show that if general conditions are present (as e.g. balanced budget rule and taxation of firms' monopoly rents), it is not necessary to set an aggressive interest rate response to inflation to avoid equilibrium indeterminacy, as corporate tax rate can interact with monetary policy and fiscal policy could even substitute the monetary policy in order to stabilize the economy.

Our main contribution is to show that, in a New Keynesian model augmented with rule-of-thumb behavior, a balanced budget rule may actually reduce the scope for indeterminacy. Hence, price rigidities and endogenous government expenditure lead to opposite result to the conventional ones found e.g. by Schmitt-Grohè and Uribe (1997) in flexible price environments. We however only partially confirm Guo and Harrison (2004) as, under balanced budget rule, only profit taxation successes in stabilizing economy, whereas e.g. income taxation increases the scope of instability.

Specifically, by extending Galì *et al.* (2003, 2004) to a fiscal policy based on an endogenous expenditure financed by tax distortions and satisfying a balanced budget constraint, we show that fiscal policy is non-neutral with respect to equilibrium determinacy since balanced budget policy facilitates the stabilizing properties of the Taylor rule by restricting the possibility of sunspot-driven fluctuations in the business cycle. If public spending is partially financed through taxes on dividends, these might fall when the markup declines, thus contributing to reduce inflation even in an economy with a large fraction of non-Ricardian consumers. An increase in corporate tax rate thus makes sunspot equilibria less likely to emerge.

The rationale of our result is as follows. An expectation-driven increase in activity gives a rise in real wages and a decline in firm markups due to price stickiness. Lower markups mean lower revenues from corporate taxation, because tax rates are kept constant. Hence, in order to balance the budget, government cuts expenditures which in itself reduce aggregate demand. This effect of fiscal policy runs completely opposite to the effect of rule-of-thumb consumption, since the latter generates a positive correlation between real wages and aggregate demand. Hence, when rule-of-thumb behavior destabilizes the

economy, profit taxation combined with the specific balanced budget arrangement stabilizes it.

Appendix A – Labor disutility and steady state employment

The steady-state level of aggregate employment is obtained as follows.

(a.1) $\qquad \dfrac{N}{1-N} = \dfrac{1}{v}\dfrac{(\varepsilon-1)(1-\alpha)}{s_c\varepsilon}\dfrac{1-\tau^Y}{1+\tau^N} = \dfrac{1}{v}\dfrac{(\varepsilon-1)(1-\alpha)(\rho+\delta)}{\varepsilon(1-s_g)(\rho+\delta)-\alpha\delta(1-\tau^Y)(\varepsilon-1)}\dfrac{1-\tau^Y}{1+\tau^N}$

(a.2) $\qquad N = \dfrac{N}{1-N}\left(\dfrac{N}{1-N}+1\right)^{-1} = \dfrac{(1-\alpha)(1-\tau^Y)}{(1-\alpha)(1-\tau^Y)+\mu v s_c(1+\tau^N)}$

By using equation (40), after tedious algebra, the above expression can be also rewritten as:

(a.3) $\qquad N = \dfrac{(1-\alpha)(\rho+\delta)(1-\tau^Y)}{v\left[(\rho+\delta)(1-s_g)(1+\tau^N)\mu-\alpha\delta(1-\tau^Y)(1+\tau^N)\right]+(1-\alpha)(\rho+\delta)(1-\tau^Y)}$

Equation (a.3) with equation (38) determines the level of employment as a function of the deep parameters only. It can be rewritten as:

(a.4) $\qquad v = \dfrac{(1-\alpha)(\rho+\delta)(1-\tau^Y)}{\varphi\left[(\rho+\delta)(1-s_g)(1+\tau^N)\mu-\alpha\delta(1-\tau^Y)(1+\tau^N)\right]}$,

which can be used to find the labor disutility consistent with a given level of employment.

