# FISCAL POLICY, MACROECONOMIC STABILITY AND FINITE HORIZONS

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**Abstract**

In this paper we analyse the stabilisation properties of distortionary taxes in a New Keynesian model with overlapping generations of finitely-lived consumers. In this framework, government debt is part of net wealth and this adds a number of interesting channels through which fiscal policy could affect output and inflation. Output volatility, in presence of technology shocks, is not substantially affected by the operation of automatic stabilisers but we find interesting composition effects. While the presence of finitely-lived households strengthens the stabilisation performance of distortionary taxes through the reduction of the volatility of consumption, it does so at the cost of more volatile investment and real money balances.

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*JEL Classification:* E21, E32, E63.

## 1. Introduction

Until recently, work on the trade-off between output and inflation variability in the context of New Keynesian economies subject to supply shocks has tended to downplay the role of fiscal policy in defining that trade-off (see Clarida *et al.*,1999, for example). The implicit reasons for ignoring fiscal policy in defining the trade-off are that the economies modelled were typically populated by infinitely-lived economic agents such that, provided the government implemented a "passive" fiscal policy through lump-sum taxation (Leeper, 1991) monetary policy was free to minimise the distortions generated by nominal inertia. However, a number of recent papers are now attempting to define the optimal combinations of monetary and fiscal policies in economies where taxation is distortionary (see, for example, Benigno and Woodford, 2003, Benassy, 2003, or Schmitt-Grohé and Uribe, 2002). There has also been some analysis of the impact of fiscal policy on the inflation-output trade-off facing monetary policy makers. For example, Galí (1994) finds, in the context of a real business cycle model, that automatic stabilisers may increase output volatility, while Andrés and Doménech (2005) find that such results can be overturned if the economy is subject to significant real and nominal rigidities.

In the current paper we assess the stabilisation potential of distortionary taxation using a model which departs from previous work in a crucial respect: we relax the assumption of infinitely lived consumers. Specifically, in section 2 we develop a model where overlapping generations of consumers, facing a probability of death, supply labour to imperfectly competitive firms. These firms produce differentiated products using this labour and capital (which is subject to capital adjustment costs). In setting their prices firms are also constrained by Calvo contracts, such that they can only change prices after random intervals of time. There are numerous sources of distortionary taxation in the model: labour income, consumption and profits taxes all affect the decisions made by economic agents within the economy.

The presence of non-Ricardian consumers adds to the canonical model at least two channels that can be relevant for fiscal policy analysis. Firstly, a positive probability of death makes aggregate consumption dynamics dependent on the amount of outstanding debt. Secondly, the steady-state real interest rate increases with the stock of debt. These features are likely to affect the performance of automatic stabilisers since both impinge upon the cyclical response of consumption and investment to technology shocks. Thus, we look at the incidence of distortionary taxation on the components of aggregate demand as well as on leisure and real money balances.

A key result of the paper, presented in section 3, is that, relative to an economy without distortionary taxation, introducing distortionary taxes and allowing automatic stabilisers to function, can reduce the volatility of some components of demand, but raise the relative volatility of others. Specifically, in economies with significant deviations from Ricardian consumption behaviour and a large debt/GDP ratio, consumption volatility can be reduced relative to an economy without distortionary taxes, while investment expenditure is more volatile. The reason is that when debt is part of consumers' net wealth the movements in government debt (partially induced by movements in real interest rates and therefore debt service costs) serve to offset the impact of real interest rate movements on consumption. In contrast, the higher volatility in real rates that emerge when consumers are not infinitely lived (consumers need greater compensation, *cet. par.*, to hold a given stock of government debt when they are finitely lived) induces greater fluctuations in investment expenditure. Section 4 concludes.

## 2. The Model

In this section we outline our model. Our economy is populated by overlapping generations of consumers who face a constant probability of death, such that, even if taxes were lump-sum, Ricardian Equivalence would not hold in our model. These consumers supply labour to imperfectly competitive firms, who combine this labour with capital rented from a representative capital rental firm, to produce a differentiated product. The accumulation of capital by the capital rental firm is subject to capital adjustment costs. The firms producing these differentiated products are also subject to the constrants implied by Calvo (1983) contracts, such that they can only adjust the price of their product after a random interval of time. Consumers' labour income is taxed, and they also pay consumption taxes. The profits of the capital rental firm and the final goods firms are also taxed. The combination of various forms of distortionary taxation, non-Ricardian consumers and sticky prices, mean that fiscal policy can affect the relative volatility of key macroeconomic aggregates in the face of technology shocks.

### 2.1 The Capital Rental Firm's Behaviour

We assume that there is a single representative firm accumulating capital for rental to the intermediate goods firms.[2] This firm seeks to maximise the discounted value of its cashflows, which are then redistributed to households. Therefore the firm's objective function is to maximise the following expression,

$$V_t = (1-\tau_t^k)p_t^k k_t - e_t + E_t \sum_{z=1}^{\infty} \frac{((1-\tau_{t+z}^k)p_{t+z}^k k_{t+z} - e_{t+z})}{\prod_{j=1}^{z}(1+r_{t+j-1})} \tag{1}$$

[2] The model solution as well as the log-linearized system describing the dynamics are contained in a technical appendix available at http://iei.uv.es/~rdomenec/ADL/tech_appendix.pdf.

