CAHIER 9409

THE EFFECTS OF GOVERNMENT FINANCIAL POLICIES : CAN WE ASSUME RICARDIAN EQUIVALENCE ?

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May 1994

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RÉSUMÉ

Cet article analyse les effets quantitatifs des déficits budgétaires sur l'économie en utilisant un modèle dynamique standard qui représente une petite économie ouverte où taxes distorsionnaires et horizons finis mènent à une violation de l'équivalence ricardienne. Les chocs technologiques et la consommation gouvernementale y sont aussi présents. Nous démontrons que les taxes distorsionnaires ont des effets importants sur l'économie et expliquent de 20 % à 40 % des changements dans la production, la consommation et le compte courant. Ainsi, contrairement à ce que plusieurs croient, les déficits budgétaires ne sont pas associés à de plus grands déficits du compte courant. De plus, les tests standards des MCO sur la forme réduite de la consommation (effectués sur des séries chronologiques simulées) peuvent être erronés.

Mots clés : équivalence ricardienne, taxes distorsionnaires, horizons finis.

ABSTRACT

This paper examines the quantitative effects of budget deficits on the economy using a standard dynamic small open economy model where both distortionary taxation and finite horizons lead to the breakdown of Ricardian equivalence. Shocks to technology and government consumption are also included. We show that distortionary taxation has important effects on the economy and explains 20 % to 40 % of the variation in output, consumption and the current account. Contrary to popular belief, though, larger budget deficits are not associated with larger current account deficits. Furthermore, standard OLS tests of the reduced form for consumption (performed by using simulated time series) can be misleading.

Key words : ricardian equivalence, distortionary taxation, finite horizons.

1 Introduction

This paper examines the quantitative effects of budget deficits on the economy using a standard dynamic model where both distortionary taxation and finite horizons lead to the breakdown of Ricardian equivalence.

Clearly, in the real world most of the conditions necessary for "Ricardian equivalence", where the financing of government spending has no real effects on the economy,[2] fail. We know that horizons are finite and that there are distortionary taxes. However, it could very well be that these effects are small (second-order as Barro, 1987, calls them). We could then separate out the decisions about how to finance spending as we would do in corporate finance when the Modigliani-Miller theorem holds. Empirical tests designed to capture the effects of taxation and budget deficits on consumption, interest rates and exchange rates using r-educed form equations abound and have given rather mixed results. For example Kormendi (1983) and Kormendi and Meguire (1986 and 1990) could not reject Ricardian neutrality, while Feldstein (1982), Modigliani and Sterling (1986 and 1990) and Feldstein and Elmendorf (1987) rejected the null hypothesis.[3] They tested the response of households to changes in the debt, budget deficits and taxes by estimating a reduced-form consumption equation. It is recognized that there are several problems with the empirical tests performed. Reduced form estimation may suffer from problems relating to the endogeneity of the crucial regressor, the

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[2] See Barro, 1974. He argues that the way in which government spending is financed has no effects on the behavior of individuals.

[3] For a good literature survey see Bernheim (1987).

budget deficit or tax revenues, and of current income which is also included as a regressor. As well, the interpretation of parameter estimates is ambiguous and a negative coefficient attached to budget deficits could be interpreted as an increase in expected future spending and/or taxation. Studies of specific episodes in which taxation has changed are probably more informative. Unfortunately, there are not many of these episodes which are clearly defined in time. In two very interesting studies, Poterba and Summers (1987) and Evans (1988) examine the effects of a change in taxation that took place in the USA in 1981. Again the results are mixed. While Poterba and Summers reject Ricardian equivalence, Evans can't reject it. Using structural models, Evans (1988 and 1990) and Leiderman and Razin (1988) test whether the finiteness of horizons leads to the rejection of Ricardian neutrality. Neither one can reject the null hypothesis.[4] Evans (1993), using the same structural model, extends his study to include nineteen countries (most studies are limited to the USA) and rejects Ricardian equivalence. The author however shows that the failure of Ricardian equivalence is not important on a practical level.

As well, one cannot find evidence of a relationship between large budget deficits and interest rates (see for example Plosser, 1982 and Evans, 1987a and 1987b), or between the current account and the budget deficit (see Evans, 1990). Under the null hypothesis of Ricardian equivalence there should be no relation between budget deficits and current account deficits. This is so simply because national saving is not affected by a redistribution of the debt over time. Barro (1987) interprets the results of the various empirical tests as

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[4] Leiderman and Razin also test whether liquidity constraints lead to the failure of Ricardian equivalence.

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being supportive of the Ricardian equivalence hypothesis.

The present study aims at an understanding of the quantitative effects of deficits in a theoretical economy by using simulated series to perform statistical tests to assess the importance of finite horizons and distortionary taxation. Are these effects really second-order? If they are not, would we, by using reduced form equations, reject Ricardian equivalence?[5]

To examine these issues we use a simple dynamic small-open economy model à la Blanchard (1985). The Blanchard model is often used in the empirical literature and is a very attractive way to nest Ricardian equivalence with the non-Ricardian alternative. In this model the channel that gives rise to deviations from Ricardian equivalence is the fact that households face a finite (but stochastic) horizon. We add a second channel that may lead to the failure of Ricardian equivalence: distortionary taxation. In our model the government finances its spending by taxing labor income. The inclusion of leisure in the household's utility function makes this type of taxation distortionary. We assume that there are strictly convex adjustment costs in investment and consider different sources of fluctuations: changes in the labor tax rate, in fiscal spending and in productivity. This allows us to examine the relative importance of debt non neutralities and create a more "realistic" environment for the empirical tests. With only one shock it is trivial to detect its effects on consumption.