Appendix B – Sensitivity Analysis

Table 1B – Sensitivity analysis on output coefficient, capital adjustment cost, and labor elasticity

a) Output coefficient

b) Capital adjustment costs

c) Labor supply elasticity
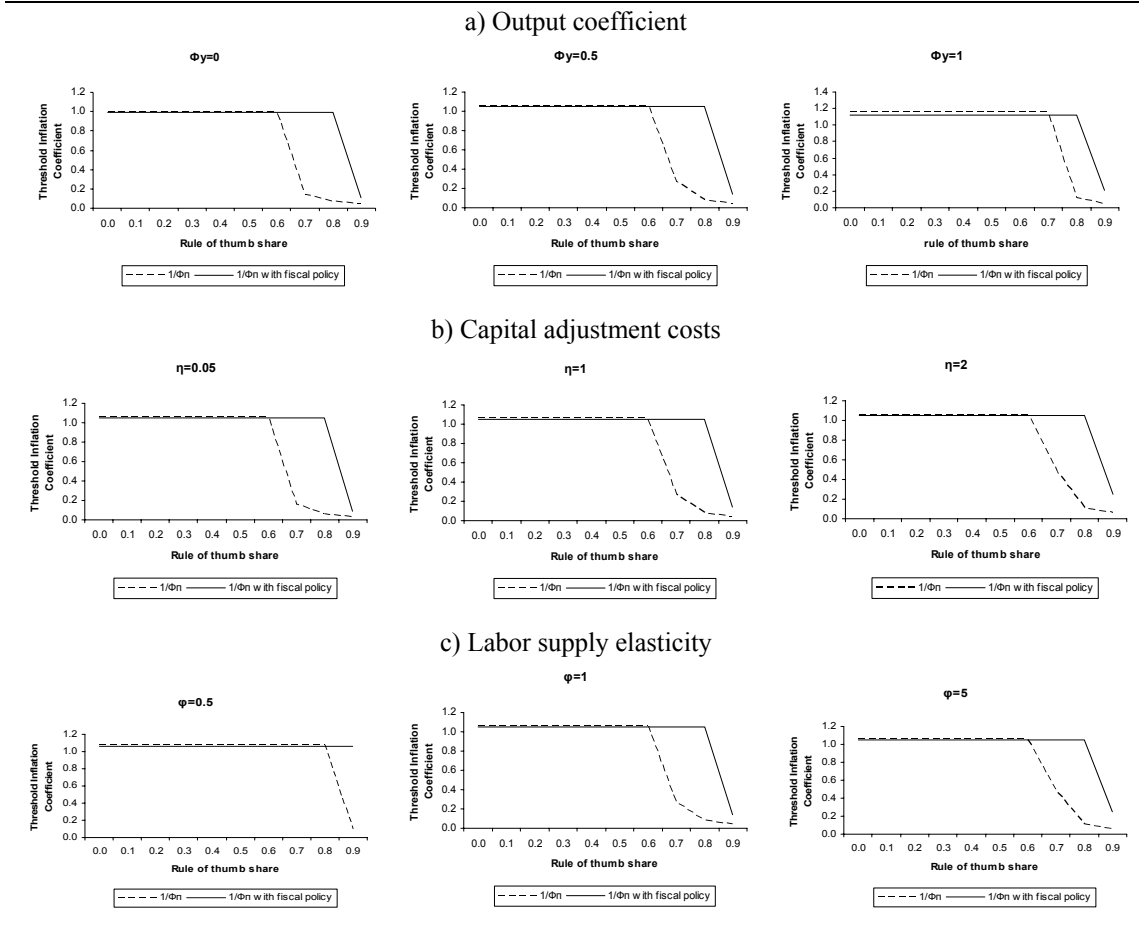
References

Ahmad, Y. (2005), Money Market Rates and Implied CCAPM Rates: Some International Evidence, *Quarterly Review of Economics and Finance*, 45: 699-729.

Amato, J. and T. Laubach (2003), Rule-of-Thumb Behavior and Monetary Policy, *European Economic Review*, 47: 791-831.

Bilbiie, F.O. (2004), The Great Inflation, Limited Asset Markets Participation and Aggregate Demand: FED Policy was Better than you Think, *European Central Bank Working Paper* No. 408.

Blanchard, O. and C.M. Kahn (1980), The Solution of Linear Difference Models under Rational Expectations, *Econometrica*, 48: 1305-1311.

Busato, F., B. Chiarini and G.M. Rey (2005), Equilibrium Implications of Fiscal Policy with Tax Evasion, *Working Paper No 4*, University of Aarhus.

Campbell, J.Y. and N.G. Mankiw (1989), Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence, *NBER Macroeconomics Annual*, MIT Press, Cambridge:185-216.

Clarida R., J. Galì, and M. Gertler (1998), Monetary Policy Rules in Practice Some International Evidence, *European Economic Review*, 42: 1033-1067.