where $p_t^k$ is the real rental cost of capital, $k_t$ is the capital stock, $e_t$ is real investment expenditure, $r_t$ is the real interest rate and $\tau_t^k$ is the rate of taxation on the income from renting capital. However, because of capital adjustment costs, only a fraction of investment, $\Phi(\frac{e_t}{k_t})k_t$, is actually converted into capital, which also depreciates at rate $\delta$. Therefore the equation of motion of the capital stock is given by,

$$k_{t+1} = \Phi(\frac{e_t}{k_t})k_t + (1-\delta)k_t \tag{2}$$

The Lagrangian associated with this problem is given by,

$$\begin{aligned} L_t &= (1-\tau_t^k)p_t^k k_t - e_t + \lambda_t^k(\Phi(\frac{e_t}{k_t})k_t + (1-\delta)k_t - E_t k_{t+1}) \\ &+ E_t \sum_{z=1}^{\infty} \left[ \begin{array}{c} \frac{(1-\tau_{t+z}^k)(p_{t+z}^k k_{t+z} - e_{t+z})}{\prod_{j=1}^{z}(1+r_{t+j-1})} + \lambda_{t+z}^k(\Phi(\frac{e_{t+z}}{k_{t+z}})k_{t+z} \\ +(1-\delta)k_{t+z} - k_{t+z+1}) \end{array} \right] \end{aligned} \tag{3}$$

Therefore, the first order condition for investment is given by,

$$\lambda_t^k \Phi'(\frac{e_t}{k_t}) = 1 \tag{4}$$

where $\lambda_t^k$ is the Lagrange multiplier associated with the equation of motion for the capital stock, which given the homogeneity of our profit function, is equivalent to Tobin's $q$. Also, differentiating the Lagrangian with respect to $k_{t+1}$ gives the equation of motion for Tobin's $q$,

$$\lambda_t^k = E_t \left\{ \frac{(1-\tau_{t+1}^k)p_{t+1}^k}{1+r_t} \right\} + E_t \left\{ \left( \Phi(\frac{e_{t+1}}{k_{t+1}}) - \Phi'(\frac{e_{t+1}}{k_{t+1}})\frac{e_{t+1}}{k_{t+1}} + (1-\delta) \right) \frac{\lambda_{t+1}^k}{1+r_t} \right\} \tag{5}$$

The capital accumulated by this sector is then rented out to the imperfectly competitive firms producing final goods for consumers, as described below.

### 2.2 Price Setting of Final Goods Firms

If the firms producing final goods, cannot change prices in every period then there is not a symmetric equilibrium in which $P_{it} = P_t$. Instead, to facilitate aggregation, we follow Calvo's model of nominal inertia (see Calvo, 1983): a percentage $\phi$ of final-goods firms set

$$P_{it} = \overline{\pi} P_{it-1} \tag{6}$$

i.e. they index their prices to the average (gross) rate of inflation, $\overline{\pi}$, whereas the rest of the firms $(1-\phi)$ select $\widetilde{P}_{it}$ to maximise the value of their shares, that is, the present discount value of future profits:

$$\max_{\widetilde{P}_{it}} \Big\{ \widetilde{P}_{it} y_{it} - P_t mc_t (y_{it} + \kappa) + \\ E_t \sum_{j=1}^{\infty} \frac{\phi^j}{\prod_{s=0}^{j} (1 + i_{t+s})} \left[ \widetilde{P}_{it} \overline{\pi}^j y_{it+j} - P_{t+j} mc_{t+j} (y_{it+j} + \kappa) \right] \Big\} \tag{7}$$

where $mc_t$ are the real marginal costs of the typical firm, which are defined in equation (14) below. This objective function is maximised subject to the demand curve implied by the CES-form of the consumption basket defined below,

$$y_{it+j} = \left( \widetilde{P}_{it} \overline{\pi} \right)^{-\varepsilon} P_{t+j}^{\varepsilon} y_{t+j} \tag{8}$$

where the production function is given by:

$$y_{it} = A k_{it}^{\alpha} l_{it}^{1-\alpha} (g_t^p)^{\theta} - \kappa \tag{9}$$

We assume that some government expenditure, $g_t^p$, is productive in the sense of entering the private sector's production function. $\kappa$ represents fixed costs of production, which in conjuction with the firms' market power defines the extent to which firms earn abnormal profits.

The first order condition is,

$$\widetilde{P}_{it} = \left( \frac{\varepsilon}{\varepsilon - 1} \right) \frac{P_t^{\varepsilon+1} mc_t y_t + E_t \sum_{j=1}^{\infty} \left[ \frac{\phi^j P_{t+j}^{\varepsilon+1} mc_{t+j} y_{t+j} \overline{\pi}^{-j\varepsilon}}{\prod_{s=1}^{j} (1+i_{t+s})} \right]}{P_t^{\varepsilon} y_t + E_t \sum_{j=1}^{\infty} \left[ \frac{\phi^j P_{t+j}^{\varepsilon} y_{t+j} \overline{\pi}^{j(1-\varepsilon)}}{\prod_{s=1}^{j} (1+i_{t+s})} \right]} \tag{10}$$

and the aggregate price index at $t$ is,

$$P_t = \left[ \phi \left( \overline{\pi} P_{t-1} \right)^{1-\varepsilon} + (1 - \phi) \widetilde{P}_t^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{11}$$

### 2.3 Capital and Labour Demand: Cost Minimization.

Once prices are set in this way, demand is given by the downward sloping curve that each firm faces. The optimal combination of capital and labour employed in the production of final goods, is obtained from the cost minimization problem of the firm:

$$w_t = mc_t (1 - \alpha) A k_t^{\alpha} l_t^{\alpha} (g_t^p)^{\theta} \tag{12}$$

$$p_t^k = mc_t \alpha A k_t^{\alpha-1} l_t^{1-\alpha} (g_t^p)^\theta \tag{13}$$

where,

$$mc_t = \left(\frac{p_t^k}{\alpha}\right)^\alpha \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha} \tag{14}$$

$w_t$ are real wages and $p_t^k$ is the rental cost of capital.

### 2.4 Consumers' Behaviour

Here we introduce the main departure from the canonical new-Keynesian model. While there is abundant evidence of a strong interaction among fiscal impulses and output (see, for example, Blanchard and Perotti, 2002, or Fatas and Mihov, 1998), standard dynamic general equilibrium models downplay the role of demand. The importance of the demand side of the economy is partially restored when there is slow adjustment in nominal and real variables, but still intertemporal substitution mechanisms and Ricardian equivalence leave consumption largely unresponsive to a fiscal stimulus. Introducing a probability of death implies that consumers discount their future disposable income more heavily, such that the the usual Ricardian experiment of a deficit-financed lump-sum tax cut now increases consumption. Let us describe in detail the environment in which households' decisions take place.