We show that distortionary taxation has important effects on consumption (it explains 20% to 40% of the consumption forecast variance) that are not easily detected by standard OLS tests. As well, despite the importance of the effects of changes in the labor income

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[5] Greenwood and Huffman, 1991 and McGrattan, 1992 and 1993 use real business cycle models to assess numerically the impact of distortionary taxation on a closed economy.

tax rate there is no significant relation between the current account and government budget deficits. Finite horizons don't have significant effects (changes in taxation explain only approximately 2% of the consumption forecast variance) in the short-run but make the Ricardian equivalence hypothesis easier to reject. Overall our OLS estimates reproduce remarkably well the estimates of the parameter coefficients (income, wealth etc.) reported in the empirical literature.

The remainder of the paper is organized as follows. In section two the model is presented. In section three the choice of the parameter values necessary for the simulation of the model is discussed. In section four the results of the model are discussed. In the last section, conclusions are drawn.

2 The Economy

We assume that international financial capital markets are perfectly integrated by imposing the uncovered interest parity condition. This assumption together with the assumption that there is only one homogeneous and tradable good implies that the domestic real interest rate is pegged to the world real interest rate. Since we don't examine the effects of exogenous changes in the world real interest rate we can assume that the domestic real interest rate is constant and drop the time subscript.

2.1 Investment

The representative firm maximizes the expected present value of profits expressed in real terms:

$$V_t = E_t \sum_{j=0}^{\infty} (1+r)^{-j} \left[Q_{t+j} - s_{t+j} N_{t+j} - \psi \frac{(K_{t+j} - K_{t+j-1})^2}{2K_{t+j}} - I_{t+j} \right] \qquad (1)$$

and

$$I_t = K_t - K_{t-1} + \delta K_t \qquad (2)$$

with K_{t-1} given.

Here, r is the (constant) real interest rate, Q is output, I is gross investment, ψ is the cost-of-adjustment parameter, K is the capital stock, δ is a constant rate of depreciation, N is labor and s is the real wage. E_t is the expectations operator conditional on information available at time t. Equation (2) implies that an investment in period t becomes a capacity increase in period t (this assumption is made to simplify the algebra). A Cobb-Douglas production function is assumed:

$$Q_t = \exp(a_t) K_t^{\phi} N_t^{(1-\phi)} \qquad (3)$$

The parameter a summarizes shocks affecting productivity and follows a stochastic process of the form:

$$a_t = \rho a_{t-1} + \xi_t \qquad (4)$$

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where the ξ_t are identically and independently distributed with $E_{t-1}\xi_t = 0$ and a constant (conditional) variance. The firm chooses the number of workers to hire and investment to maximize the present value of its profits. The first order conditions of this maximization problem are:

$$Q_{N,t} = s_t \tag{5}$$

$$K_t - K_{t-1} = \frac{K_t}{\psi}(q_t - 1) \tag{6}$$

where q (also known as "Tobin's q") is equal to:

$$q_t = E_t \sum_{j=0}^{\infty} (1 + r)^{-j} \left\{ Q_{K,t+j} + \frac{\psi}{2} \frac{(K_{t+j} - K_{t+j-1})^2}{K_{t+j}^2} - \delta \right\}$$

and by taking:

$E_t q_{t+1} - (1 + r) q_t$, we have:

$$E_t q_{t+1} = (1 + r) \left[q_t - Q_{K,t} - \frac{\psi}{2} \left(\frac{K_t - K_{t-1}}{K_t} \right)^2 + \delta \right] \tag{7}$$

2.2 Households

We use Blanchard's (1985) assumption that horizons are finite and stochastic and that each household faces a constant probability of death equal to λ. It can be shown (see Blanchard, 1985) that the household's maximization problem can be rewritten by weighting

the expected utility at time t+j by the probability that the household is alive at time t+j, which is $(1+\lambda)^{-1}$. An agent born at time i, at time t maximizes:

$$U_{i,t} = E_t \sum_{j=0}^{\infty} (1+\lambda)^{-j} (1+\theta)^{-j} [\ln(c_{i,t+j}) + \vartheta \ln(L_{i,t+j})]$$

Households hold wealth (w) in the form of government bonds (b), shares in domestic firms (V) and net foreign assets (f). All bonds are indexed. Wealth in real terms is given by:

$$w_t = b_t + f_t + V_t \equiv b_t + f_t + q_t K_{t-1} \tag{8}$$

It can be easily shown that the last equality holds for linearly homogeneous production and cost functions (these are the same conditions for marginal and average q to coincide in a continuous time non-stochastic model; see Hayashi, 1982).

The households' budget constraint is:

$$w_{t+1} = (1+r)(1+\lambda)[w_t + s_t N_t (1-\tau_t) - c_t - T_t] \tag{9}$$

where T are lump sum taxes and τ are labor income taxes (which are distortionary when ϑ is different from zero).