Clarida R., J. Galì, and M. Gertler (1999), The Science of Monetary Policy, *Journal of Economic Literature*, 37: 1661-1707.

Di Bartolomeo, G. and L. Rossi (2007), Efficacy of Monetary Policy and Limited Asset Market Participation, *International Journal of Economic Theory*, 3: 213-218.

Erceg, C.J., W.H. Dale, and A. Levin (2000), Optimal Monetary Policy with Staggered Wage and Price Contracts, *Journal of Monetary Economics*, 46: 281-313.

Fuhrer, J.C. (2000), Habit Formation in Consumption and Its Implications for Monetary-Policy Models, *American Economic Review*, 90: 367-90.

Fuhrer, J.C. and G.D. Rudebusch (2003), Estimating the Euler Equation for Output, Federal Reserve Bank of Boston, *mimeo*.

Galì, J., D. Lòpez-Salido and J. Vallés (2003), Rule-of-Thumb Consumers and the Design of Interest Rate Rules, *Journal of Money, Credit, and Banking*, 36: 739-764.

Galì, J., D. Lòpez-Salido and J. Vallés (2004), Understanding the Effects of Government Spending on Consumption, *European Central Bank Working Paper* No 333.

Guo, J. T. and S. G. Harrison (2004). Balanced-Budget Rules and Macroeconomic (in)Stability, *Journal of Economic Theory*, 119: 357-363.

Jappelli, T. (1990) Who is Credit Constrained in the US Economy?, *Quarterly Journal of Economics*, 219-234.

Leeper, E.M. (1991), Equilibria under 'Active' and 'Passive' Monetary and Fiscal Policies. *Journal of Monetary Economics*, 27, 129–147.

Leith, C. and S. Wren-Lewis (2000) Interactions between Monetary and Fiscal Rules. *The Economic Journal*, 110: C93-C108.

Mankiw, G.N. (2000), The Saver-Spenders Theory of Fiscal Policy, *American Economic Review*, 90: 120-125.

Parker, J. (1999), The Response of Household Consumption to Predictable Changes in Social Security Taxes, *American Economic Review*, 89: 959-973.

Schmitt-Grohe, S. and M. Uribe (1997a), Balanced-Budget Rules and Macroeconomic (in)Stability. *Journal of Economic Theory*, 119: 357-363.

Schmitt-Grohe, S. and M. Uribe (1997b), Balanced-Budget Rules, Distortionary Taxes, and Aggregate Instability, *Journal of Political Economy*, 105: 976-1000.

Schmitt-Grohe, S. and M. Uribe (2000), Price Level Determinacy and Monetary Policy under a Balanced-Budget Requirement, *Journal of Monetary Economics*, 45: 211-246.

Shea, J. (1995), Union Contracts and the Life-Cycle/Permanent-Income Hypothesis, *American Economic Review*, 85: 186-200.

Sims, C. (1994), A Simple Model for the Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy, *Economic Theory*, 4: 381-399.

Sinn, H.W. (1991), The Vanishing Harberger Triangle, *Journal of Political Economy*, 45: 271-300.

Souleles, N.S. (1999), The Response of Household Consumption to Income Tax Refunds, *American Economic Review*, 89: 947-958.

Walsh C. (2003), *Monetary Theory and Policy*, 2nd Edition, MIT Press, Cambridge.

Woodford, M. (1994). Nonstandard Indicators for Monetary Policy: Can Their Usefulness Be Judged from Forecasting Regressions? in *Monetaly Policy,* edited by N. Gregory Mankiw, University of Chicago Press, Chicago.

Woodford, M. (2004), The Taylor Rule and Optimal Monetary Policy, *American Economic Review*, 91: 232-237.