A consumer born at time $t-i$, receives utility from consuming a basket of consumer goods,

$$c_t^i = \left[\int_0^1 c_t^i(z)^{\frac{\epsilon-1}{\epsilon}} dz\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{15}$$

holding real money balances, $M_t^i/P_t$ and suffers disutility from supplying labour to imperfectly competitive firms, $l_t^i$ ,

$$E_t U = E_t \sum_{z=0}^{\infty} (\beta\gamma)^z (\ln c_{t+z}^i + \chi \ln \frac{M_{t+z}^i}{P_{t+z}} + \varkappa \ln(1 - l_{t+s}^i) \tag{16}$$

There are three sources of uncertainty in the model: consumers face a constant probability of death $(1-\gamma)$, the firms that employ them can only set their prices at stochastic intervals and there are productivity shocks. Consumers pool the risks associated with the probability of death by taking out contracts with competitive insurance companies. This then serves to multiply their discount factor by the probability of survival, $\gamma$ thereby effectively raising their rate of time-preference and their expectations over future values of variables are taken as if they are infinitely lived.

Consumers seek to maximise utility subject to the demand schedule for their labour services and their budget constraint, which in nominal terms can be written as

$$\begin{aligned} & \gamma M_t^i + \frac{\gamma B_t^i}{1+i_t} + P_t(1+\tau_t^c)c_t^i \\ = \quad & P_t(1-\tau_t^w)w_t l_t^i + B_{t-1}^i + M_{t-1}^i + P_t s_t^i + (1-\tau_t^k)(\int_0^1 \Omega_t^j dj) + \Omega_t^k \end{aligned} \quad (17)$$

Here consumers earn after tax income from their labour services $P_t(1-\tau_t^w)w_t l_t^i$ , receive their share of the profits of intermediate goods producers, $(1-\tau_t^k)\int_0^1 \Omega_t^j dj$ and capital rental companies $\frac{\Omega_t^k}{P_t}$and public transfers, $P_t s_t$ . Their consumption purchases are taxed at the rate, $\tau_t^c$. Households also hold their assets in two forms: money, $M_t^i$ , and government bonds, $B_t^i$ . Money pays no interest, while bonds earn interest at the rate $i_t$. It would be possible for consumers to invest in a portfolio of equity holdings of intermediate goods firms and capital rental firms - in the case of the intermediate goods producers this would also diversify the risk due to staggered price setting and would affect the distribution of profits across consumers at different stages in their life cycle. However, in aggregate, this does not matter, so, for simplicity, we assume a simple lump-sum redistribution of aggregate profits. The gross nominal rate of return on financial assets is given by $1+i_t$, and competitive insurance companies contract with individuals to receive their financial wealth should they die in return for a insurance premium equal to the probability of death -this raises the effective rate of interest to $\frac{1+i_t}{\gamma}$. We can therefore, rewrite the individual's flow budget constraint in real terms as,

$$\begin{aligned} & \gamma m_t^i + \frac{\gamma b_t^i}{1+i_t} + (1+\tau_t^c)c_t^i \\ = \quad & (1-\tau_t^w)w_t l_t^i + \frac{b_{t-1}^i + m_{t-1}^i}{\pi_t} + s_t^i + (1-\tau_t^k)\int_0^1 \left(\frac{\Omega_t^j}{P_t}dj + \frac{\Omega_t^k}{P_t}\right) \end{aligned} \quad (18)$$

where lower case letters denote real variables and $\pi_t \equiv P_t/P_{t-1}$.

Let us define

$$\Omega_t^i \equiv \int_0^1 \left(\frac{\Omega_t^j}{P_t}dj + \frac{\Omega_t^k}{P_t}\right) \quad (19)$$

$$H_t^i \equiv \left((1-\tau_t^w)w_t l_t^i + s_t^i + (1-\tau_t^k)\Omega_t^i\right) \quad (20)$$

and

$$\Lambda_t^i \equiv H_t^i - (1+\tau_t^c)c_t^i - \frac{i_{t-1}}{\pi_t} m_{t-1}^i \tag{21}$$

Then, the budget constraint can be written as

$$b_{t-1}^i + (1+i_{t-1})m_{t-1}^i = -\pi_t \Lambda_t^i + \frac{\gamma \pi_t}{1+i_t}\left[m_t^i(1+i_t) + b_t^i\right] \tag{22}$$

Integrating the flow budget constraint forwards and imposing the no-Ponzi Game condition yields the consumer's intertemporal budget constraint,

$$b_{t-1}^i + (1+i_{t-1})m_{t-1}^i = -\pi_t \Lambda_t^i - \pi_t E_t \sum_{z=1}^{\infty} \frac{\gamma^z \Lambda_{t+z}^i}{\prod_{j=1}^{z}(1+r_{t+j-1})} \tag{23}$$

where $1 + r_t \equiv (1+i_t)/\pi_{t+1}$ is the ex post real rate of return on financial assets.