The first-order conditions of the consumer's problem are:

$$\frac{1}{c_t} = \frac{(1+r)}{(1+\theta)} E_t \left(\frac{1}{c_{t+1}}\right) \tag{10}$$

and

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$$N_t = -\vartheta \frac{c_t}{s_t (1 - \tau_t)} + 1 \qquad (11)$$

which is the consumer's labor supply function. The labor tax rate only affects the labor supply equations. In absence of leisure in the utility function ($\vartheta = 0$) there would be no changes in the consumer's behavior (assuming infinite horizon) as agents cannot make intertemporal substitutions to reduce the impact of taxation. The consumer's first order condition indicates that in the absence of policy-induced distortions, despite the finite horizon the equilibrium attained is Pareto efficient. By taking a first order Taylor approximation of equation (10) we can use the intertemporal budget constraint (assuming that there are no Ponzi games) and the definition of human wealth to derive consumption as a function of human and financial wealth:[6]

$$c_t = \beta (w_t + h_t) \qquad (12)$$

where:

$$\beta = \frac{(1 + \lambda)(1 + \theta) - 1}{(1 + \lambda)(1 + \theta)}$$

and human wealth is defined as:

$$h_t = \sum_{j=0}^{\infty} (1 + r)^{-j} (1 + \lambda)^{-j} [s_{t+j} N_{t+j} (1 - \tau_{t+j}) - T_{t+j}] \qquad (13)$$

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[6]

  If we take a first-order Taylor expansion around the (deterministic) initial steady state, equation (10) can be approximated by:
$E_t c_{t+1} = \frac{(1+r)}{(1+\theta)} c_t$.

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2.3 Aggregate Consumption

Until now the analysis has dealt with the individual's decisions and because individuals are born at different points in time the aggregate model has to sum up over all the individuals still alive at time t. The relation between aggregate and individual variables (see Blanchard, 1985) is given by:[7]

$$x_t^a = \frac{\lambda}{1+\lambda} \sum_{s=-\infty}^{t} \left(\frac{\lambda}{1+\lambda}\right)^{t-s} x_{s,t} \tag{14}$$

It can be shown that if we assume that labor income is the same across individuals aggregate human wealth is equivalent to (13) and financial wealth evolves independently of λ :

$$w_{t+1} = (1+r)\left[w_t + s_t N_t (1 - \tau_t) - c_t - T_t\right] \tag{15}$$

The death of individuals has no effects on aggregate financial wealth. Using equation (12) (and aggregating over all the individuals alive), (13) and (15) we obtain the equation that characterizes the dynamics of aggregate consumption:

$$E_t c_{t+1} = \frac{1+r}{1+\theta} c_t - \lambda \beta E_t w_{t+1} \tag{16}$$

With $\lambda = 0$ (infinite horizon), $\beta = 0$ and (16) becomes the standard equation for consumption.

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[7] We later drop the superscript "a". From now on all variables are aggregated macro variables. Only for consumption and financial wealth is there a difference between the aggregate and the individual variable.

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2.4 Government

The government has to satisfy the following constraint:

$$b_{t+1} = (1+r)\left[b_t - s_t N_t \tau_t - T_t + G_t\right] \tag{17}$$

with

$$T_t = \frac{\gamma}{(1+r)} b_t + T_{1t} \tag{18}$$

where $\gamma < r$. We impose this condition to rule out the possibility that the government takes part in Ponzi games.

2.5 The Macro Model Linearized

The current account equation can be derived from equations (5), (6), (7), (8), (15) and (17) :

$$f_{t+1} = (1+r)\left[f_t + Q_t - c_t - G_t - \psi \frac{(K_t - K_{t-1})^2}{2K_t} - I_t\right] \tag{19}$$

Equations (6), (7), (8), (11), (16), (17) and (18) constitute the equations of the model that are going to be parameterized, calibrated and simulated. All the equations of the model are linearized by taking a first-order Taylor expansion around the a deterministic initial steady state and $\hat{x} = x_t - x_o$ where x_o is the value of x in the initial steady state (see also King, Plosser and Rebelo, 1988) .

$$\hat{K}_t = \hat{K}_{t-1} + \frac{K_o}{\psi}\hat{q}_t \tag{20}$$

$$\hat{b}_{t+1} = (1+r)\left[\hat{b}_t - \hat{T}_t + \hat{G}_t - \tau_o(N_oQ_{NN_o} + Q_{N_o})\hat{N}_t - \tau_oN_o(Q_{NK_o}\hat{K}_t + Q_{Na_o}\hat{a}_t) - N_oQ_{N_o}\hat{\tau}_t\right] \tag{21}$$

$$\hat{f}_{t+1} = (1+r)\left[\hat{f}_t + Q_{N_o}\hat{N}_t + (Q_{K_o} - \delta)\hat{K}_t + Q_{a_o}\hat{a}_t - \hat{c}_t - \hat{G}_t - \frac{K_o}{\psi}\hat{q}_t\right] \tag{22}$$

$$E_t\hat{q}_{t+1} = (1+r)\left[\hat{q}_t - Q_{KK_o}\hat{K}_t - Q_{Ka_o}\hat{a}_t - Q_{KN_o}\hat{N}_t\right] \tag{23}$$

$$E_t\hat{c}_{t+1} = \frac{1+r}{1+\theta}\hat{c}_t - \lambda\beta E_t\hat{w}_{t+1} \tag{24}$$

$$\hat{w}_t = \hat{b}_t + \hat{f}_t + q_o\hat{K}_{t-1} + K_o\hat{q}_t \tag{25}$$

$$\hat{N}_t = \frac{\vartheta c_o}{Q_{N_o}^2(1-\tau_o)}\left[Q_{NN_o}\hat{N}_t + Q_{Na_o}\hat{a}_t - \frac{Q_{N_o}}{(1-\tau_o)}\hat{\tau}_t + Q_{NK_o}\hat{K}_t - \frac{Q_{N_o}}{c_o}\hat{c}_t\right] \tag{26}$$

where Q_{N_o} is the derivative of Q with respect to N, evaluated at its initial steady state value.