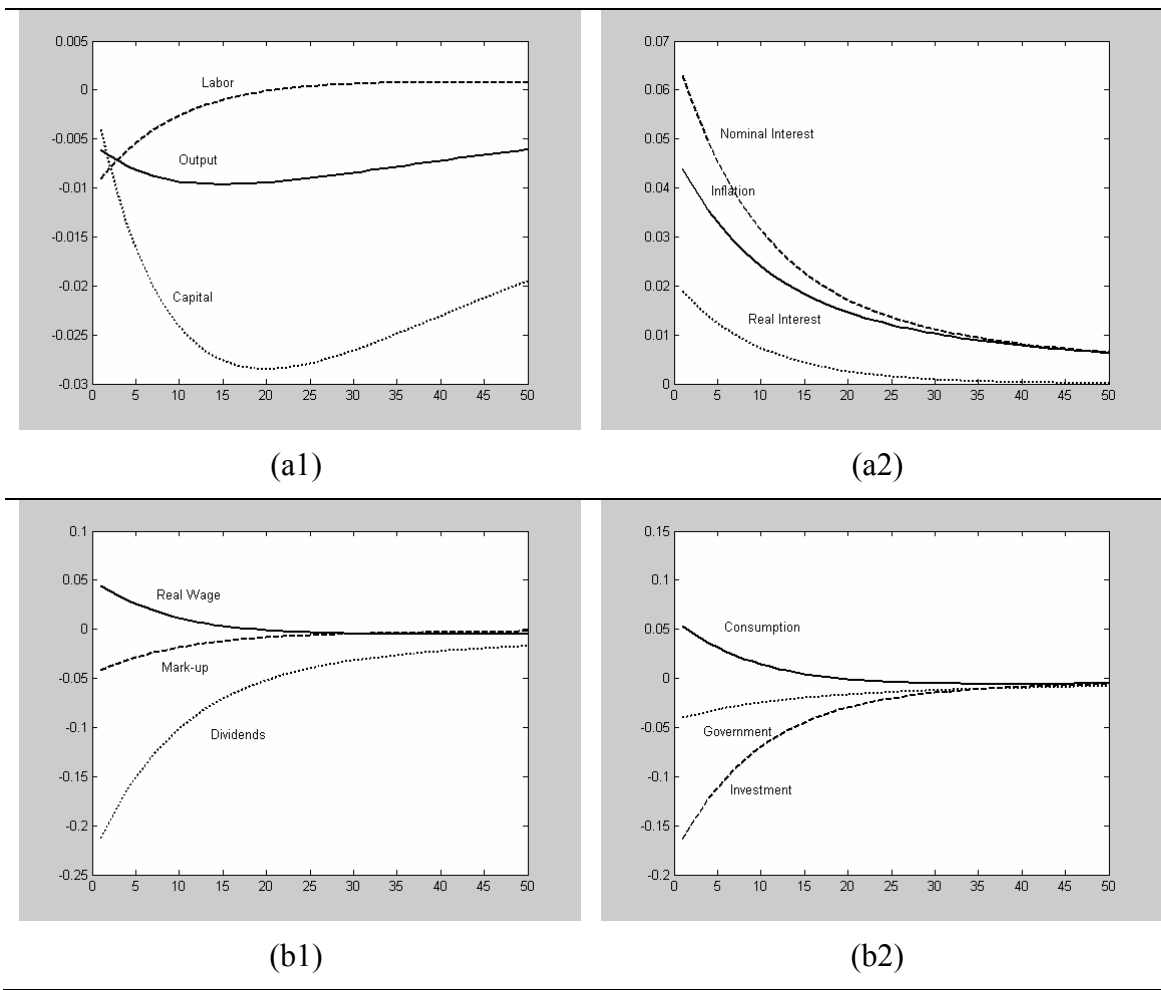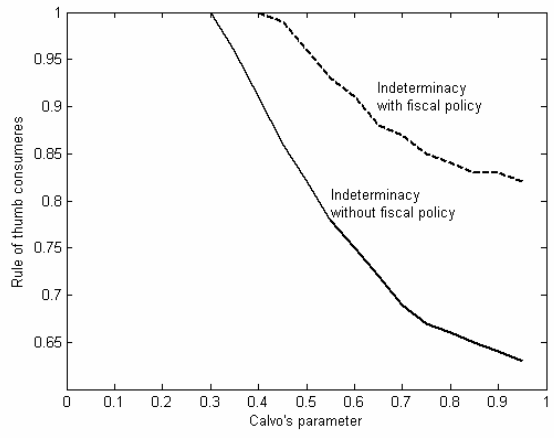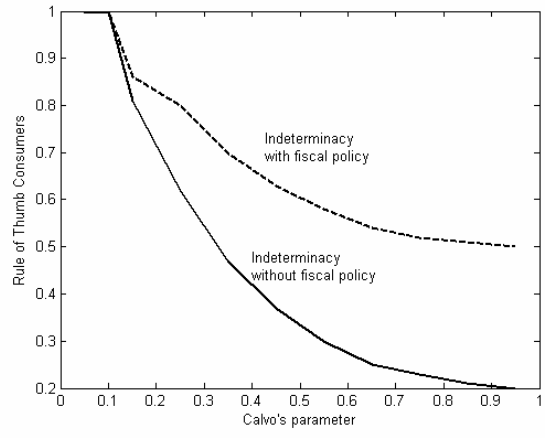Figure 1 – Dynamic response to a positive shock in the economic activity (λ=0.67)