Maximising utility subject to this intertemporal budget constraint yields the following first order conditions. Firstly for consumption,

$$(1+\tau_{t+z}^c)c_{t+z}^i = \beta^z \frac{1}{\lambda_t^i} \prod_{j=1}^{z}(1+r_{t+j-1}) \tag{24}$$

where $\lambda_i$ is the Langrange multiplier associated with the intertemporal budget constraint in the consumer's optimisation. This expression can be used to derive the individual consumer's consumption Euler equation,

$$E_t\left\{(1+\tau_{t+1}^c)c_{t+1}^i\right\} = \beta(1+\tau_t^c)c_t^i(1+r_t) \tag{25}$$

There is also a first-order condition for the holding of money balances,

$$m_t^i = \frac{\chi}{\gamma}\frac{1+i_t}{i_t}(1+\tau_t^c)c_t^i \tag{26}$$

and for labour supply,

$$(1-\tau_t^w)w_t(1-l_t^i) = \varkappa(1+\tau_t^c)c_t^i \tag{27}$$

Using the money-demand equation and the Euler equation we can obtain the consumer's consumption function,

$$(1+\tau_t^c)c_t^i = \frac{1-\gamma\beta}{1+\chi(\gamma\beta)^{-1}}\left[\frac{b_{t-1}^i + (1+i_{t-1})m_{t-1}^i}{\pi_t} + H_t^i + E_t \sum_{z=1}^{\infty} \frac{\gamma^z H_{t+z}^i}{\prod_{j=1}^{z}(1+r_{t+j-1})}\right] \tag{28}$$

### 2.5 Aggregating across Consumers and Consumption Dynamics.

If the size of each cohort when born is 1, then the size of a cohort of age $i$ is given by, $\gamma^i$. Therefore the total size of the population is given by[3],

$$\sum_{s=1}^{\infty} \gamma^{i-1} = \frac{1}{1-\gamma} \tag{29}$$

It is therefore possible to aggregate across consumers different generations to generate an aggregate per capita consumption function,

$$(1+\tau_t^c)c_t = \frac{1-\gamma\beta}{1+\chi(\gamma\beta)^{-1}} \left[ \frac{b_{t-1} + (1+i_{t-1})m_{t-1}}{\pi_t} + lw_t \right] \tag{30}$$

where discounted human wealth is given by,

$$lw_t \equiv H_t + E_t \sum_{z=1}^{\infty} \frac{\gamma^z H_{t+z}}{\prod_{j=1}^{z}(1+r_{t+j-1})} \tag{31}$$

In this simple closed economy model net financial assets will correspond with government debt.

Aggregating consumers' labour supply yields,

$$(1-\tau_t^w)w_t(1-l_t) = \varkappa(1+\tau_t^c)c_t \tag{32}$$

and the aggregate demand for money is given by,

$$m_t = \frac{\chi}{\gamma}\frac{1+i_t}{i_t}(1+\tau_t^c)c_t \tag{33}$$

where all variables are now in per capita terms.

Finally, from the aggregate consumption function and using the government budget constraint, after some algebra (see the Appendix) we obtain the dynamics for aggregate consumption in the presence of Ricardian consumers,

$$\begin{aligned} E_t\left\{(1+\tau_{t+1}^c)c_{t+1}\right\} &= \frac{1-\gamma\beta}{1+\chi(\gamma\beta)^{-1}} \left\{ \frac{(1+r_t)\beta(1+\chi(\gamma\beta)^{-1})(1+\tau_t^c)c_t}{(1-\gamma\beta)} + \right. \\ &\quad \left. + \frac{(\gamma-1)(1+r_t)}{\gamma}\left[m_t + \frac{b_t}{1+i_t}\right]\right\} \end{aligned} \tag{34}$$

[3] Note that this implies that an infinitesimally small number of consumers will live-forever. This is why this means of introducing non-Ricardian behaviour is sometimes called the `perpetual youth model'.

This expression summarises the two main changes that a model with finitely-lived agents opens up for fiscal policy. Firstly, when consumers have finite lives, $\gamma < 1$, Ricardian equivalence breaks down and government debt affects the path of aggregate consumption. Secondly, since non-Ricardian consumers require higher real interest rates to be prepared to hold higher levels of government debt, *cet par*, fluctuations in government debt also affect the real interest rate in general equilibrium thereby influencing the cyclical response of consumption, investment and hours to technology shocks.

### 2.6 Monetary and Fiscal Policy

Monetary and fiscal policy is modeled as in Andrés and Doménech (2005). In particular, monetary policy is represented by a standard Taylor rule:

$$i_t = \rho_r i_{t-1} + (1-\rho_r)\bar{i} + (1-\rho_r)\rho_\pi(\pi_t - \overline{\pi}) + (1-\rho_r)\rho_y \widehat{y}_t + z_t^i \tag{35}$$

in which the monetary authority sets the interest rate ($i_t$) to prevent inflation deviating from its steady-state level $(\pi_t - \overline{\pi})$ and to counteract movements in the output gap $(\widehat{y}_t)$; $\bar{i}$ is the steady-state interest rate and the current rate moves smoothly $(0 < \rho_r < 1)$ and has an unexpected component, $z_t^i$.

When $\rho_\pi > 1$ monetary policy is said to satisfy the `Taylor principle', where nominal interest rates will be raised more than one-for-one with excess inflation such that real interest rates rise. This has been found to be a necessary condition for determinacy in standard New Keynesian monetary policy models (see Woodford 2003, for example). Assuming monetary policy behaves in this way fiscal policy must be designed to satisfy the present value budget constraint of the public sector for any price level in order to obtain a unique monetary equilibrium (Leeper, 1991, Woodford, 1996).A simple way of making this requirement operational is to assume that either taxes or public spending respond sufficiently to the level of debt. We use fiscal rules in which the deviation of each component of public spending (consumption ($g_t^c$), investment ($g_t^p$) and/or transfers ($g_t^s$)) from its steady-state value is a function of the deviation of the debt to output ratio from its target:

$$\frac{g_t}{\overline{g}} = \left(\frac{b_{t-j}}{y_{t-j}}\frac{\overline{y}}{\overline{b}}\right)^{-\alpha_b}\left(\frac{y_t}{\overline{y}}\right)^{-\alpha_y}, \qquad \alpha_b, \alpha_y \geq 0 \tag{36}$$

where the bar over the variables indicates steady-state values. Furthermore, Leith and Wren-Lewis (2000) show that when consumers are finitely lived, the required elasticities of fiscal instruments with respect to debt disequilibrium are greater to ensure fiscal solvency and support the active targetting on inflation. The reason for this is that when consumers are finitely lived there is a wealth-effect from government debt which is not present when consumers are infinitely-lived. Therefore, when monetary policy satisfies the Taylor principle it can induce a potentially destabilising debt-interest spiral, unless fiscal instruments adjust to stabilise the debt stock.