There are seven endogenous variables (K, b, f, q, c, w, N) and seven equations. The system can be rewritten in compact matrix notation:

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$$\Gamma_1 E_t X_{t+1} = \Gamma_2 X_t + \Gamma_3 E_t Y_{t+1} + \Gamma_4 Z_t \tag{27}$$

and:

$$E_t Y_{t+1} = \Psi_1 E_t X_{t+1} + \Psi_2 X_t + \Psi_3 Z_t \tag{28}$$

where $X_t = \left\{ \hat{K}_{t-1}, \hat{b}_t, \hat{f}_t, \hat{c}_t, \hat{q}_t \right\}$, $E_t Y_{t+1} = \left\{ E_t \hat{w}_{t+1}, \hat{N}_t \right\}$ and $Z_t = \left\{ \hat{\tau}_t, \hat{G}_t, \hat{a}_t \right\}$

In state space form we have:

$$E_t X_{t+1} = A X_t + B Z_t \tag{29}$$

The state vector X_t includes three predetermined variables $\left\{ \hat{K}_{t-1}, \hat{b}_t, \hat{f}_t \right\}$, which are associated with an initial condition, and two variables that are *free*. These are the two forward looking variables $\{\hat{c}_t, \hat{q}_t\}$. For a (regular) saddle point equilibrium we need three stable roots and two unstable ones. For all the parameter values considered we found that this condition was respected. The elements in the matrices A and B are described in the appendix. We assume that the forcing variables follow a first-order autoregressive process:

$$Z_{t+1} = \Omega Z_t + \Sigma_{t+1}$$

where the disturbances Σ_t are independently and identically distributed through time.

3 Model Parameterization and Simulation

A quantitative analysis of the effects of taxation on business cycles requires us to make some assumptions about the values of the following parameters: $r, \theta, \delta, \lambda, \phi, \tau_o, \gamma, v, G_o, T_{1o}, N_o$. Once we have assigned values to these parameters we can derive endogenously the values of ϑ and the initial steady state values of the state variables $\left\{ \hat{K}_{t-1}, \hat{b}_t, \hat{f}_t, \hat{c}_t, \hat{q}_t \right\}$. Following the calibration procedure initiated by Kydland and Prescott (1982) we chose parameters values using previous empirical studies and information about the US historical series. To begin with, since we chose our time unit to be a year, .04 was chosen for the real interest rate. The rate of depreciation is set to 10% per annum and labor's share, $1 - \phi$, was set equal to .60 (which is approximately the average ratio of total employee compensation to GNP in the USA for the period considered). The cost-of-adjustment parameter was set equal to 0.5 to reproduce the observed volatility in the investment series. γ describes how quickly a deficit will bring higher taxes (see equation 18). A sensitivity analysis was performed (see Figure 17). In the results reported γ is set equal to .045. With finite horizons consumers are more affected by a change in the labor tax rate the closer this parameter value is to the real interest rate (the probability that the benefits of higher taxes today may fall on the future generation is higher). Values of γ closer to the real interest rate (which is set to .04) produced similar results to the ones reported. Four different cases are considered:

1) Infinite horizon and no leisure with $N = 1$ and $\vartheta = 0$. The infinite horizon case is approximated by $\lambda = .0000135$ and the subjective discount rate, θ, is set equal to .039995.

2) Distortionary taxation and infinite horizon. In this case $\lambda = .0000135$ and $\theta = .039995$.

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As in King, Plosser and Rebelo (1988) we set the steady state value of N to be equal to 0.2. The leisure share parameter, ϑ (which is derived endogenously) is 2.74831.

3) Finite horizon and no leisure. The value of λ (probability of death) was chosen by looking at life expectancy at birth, This is $\frac{1}{\lambda}$. Hence a choice of $\lambda = 0.0135$ implies that life expectancy at birth is roughly 74 years. The subjective discount rate is set equal to .039, N $= 1$ and $\vartheta = 0$.

4) Distortionary taxation and finite horizon with $\lambda = 0.0135$, $\delta = .039$ and N $= 1$.

For all of the above cases the initial steady state ratio of the capital stock to output is 2.88889 (in Kydland and Prescott, 1982, the ratio is 2.4).

The initial steady state labor income tax rate (τ_o) is set equal to .23 (which is approximately the average of the effective labor income tax rate for the period under consideration). The initial values of taxes (T_{1o}) and fiscal spending (G_o) are set so that with distortionary taxation fiscal spending is 20.7% of national income and the budget deficit is 1.6% of national income (between 1956 and 1987 the mean values for the USA were 20% and 1.5% respectively).

To perform the numerical simulations we also need to establish the parameters that characterize the autoregressive stochastic processes governing productivity, labor tax and fiscal spending changes. We assume a standard error for the productivity shock equal to .0071 (see Prescott, 1986) and for taxes and fiscal spending we use the standard errors of the US labor tax rate and fiscal spending series. For the period 1957-1987 the standard error for the labor income marginal tax rate is .00703 (the calculations were made using

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the procedure in Joines, 1981, and the extended series derived in McGrattan, 1993). The fiscal spending shock is parameterized so that the variance of the log first difference of the simulated series is the same as in the data, approximately .028. We assume that all shocks are independent and highly persistent (.95, which is approximately the estimated values of the AR(1) processes).

The numerical simulation method employed is the forward-backward method for rational expectation models described in Blanchard and Kahn (1980) and Blanchard (1983).

4 Results

The model was simulated and 60 yearly observations were used to calculate all the reported statistics. To examine the robustness of the results we repeated the experiments 20 times. The results we report are generated using unfiltered series to be consistent with the empirical literature on Ricardian equivalence.