(a1)

(a2)

(b1)

(b2)

Figure 2 – Regions of indeterminacy

(a)

(b)

Figure 3 – Dynamic response to a negative cost push shock (λ=0.67)

(a1)

(a2)

(b1)

(b2)
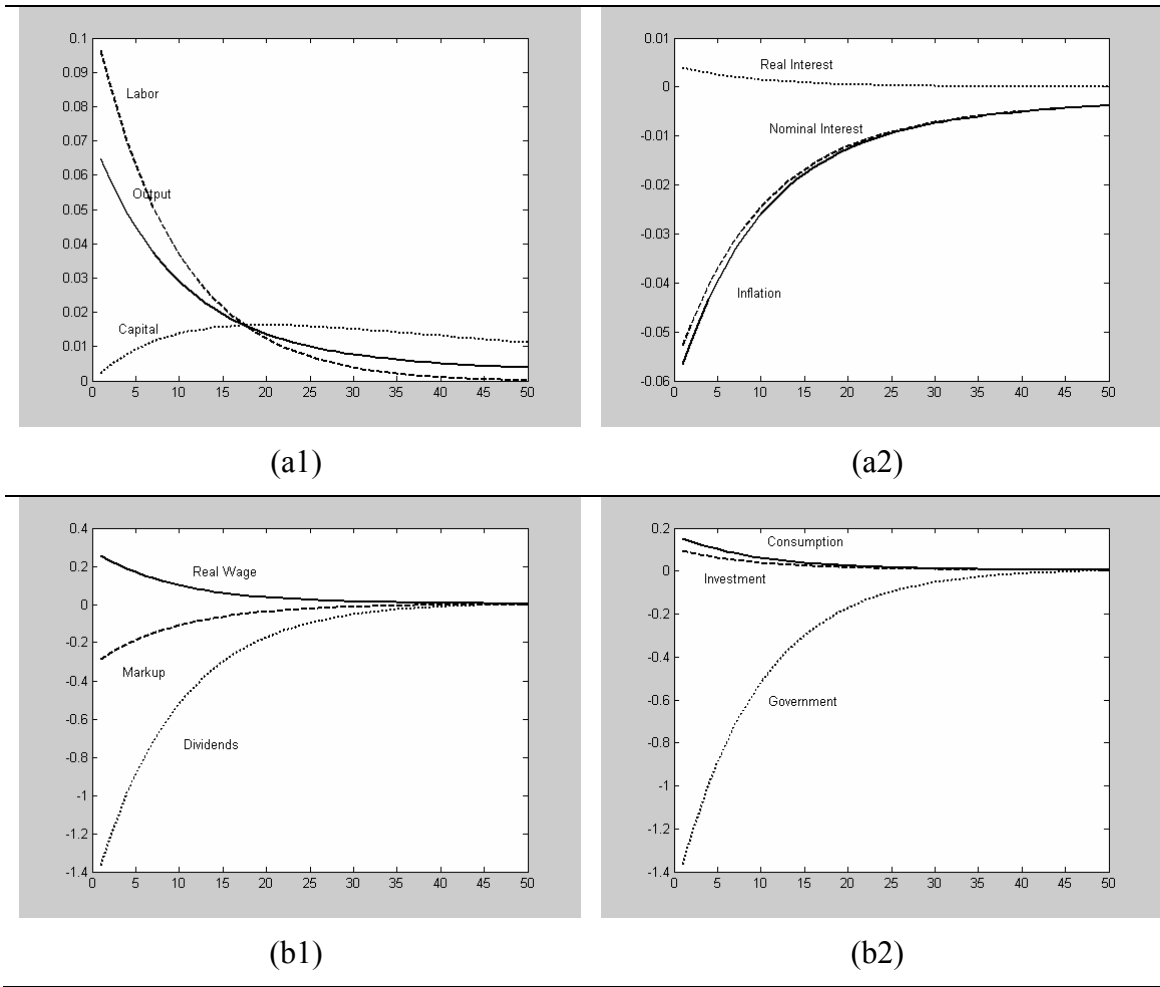