### 2.7 Calibration

In order to analyse the main implications of our model, we have obtained a numerical solution of the steady state as well as of the log-linearised system. Table 1 summarises the values of the calibrated baseline parameters. The assumed data peiod for the calibration is quarterly. Most of them are taken from Andrés and Doménech (2005) and are similar to other DGE models as, for example, the parameters of the production function, the Taylor rule or the Phillips curve. Although most of these parameters refer to EMU, in some cases, when no evidence exists for European countries, it is assumed that they are similar to the values habitually used for the United States. Thus, the the discount factor ($\beta$) is $0.9926$, following Christiano and Eichenbaum (1992), and, since we assume that in the steady state households allocate $0.31$ of their time to market activities (as in Cooley and Prescott, 1995), $\varkappa$ is set equal to $1.28$. The elasticity of output with respect to private capital ($\alpha$) is $0.4$, as in Cooley and Prescott (1995) and the output elasticity to public capital ($\theta$) is set to $0.1$, within the range of the estimated values obtained by Gramlich (1994). The depreciation rate ($\delta$) is equal to $0.021$ as estimated by Christiano and Eichenbaum (1992). The standard deviation ($\sigma_z$) and the first order autocorrelation coefficient ($\rho_z$) of the technology shock are set to $0.874$ and $0.8$ respectively, whereas the investment ratio elasticity of the price of capital ($\Theta \equiv \Phi'' \left(\overline{e}/\overline{k}\right) / \Phi'$) is set to $-0.25$. These values have been chosen in order to reproduce the volatility of output and investment observed in EMU in our baseline model (see Agresti and Mojon, 2001). Following Christiano, Eichembaum and Evans (1997), the elasticity of demand with respect to price ($\varepsilon$) is set to $6$, consistent with a steady-state mark-up, $\varepsilon/(\varepsilon - 1)$, equal to $1.2$. The fixed cost in production ($\kappa$) is set to $0.2$, to produce zero profits in the steady state, where the output has been normalised to $1$ in the baseline model. The probability of price adjustment in a given period ($1 - \phi$) is $0.25$, in line with some of the estimated values of this parameter for the Euro area by Galí, Gertler and López-Salido (2001) and Leith and Malley (2005). Fiscal policy parameters have been calibrated after computing average tax rates for EMU members in the nineties: $0.439$ for labor taxes ($\tau^w$), $0.21$ for taxes on capital income ($\tau^k$) and $0.14$ for consumption taxes ($\tau^c$). For the same sample of countries and years, government consumption over GDP ($\overline{g}^c/\overline{y}$) is $0.18$, transfers ($\overline{s}/\overline{y}$) are $0.16$ and productive public expenditure ($\overline{g}^p/\overline{y}$) is $0.06$. We set the autocorrelation coefficient of the interest rate ($\rho_r$) equal to $0.5$ and the response to inflation deviations from target ($\rho_\pi$) equal to $2$. These values imply a response of the interest rate to inflation slightly quicker and more aggressive than the one usually estimated for EMU countries

Table 1
Calibration of baseline model

| $\chi$ | $\beta$ | $\gamma$ | $\alpha$ | $\theta$ | $\delta$ | $\sigma_z$ | $\rho_z$ | $\varepsilon$ | $\kappa$ | $\Theta$ | $\phi$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0285 | 0.9926 | 0.995 | 0.40 | 0.10 | 0.021 | 0.874 | 0.80 | 6.0 | 0.20 | -0.25 | 0.75 |
| $\tau^w$ | $\tau^k$ | $\tau^c$ | $g^c/y$ | $g^s/y$ | $g^p/y$ | $\alpha_b^c, \alpha_b^p$ | $\alpha_b^s$ | $\rho_r$ | $\rho_\pi$ | $\pi$ | $\varkappa$ |
| 0.439 | 0.21 | 0.14 | 0.18 | 0.16 | 0.06 | 0.00 | 0.15 | 0.5 | 2.0 | $1.02^{0.25}$ | 1.28 |

(see, Doménech, Ledo and Taguas, 2002). The steady-state level of gross inflation ($\overline{\pi}$) is set to $1.02^{0.25}$, that is, the target level of the ECB.

Since some parameters are specific to our model, they should be calibrated. Thus, $\chi$ has been chosen to match the ratio of M1 to quarterly GDP in EMU, using data from 2002, when this ratio was 1.37. Parameter $\varkappa$ was set to $1.28$ since we assume that in the steady state households allocate $0.31$ of their time to market activities, as in Cooley and Prescott (1995). Under the assumption that the consolidation of public debt to the target $b/y = 2.4$ (i.e., a annual debt to GDP ratio of 60 per cent which was the reference level in the Maastricht Treaty. ) is made only through transfers ($\alpha_b^s = 0.15$ and $\alpha_b^c = \alpha_b^p = 0.0$) and that $\gamma = 0.995$ (implying an expected adult life of 50 years[4]), the simulated model reproduces the most salient facts of European business cycles which appear in Table 2 as, for example, the relative volatility of consumption ($\sigma_c/\sigma_y$), investment ($\sigma_e/\sigma_y$) or correlation between the primary budget surplus and output ($\sigma_{pbs,y}$). The model also yields close values of the private consumption and investment to GDP ratios in steady state ($\overline{c}/\overline{y}$ and $\overline{e}/\overline{y}$ respectively) to the average values observed in EMU from 1960 to 1999.[5]

The model with supply shocks has been simulated $100$ times, producing $200$ observations. We take the last $100$ observations and compute the steady-sate value ($\overline{x}$), the relative standard deviation to output ($\sigma_x/\sigma_y$, except for GDP which is just $\sigma_y$), the first-order autocorrelation ($\rho_x$) and the contemporaneous correlation with output ($\rho_{xy}$) of each variable. We have also simulated an economy with zero tax rates on consump-

[4] We focus on economically active individuals (from 15 to 64 years old). 50 years is then a compromise between the years that Europeans are active (since life expectancy is around 72 years, on average workers complete their active life), which it is the reference variable for labour, and life expectancy which is probably a more relevant variable for consumption. We also set ``economic'' life expectancy equal to 50 years as a way of having a lower discount rate and, therefore, higher non-Ricardian effects. Nevertheless, in the Figures we analyse the consequences of having a lower probability of death.