Table 1 summarizes the dynamic behavior of the current account and the budget deficit ratios to output in the G-7 countries between 1956 and 1989 (using annual data).[8] The correlation between these two series is very variable and not very high except for the USA. Even in this case the correlation coefficient for the period from 1956 to 1982 is much lower.

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[8] Backus, Kydland and Kehoe (1993) have explored the dynamic properties of several macro-variables for the G-7 countries (and other industrialized countries as well) and found substantial similarities accross these countries. Our simulations reproduce the standard stylized facts reported in King, Plosser and Rebelo (1988), Finn (1990), Mendoza (1991), Cardia (1991),Backus, Kehoe and Kydland (1992) and Baxter and Crucini (1993). The one difference we observed is that distortionary taxation increases the volatility of the generated macro time-series (a similar result is found in Greenwood and Huffman, 1991). With distortionary taxation and infinite horizons the standard error of the rate of growth of output is 1.839, of saving is 6.368, of investment is 9.445 and of consumption is .5479. All variables are highly procyclical. With infinite horizon the standard error of the rate of growth of output is .9.

Barro (1987) interprets the lack of relation between government budget and current account deficits as indirect evidence for Ricardian equivalence. The correlation between the current account and the budget deficit ratios to output using the simulated series is reported in Table 2. As can be seen there is no systematic relation between these two series (the standard error across the 20 experiments is very high). The correlations that we observe for the G-7 countries could have been generated by either a model with distortionary taxation, finite horizon (or both) or Ricardian equivalence. The mean value of the correlation decreases if we exclude fiscal spending shocks. These results indicate that we should not expect a systematic relation between budget deficits and current accounts even if Ricardian equivalence does not hold.

To examine the importance of changes in the labor tax rate with a finite horizon and with endogenous labor supply we have calculated the fraction of the consumption forecast variance explained by innovations in the labor tax rate, technological changes and government consumption.[9] The innovations were ordered as follows: first the innovation in technology, second in government consumption and third in the labor tax rate. By doing so we are attributing most of the changes in consumption, output or the current account to changes in technology and least to taxation. If anything we are underestimating the effects of distortionary taxation or finite horizons on the economy. These results are reported in Figures 9 through 16. The results in Figures 9 through 12 are derived assuming that taxation is distortionary and horizons are infinite (see the parameter values described in case 2). The

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[9] A Cholesky factorization was used for the decomposition of the variances. We used the programs in GAUSSX.

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simulation results described in Figures 13 through 16 are instead derived assuming finite horizons and a vertical labor supply curve (see the parameter values described in case 3).

In Figures 9, 10, 13 and 14 the percentages of forecast variances of consumption explained by innovations in technology, fiscal spending and the labor tax rate are shown for several forecast horizons. Figures 9 and 13 describe the mean values obtained for the 20 experiments performed and Figures 10 and 14 describe the effects of innovations in the labor tax rate in all 20 experiments. The results indicate that distortionary taxation has important effects on consumption (similar conclusions are reached by McGrattan, 1993). Changes in the labor tax rate explain 20% to 40% of the forecast variance of consumption.[10] On average, technology explains about 70% of the variation in the consumption forecast variance and changes in fiscal spending explain about 4%. In Figures 11 and 12 we report the effects that the different shocks have on output and on the current account. The results show that output and consumption are affected in a similar way and that the impact effect of fiscal spending and taxation explains about 40% of the changes in the current account. Productivity shocks are still a very important component. With finite horizons, innovations in the labor tax rate only explain 2% (a mean value) of the consumption forecast variance. These effects increase slightly over time and in some cases may become rather important (see Figure 14) relatively to the other two sources of fluctuations. The reason for these delayed effects on consumption becomes clear by looking at Figures 17 and 18. Figure 17 depicts the effects of a 1% change in the labor tax rate (which is permanent and compensated by changes in

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Similar results where obtained when we performed the simulations keeping government consumption constant.

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lump-sum-taxation, see equation 14). Figure 17 shows that in response to a 1% increase in τ, consumption decreases at first for several years and eventually increases above its initial steady state level (Figure 18, $\gamma = .045$ is the parameter value used in the simulations we report). This is because the initial decrease in taxation leads to a faster repayment of the government debt and to lower taxation in the future. Figure 17 also illustrates the response of consumption to a change in the labor tax rate with different values of γ . With a higher value of γ, the change in the tax rate is more readily offset by a change in lump-sum taxation. In this case the change in taxation is more temporary and the effects on consumption are less important. We chose a fairly low value for γ (close to .04, the real interest rate) to be sure to have some important effects on consumption (values closer to .04 did not produce different results). Despite this, the relative effect of taxation vis-a-vis technological and fiscal spending changes is rather small in the short run. Figure 18 shows the time path of consumption in response to a 1% change in the tax rate with infinite horizon (which was approximated by setting $\lambda = .0000135$). As one would expect, consumption does not change in response to a temporary change in taxation.

OLS estimates of the consumption reduced form equations using the generated series are reported in Tables 3 through 6. All the values of the statistics reported are the mean values from the 20 simulations performed. The regressions we run are similar to the ones estimated by Kormendi (1983) who cannot reject the null hypothesis of Ricardian equivalence. Similar equations were estimated by Kormendi and Meguire (1986 and 1990), Modigliani and Sterling (1986 and 1990), Feldstein (1982) and Feldstein and Elmendorf (1987). Kormendi and

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Meguire produced results similar to Kormendi's (1983). Feldstein, Modigliani and Sterling, Feldstein and Elmendorf rejected the hypothesis of Ricardian equivalence.