Figure 4 – Dynamic response to a negative cost push shock (λ=0.66; τ_Π= τ_N =0; τ_Y =0.1)
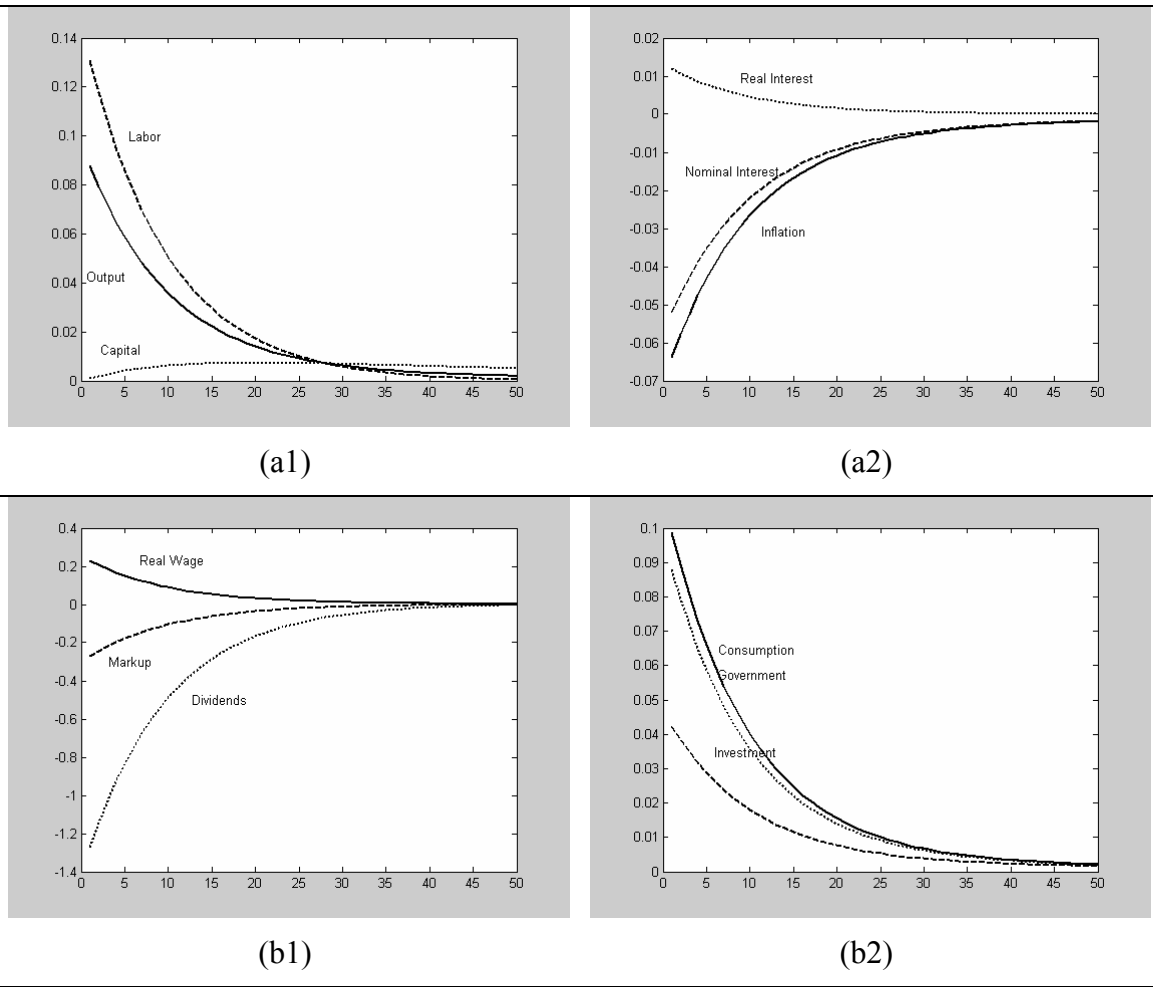

(a1)

(a2)

(b1)

(b2)

Figure 5 – Dynamic response to a negative cost push shock (λ=0.6; τ_Π= τ_Y =0; τ_N =0.1)

(a1)

(a2)

(b1)

(b2)