[5] Standard deviations have been taken from Agresti and Mojon (2001), using the HP filter. Consumption and investment shares have been calculated using OECD Economic Outlook annual data from 1960 to 1999. Finally, the cross correlation of the primary budget surplus and output refers to EMU from 1970 to 2001.

Table 2
Comparison of EMU and model data

| | EMU | Model |
|---|---|---|
| $\sigma_y$ | 1.0 | 1.0 |
| $\sigma_c/\sigma_y$ | 0.7 | 0.8 |
| $\sigma_e/\sigma_y$ | 2.2 | 2.5 |
| $\sigma_{pbs,y}$ | 0.71 | 0.73 |
| $\overline{c}/\overline{y}$ | 0.55 | 0.53 |
| $\overline{e}/\overline{y}$ | 0.23 | 0.23 |

tion, labour and capital incomes, in which public spending is financed using a lump-sum tax such that $\overline{g}^s/\overline{y} = -0.26$, but with otherwise identical fiscal structure as that in the benchmark model ($\overline{g}^c/\overline{y} = 0.18$, $\overline{g}^p/\overline{y} = 0.06$, $\overline{b}/\overline{y} = 0.6$).

We shall see below that output volatility is sensitive to the fiscal instrument used to stabilise debt, the level of debt and the extent to which consumers discount the future more heavily due to finite lives. Indeed the sensitivity of this result to these factors stems from the fact that the introduction of finite lives consumers has very different impacts on key components of aggregate demand. The volatility of consumption relative to output will tend to be less in the non-lump-sum economy, while the volatility of investment will be higher. The reason for this is that, in the presence of finite lives, the wealth effect of government debt on consumption will tend to offset the effect of any movements in real interest rates induced by changes in the outstanding stock of government liabilities. With no such finite horizon effect operating on investment, the response of investment to changes in interest rates is that much stronger.

## 3. Finite Horizons, Debt and Output Volatility

In this section we use the model in section 2 to assess the contribution to macroeconomic stability of distortionary taxes. The statistic used to summarise our result is relative output volatility, which is defined as the standard deviation of output in the economy with distortionary taxes ($\sigma_y^d$) relative to the standard deviation in the economy with lump-sum taxes ($\sigma_y^l$). In particular a ratio below one implies that distortionary taxes are functioning as automatic stabilisers, in particular dampening the movements of disposable income in response to technology shocks. Although it may seem natural for distortionary taxes to have this effect Galí (1994) demonstrates, in the context of a real business cycle model, that income taxes actually tend to magnify output volatility as compared with lump-sum ones. The explanation of such a result can be found in the destabilizing effect that distortionary taxes generate in the use of productive factors, with a reduction of the steady state value of capital and labour, thus magnifying the relative size of cyclical fluctuations. Indeed, the RBC version of our model ($\Phi(\frac{e}{k}) = \frac{e}{k}$, $\phi = 0$, $\gamma = 1$) reproduces that result with a ratio $\sigma_y^d/\sigma_y^l = 1.2$. Andrés and Doménech (2005) have shown that this ratio is diminished in economies with substantial nominal and real frictions; the rationale for this is that those frictions give a more important role to developments on the demand side of the economy. When taxes are linked to consumption and income, countercyclical movements on the aggregate demand interact with those on the supply side, helping to mitigate the volatility of output. Our model under $\gamma = 1$ reproduces that result since $\sigma_y^d/\sigma_y^l = 0.93$.[6]

The aim of this section is to focus on the new dimension of the model introduced by allowing consumers to behave in a non-Ricardian manner. In particular, we analyse how the cyclical properties of the main variables are affected by the value of the survival probability ($\gamma$) and the debt to output ratio ($B/Y$). Strictly speaking only the value of $\gamma$ characterises the extent of non-Ricardian behaviour. Nevertheless, for non-zero probability of death the steady-state stock of outstanding debt matters both because of its direct effect on consumption and also because it influences the steady-state real rate of interest. To isolate the effects of these changes in $\gamma$ and in $B/Y$ we consider a fiscal rule only in transfers (i.e., $\alpha_b^c = \alpha_b^p = 0$), since the consolidation of public debt through public consumption and/or investment may induce additional demand and supply impacts.

The first result to notice is summarised in Figure 1[7]. Somewhat strikingly, relative output volatility ($\sigma_y^d/\sigma_y^l$) seems to be relatively immune to changes in either these two parameters. Except for very low values of $\gamma$ and high $B/Y$ both tax structures generate a similar volatility of output, although distortionary taxes seem to perform slightly better: relative output volatility is lower than one. This unchanged ratio is the result of a common pattern associated with both tax structures: as the non-Ricardian friction becomes larger, the volatility of output decreases.

A closer look at the response of aggregate demand components reveals significant differences across them implying automatic stabilisers may have a far greater impact than that measured by relative output volatility. This can be seen in Figure 2 which represents how the relative volatility of the main variables varies across $\gamma$ and $B/Y$. The first thing to notice is that the relative volatility of investment, hours and real balances is always

[6] The correpsonding ratios for the volatitlity of private consumption are $\left(\sigma_c^d/\sigma_c^l\right)_{Galí} = 1.24$ and $\left(\sigma_c^d/\sigma_c^l\right)_{A\&D} = 1.05$

[7] In the simulations we focus on the case of $b/y > 1$ (i.e., a debt to GDP ratio, based on annual data, of more than 25%). This is generally empirically plausible and representative for the Euro area, with the exception of Luxembourg, where the debt to GDP ratio was 4.5% in 2004. For other EMU countries this ratio ranged in this year from 32.4% (Ireland) to 106% (Italy).