Table 3 describes the OLS estimates obtained assuming distortionary taxation and infinite horizons (case 2). Our results are remarkably similar to the ones found in the empirical literature. In our simulations the coefficient estimate of the parameter attached to the income variable has a mean value around .20 and .21 (depending on the specification) and a very low variance across the 20 simulations. The same coefficient is between .28 and .34 in Kormendi (1983) and between .22 and .36 in Kormendi and Meguire (1986 and 1990). With the simulated series the mean value of the coefficient attached to wealth (minus government bonds) is between .01 and .012 with a low variance across the 20 simulations. In Kormendi (1983) this coefficient varies between .02 and .046. In Modigliani and Sterling (1986 and 1990) it is between .01 and .032 and in Kormendi and Meguire (1986 and 1990) is between .006 and .037. The coefficient attached to fiscal spending is around -.14 in the simulations and between -.17 and -.28 in Kormendi (1983), -.11 and -.26 in Kormendi and Meguire (1986 and 1990) and -.04 and -.22 in Modigliani and Sterling (1986).

When distortionary taxation (and infinite horizon) is assumed the mean values of the parameters attached to tax revenue and government bonds are not significantly different from zero (see Table 3). Figures 1 to 8 illustrate the variability of the parameter values and the t-statistics over the 20 simulations. We only focus on the tax related parameters because they are the only ones that are not robust. Table 7 summarizes these results in a compact way. When estimating equation 1 (see Tables 3 and 7) we can reject the null hypothesis only 6

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times (at a 5 per cent or lower significance level). When we estimate equation 3 we can reject Ricardian equivalence 5 times. Figures 1 to 8 show that the t-statistics vary considerably. In most cases we are not be able to reject Ricardian equivalence, yet we know that distortionary taxation has important effects on consumption. Similar results (not reported) are obtained with a Cochrane-Orcutt iterative correction. When we use productivity (which is exogenous in our model) as a proxy for output the results improve remarkably. With equation 1 the null hypothesis is rejected 17 out of 20 times, with equation 2, 19 out of 20 times and with equation 3, only 4 out 20 times. Excluding shocks to fiscal spending from the simulations does not change the results. These elements seem to suggest that the endogeneity problems related to the inclusion of regressors like current income, government bonds and wealth may be rather important and make the results not robust.

Table 4 describe the results from the OLS regressions assuming finite horizons and non-distortionary taxation (case 3, with a vertical labor supply, $\vartheta = 0$). The estimated coefficients of the parameters attached to income, wealth and fiscal spending are higher although still plausible relative to the ones reported in the empirical literature. In most cases we reject the null hypothesis of Ricardian equivalence (see also Table 7). However when equation 1 is estimated, the null hypothesis is rejected 13 times out of 20 (see Table 7) and when equation 6 is estimated we can never reject Ricardian equivalence. Similar results are obtained when we assume both distortionary taxation and finite horizons (case 4, see Tables 5 and 7). However, the introduction of leisure in the utility function makes the parameter estimates of income, wealth and fiscal spending closer to the ones reported in the different empirical

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studies.

With infinite horizons and a vertical labor supply curve (case 1, see Tables 6 and 7 changes in the labor income tax rate are non distortionary and as we would expect, in most cases, we can't reject Ricardian equivalence.

5   Conclusions

This paper examined the relative impact of tax distortions and finite horizons in a small open economy. An intertemporal model with optimizing agents and firms was calibrated and simulated. When the generated series are used to estimate the reduced form for consumption, the estimates of the coefficients attached to income, wealth and government spending are remarkably close to the ones produced in the empirical literature (see for example Kormendi, 1983). These estimates are also very robust across the different specifications estimated and are always significant. The only estimates that are not robust are the ones of the coefficients attached to the tax revenue and to the government bond variables.

Distortionary taxation explains between 20% and 40% of the changes in consumption, output and current account. These effects cannot easily be called second order. Despite this, the OLS estimates of the reduced form equation for consumption (using the generated series) most often don't lead to the rejection of the null hypothesis of Ricardian equivalence.

With finite horizons, changes in the time path of taxes by themselves don't seem to have important effects on the behavior of households. Innovations to the labor tax rate when we assume finite horizons and a vertical labor supply curve (taxes are non-distortionary in

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this case) only explain around 2% of the consumption forecast variance. Despite this, the estimates often lead to the rejection of Ricardian equivalence. These results are consistent with the findings of Evans (1993). Using the Blanchard model he tests the Ricardian hypothesis against the non-Ricardian alternative (where the deviations from Ricardian equivalence are uniquely due to the finiteness of the horizons). He strongly rejects the null hypothesis but finds that the effects on consumption of the departure from Ricardian equivalence are relatively small.

As well, despite popular belief, the current account and the budget deficit do not show a systematic relation in any of the cases considered. This would seem to indicate that the lack of a strong relation between these two series should not be considered an element in support of Ricardian equivalence.

1 Appendix: The State Space Form of the Model

The system of equations to be simulated can be written in compact matrix form:

$$\Gamma_1 E_t X_{t+1} = \Gamma_2 X_t + \Gamma_3 E_t Y_{t+1} + \Gamma_4 Z_t \tag{1}$$

$$E_t Y_{t+1} = \Psi_1 E_t X_{t+1} + \Psi_2 X_t + \Psi_3 Z_t \tag{2}$$

where $X_t = \left\{ \hat{K}_{t-1}, \hat{b}_t, \hat{f}_t, \hat{c}_t, \hat{q}_t \right\}$, $E_t Y_{t+1} = \left\{ E_t \hat{w}_{t+1}, \hat{N}_t \right\}$ and $Z_t = \left\{ \hat{\tau}_t, \hat{G}_t, \hat{a}_t \right\}$

In state space form we have:

$$E_t X_{t+1} = A X_t + B Z_t \tag{3}$$

The matrices $\Gamma_1, \Gamma_2, \Gamma_3, \Gamma_4, \Psi_1, \Psi_2$ and Ψ_3 are defined below:

$$\Gamma_1 = I - \Gamma_o$$

and:

$$\Gamma_o = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ -(1+r)\tau_o Q_{NK_o} N_o & 0 & 0 & 0 & 0 \\ (1+r)(Q_{K_o} - \delta) & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ -(1+r)Q_{KK_o} & 0 & 0 & 0 & 0 \end{bmatrix}$$

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$$\Gamma_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & K_o/\psi \\ 0 & 1+r-\gamma & 0 & 0 & 0 \\ 0 & 0 & 1+r & -(1+r) & -(1+r)K_o/\psi \\ 0 & 0 & 0 & \dfrac{(1+r)}{(1+\theta)} & 0 \\ 0 & 0 & 0 & 0 & (1+r) \end{bmatrix}$$

$$\Gamma_3 = \begin{bmatrix} 0 & 0 \\ 0 & -(1+r)(Q_{NN_o}N_o + Q_{N_o})\tau_o \\ 0 & (1+r)Q_{N_o} \\ -\lambda\beta & 0 \\ 0 & -(1+r)Q_{KN_o} \end{bmatrix}$$

$$\Gamma_4 = \begin{bmatrix} 0 & 0 & 0 \\ -(1+r)Q_{N_o}N_o & (1+r) & -(1+r)\tau_o N_o Q_{Nao} \\ 0 & -(1+r) & (1+r)Q_{ao} \\ 0 & 0 & 0 \\ 0 & 0 & -(1+r)Q_{Kao} \end{bmatrix}$$

$$\Psi_1 = \begin{bmatrix} 1 & 1 & 1 & 0 & K_o \\ \gamma_2 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\Psi_2 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \gamma_1 & 0 \end{bmatrix}$$

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$$\Psi_3 = \begin{bmatrix} 0 & 0 & 0 \\ \gamma_4 & 0 & \gamma_3 \end{bmatrix}$$

and where:

$$\beta_1 = -\frac{\vartheta}{Q_{No}(1 - \tau_o)}$$

$$\beta_2 = \frac{\vartheta c_o}{Q_{No}^2(1 - \tau_o)}$$

$$\beta_3 = -\frac{\vartheta c_o}{Q_{No}(1 - \tau_o)^2}$$

$$\gamma_1 = \frac{\beta_1}{1 - \beta_2 Q_{NNo}}$$

$$\gamma_2 = \frac{\beta_2 Q_{NKo}}{1 - \beta_2 Q_{NNo}}$$

$$\gamma_3 = \frac{\beta_2 Q_{Nao}}{1 - \beta_2 Q_{NNo}}$$

$$\gamma_4 = \frac{\beta_3}{1 - \beta_2 Q_{NNo}}$$

Table 1

Budget Deficit - Current Account Correlations[a]

G-7 Countries, 1956-1989

Country	Correlation
USA	.6745[b]
Canada	-.3224
France	.0956
Germany	.0227
Italy	.4513
Japan	-.2736
UK	-.0902

a. Using yearly values from IFS (CD-ROM).
b. The correlation is .3615 between 1956 and 1982.

Table 2

Simulation Results: Correlations

Cases	all shocks ca/y,bd/y	shocks to technol. & labor tax rate ca/y,bd/y
Infinite Horizon	.4507 (.3402)	.0132 (.2976)
Finite Horizon	.5617 (.2146)	.1332 (.2426)
Distort. Taxation	.3208 (.3818)	.2951 (.3791)
Finite Horizon & Distort. Taxation	.4227 (.3440)	.1792 (.2107)

a. Standard errors in parentheses (variation of the
   correlation coefficients over 20 experiments)

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Table 3

OLS Estimates of Consumption Equation

(distortionary taxation and infinite horizons)[a]

Equation C(t)	(1) levels	(2) levels	(3) levels	(4) first diff.	(5) first diff.	(6) first diff.
const	.2010 (92.09)	.2013 (70.86)	.2002 (90.44)	.0000 (-.3195)	.0000 (.1226)	.0000 (.0383)
Y(t)	.2155 (29.50)	.2144 (30.06)	.2154 (29.21)	.2020 (45.76)	.2025 (46.01)	.2024 (46.08)
Y(t-1)	-.0985 (-13.25)	-.0936 (-12.70)	-.0977 (-13.14)	-.0564 (-12.75)	-.0552 (-12.61)	-.0560 (-12.94)
W^b(t)	.0126 (40.90)	.0125 (28.30)	.0127 (30.60)	.0102 (5.153)	.0106 (4.032)	.0103 (3.945)
G(t)	-.1433 (-9.77)	-.1467 (-9.63)	-.1452 (-9.69)	-.1499 (-11.58)	-.1486 (-11.41)	-.1497 (-11.52)
TR(t)	-.0085 (-.4995)	-.0193 (-1.123)		-.0173 (-.8896)	-.0211 (-1.045)	
B(t)		.0018 (.8409)	.0012 (.5489)		.0051 (.6455)	.0029 (.3627)

a. t-statistics in parentheses. All statistics are the averages over 20 simulations.
C = consumption, Y = output (Q, in the model), TR = tax revenue, B = government
bonds, G = government spending, W^b = financial wealth minus government bonds.