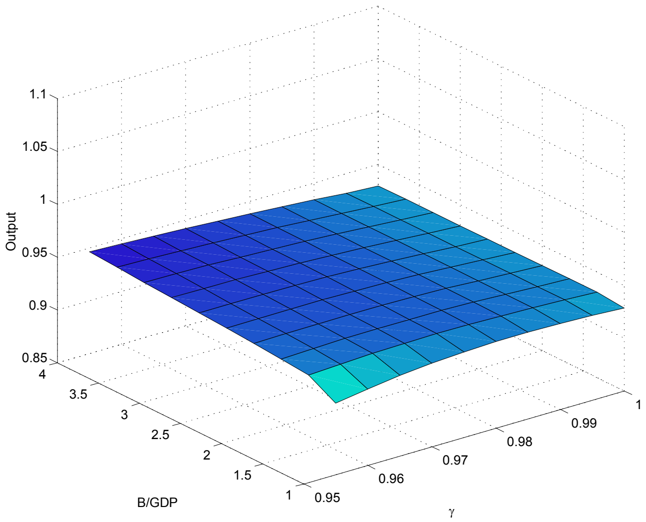


**Figure 1:** *Relative volatility of output as a function of* $\gamma$ *and* $B/GDP$.

greater than one, and so is that of private consumption for low values of the debt to GDP ratios. This is not inconsistent with relative output volatility being less than one and merely reflects a composition effect since the steady-state level of investment is much greater in an economy without distortionary taxation.[8] What is more remarkable though is the divergent patterns that emerge as we depart from the world of Ricardian consumers. As the debt to GDP ratio increases and $\gamma$ falls, the relative volatility of investment rises sharply, even in the presence of significant capital adjustment costs.

The reason for this can be seen in Figure 3 which reveals that the steady-state interest rate level is much higher for low $\gamma$ and high $B/Y$, leading to a lower demand for capital and, thus, to larger relative fluctuations in investment under distortionary taxes. Therefore, as $B/Y$ and $(1-\gamma)$ increase so does the volatility of investment, and the rise is higher in the economy with distortionary taxes since the size of the response of capital to the technology shock is a positive function of the steady state level of the output to capital ratio, which increases with the tax rates. Hours worked are also affected in the same manner, since lower steady-state capital means less hours worked and hence

[8] Since the fiscal rule operates only through transfers, public consumption and investment are constant, implying that their variances and covariances are zero. Figure 2 shows that for low values of $b/y$ $\sigma(c)^l < \sigma(c)^d < \sigma(e)^l < \sigma(e)^d$. Since the covariance between private consumption and investment are also higher in the economy with distortionary taxes, only the composition effect can explain that $\sigma(y)^d < \sigma(y)^l$. We have checked that this is the case since the private investment share is much larger in the economy with lump-sum taxes than in the economy with distortionary capital income taxes, which also suffers from a lower $k/y$.

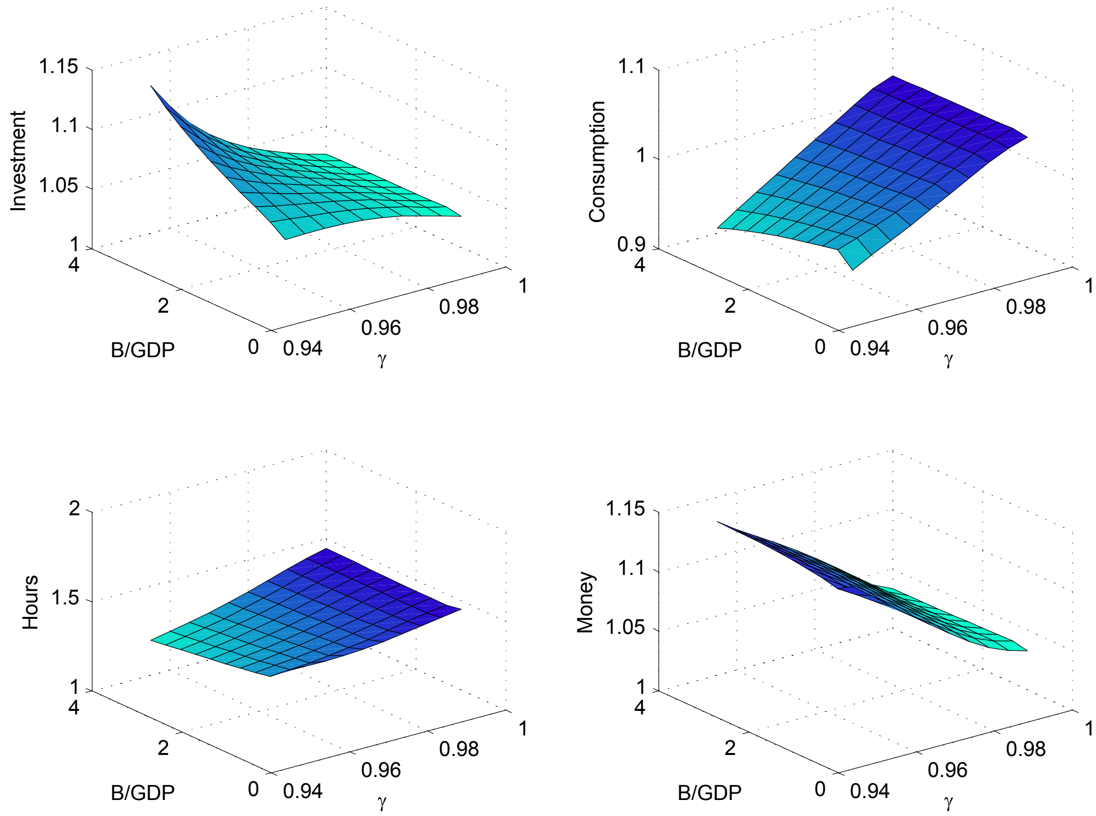


**Figure 2:** *Relative volatility of investment, consumption, hours and output as a function of* $\gamma$ *and* $B/GDP$*.*

stronger cyclical fluctuations.

Changes in public debt and the probability of death have the opposite effect on consumption. As $\gamma$ falls the variance of consumption increases in both economies. This is consistent with the Euler equation for consumption, because now the volatility of consumption is affected by the volatility of wealth, as expression (34) makes clear. When $\gamma = 1$ consumption is affected only by the expected path of real interest rates, but $\gamma < 1$ means that consumers are more aware of changes in their current real wealth. However, the increase in the volatility of consumption is more pronounced in the economy with lump-sum taxes because in this case consumption is more responsive to changes in wealth. The coefficient of the changes in real wealth in the dynamic version of the Euler equation is a negative function of $\tau_c$ and the ratio of private consumption to GDP in

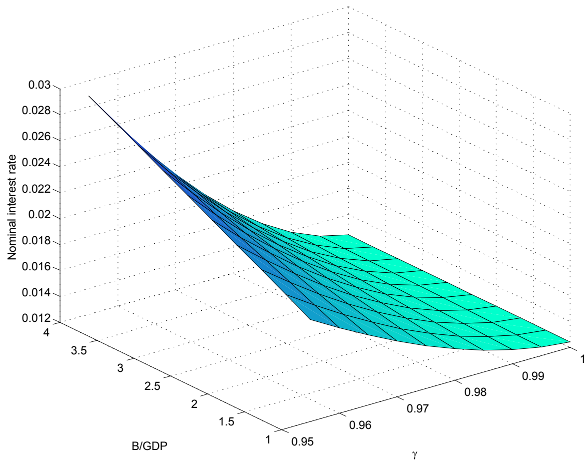


**Figure 3:** *Real interest rate in the steady state as a function of $\gamma$ and $B/GDP$.*

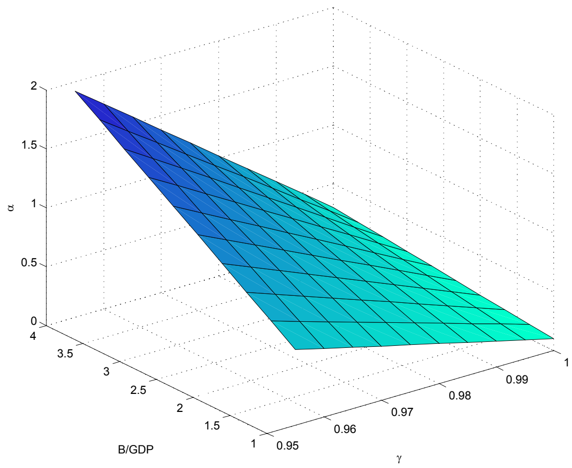


**Figure 4:** *Minimun values of $\alpha_b^s$ required for being in a regime with pasive fiscal policy as a function of $\alpha_y^s$ and $B/Y$.*

the steady state. Since both $\tau_c$ and $\overline{c}/\overline{y}$ are higher in the economy with distortionary taxation, it follows that the increase of the variance of consumption is higher in the economy with lump-sum taxes.

The volatility of consumption, is also affected by another interesting feature of the non-Ricardian model. As the survival rate falls the elasticity of transfers to the debt to GDP ratio ($\alpha^b$ in the fiscal rule) needed to ensure a unique monetary equilibrium increases. This increase is much larger as the steady state $B/Y$ rises as Figure 4 shows. High (low) debt (survival rate) is associated with high interest payments so that the fiscal rule must be more aggressive in preventing deviations of the debt to GDP ratio from target. Otherwise, following shocks, significant changes in the level of debt may prevent convergence to the steady state. However, as the aggressiveness of the fiscal rule is increased the ability of debt to reduce the volatiltity of consumption is reduced.[9]

## 4. Conclusions

In this paper we have developed a New Keynesian model with overlapping generations of finitely-lived consumers such that government debt is part of net wealth. This extends the number of channels through which fiscal policy could affect real and nominal variables, as compared with standard models with Ricardian consumers. Households supply labour to imperfectly competitive firms who produce goods using this labour and physical capital. To introduce a non-trivial role for monetary policy, prices set by firms are sticky in the manner of Calvo (1983). Labour income, profits and consumption expenditure are all subject to distortionary taxation, such that consumption, labour supply, pricing and investment decisions are all affected by taxation. The government also spends resources in consumption transfers and productive expenditures which affect productivity. As a result the description of fiscal policy within our economy is very rich. We then calibrate the model to capture the main business cycle stylised facts for the European economies and assess the role of automatic stabilisers in affecting the volatility of the key components of aggregate demand.

We find that, the presence of finitely-lived households has little effect on the volatility of aggregate ouput. However, a closer look at the output components uncovers an interesting pattern. A higher probability of death increases the automatic stabilization of distortionary taxes through the reduction of the volatility of consumption in the face of technology shocks, but at the cost of increasing the volatility of investment and labour supply. The net impact on volatility depends crucially on the size

[9] However if $\alpha^b$ is increased in line with the minimal requirements of fiscal solvency as the survival probability is reduced, then the stabilising effect on consumption volatility of increasing the degree of non-Ricardian behaviour dominates the procyclical effect of a `tougher' fiscal rule.

of the outstanding stock of government debt and the extent to which consumer behaviour is non-Ricardian. Typically, such a wealth effect will tend to reduce consumption variability, with repercussions for movements in labour supply. However, when the outstanding stock of debt is relatively high, then the volatility in investment expenditures in the presence of distortionary taxation is so great that it dominates the stabilising impact on consumption.

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