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Table 4

OLS Estimates of Consumption Equation

(Finite horizon and $\vartheta = 0$)[a]

Equation C(t)	(1) levels	(2) levels	(3) levels	(4) first diff.	(5) first diff.	(6) first diff.
const	.3119 (23.65)	.3185 (48.45)	.2871 (20.41)	.0000 (-.2283)	.0000 (.2092)	.0000 (.1963)
Y(t)	.3890 (30.94)	.3985 (77.86)	.3853 (30.83)	.4030 (104.0)	.3972 (107.4)	.3884 (36.51)
Y(t-1)	-.0488 (-3.978)	-.0598 (-11.29)	-.06237 (-4.786)	-.0337 (-9.572)	-.0334 (-11.12)	-.0351 (-4.114)
W^b(t)	.0319 (24.00)	.0456 (49.71)	.0483 (24.14)	.0268 (10.04)	.0401 (9.835)	.0295 (2.678)
G(t)	-.3746 (-36.01)	-.3820 (-78.54)	-.3740 (-33.51)	-.3866 (-76.28)	-.3860 (-88.38)	-.3849 (-30.20)
TR(t)	-.0753 (-5.73)	-.1215 (-17.61)		-.1125 (-16.96)	-.1190 (-20.14)	
B(t)		.0147 (23.48)	.0102 (8.39)		.0117 (4.286)	-.0057 (-.4678)

a. See note to Table 3.

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Table 5

OLS Estimates of Consumption Equation

(distortionary taxation and finite horizon)[a]

Equation C(t)	(1) levels	(2) levels	(3) levels	(4) first diff.	(5) first diff.	(6) first diff.
const	.1106 (31.43)	.1189 (52.08)	.1061 (45.68)	.0000 (-.4908)	.0000 (.3406)	.0000 (.1195)
$Y(t)$	.2784 (18.31)	.2931 (35.87)	.3028 (24.68)	.2849 (50.36)	.2846 (53.33)	.2902 (36.64)
$Y(t-1)$	-.1014 (-6.508)	-.1043 (-12.10)	-.1216 (-9.636)	-.0659 (-11.52)	-.0643 (-12.54)	-.0694 (-9.131)
$W^b(t)$	.0241 (21.11)	.0292 (36.32)	.0306 (29.35)	.0193 (7.510)	.0244 (7.630)	.0209 (4.797)
$G(t)$	-.1199 (-5.625)	-.1263 (-10.64)	-.1074 (-6.470)	-.1229 (-10.04)	-.1160 (-10.38)	-.1203 (-7.136)
$TR(t)$	-.0462 (-1.682)	-.1568 (-8.878)		-.1301 (-7.064)	-.1427 (-8.265)	
$B(t)$		.0200 (14.08)	.0137 (8.156)		.0204 (3.312)	.0069 (.7487)

a. See note to Table 3.

Table 6

OLS Estimates of Consumption Equation

(infinite horizon and $\vartheta = 0$)[a]

Equation	(1)	(2)	(3)	(4)	(5)	(6)
C(t)	levels	levels	levels	first diff.	first diff.	first diff.
const	.4161 (48.16)	.4297 (34.06)	.4297 (35.37)	.0000 (.1790)	.0000 (-.0588)	.0000 (-.0932)
Y(t)	.3553 (64.19)	.3559 (66.51)	.3565 (65.40)	.3515 (108.7)	.3536 (100.4)	.3537 (102.5)
Y(t-1)	-.0615 (-10.83)	-.0584 (-10.92)	-.0610 (-11.02)	-.0327 (-11.11)	-.0323 (-11.18)	-.0322 (-11.26)
W^b(t)	.0366 (78.48)	.0350 (41.61)	.0352 (47.68)	.0318 (13.75)	.0278 (7.153)	.0280 (7.306)
G(t)	-.4418 (-99.16)	-.4405 (-89.83)	-.4403 (-89.84)	-.4408 (-101.6)	-.4405 (-102.6)	-.4406 (-102.8)
TR(t)	-.0047 (-.7104)	-.0016 (-0.366)		-.0006 (-.0466)	.0012 (.2176)	
B(t)		.0005 (-.0851)	-.0005 (-.4166)		-.0023 (-.5891)	.0020 (.5477)

a. See note to Table 3.

Table 7a

OLS Estimates

number of significant coefficients on B and TR[a]

Equations	all shocks (1), (3), (4), (6)	shocks to technol. & labor tax rate (1), (3), (4), (6)
Infinite Horizon	5, 5, 1, 2	8, 4, 0, 3
Finite Horizon	13, 16, 20, 0	15, 19, 20, 1
Distort. Taxation	6, 5, 1, 3	3, 12, 2, 6
Finite Horizon & Distort. Taxation	12, 18, 20, 5	14, 19, 20, 6

a. At a 5% significance level

Table 7b

OLS Estimates

number of significant coefficients on B or TR[a]

Equations	all shocks (2), (5)	shocks to technol. & labor tax rate (2), (5)
Infinite Horizon	6 2	5, 4
Finite Horizon	20, 20	20, 20
Distort. Taxation	10, 4	12, 8
Finite Horizon & Distort. Taxation	20, 19	20, 20

a. at a 5% significance level

Figure 1
OLS Estimates of TR
Distortionary taxation, case 2. See equation 1, Table 3

Figure 2
OLS Estimates of TR
Distortionary taxation, case 2. See equation 2, Table 3

Figure 3
OLS Estimates of B
Distortionary taxation, case 2. See equation 2, Table 3

Figure 4
OLS Estimates of B
Distortionary taxation, case 2. See equation 3, Table 3

Figure 5
OLS Estimates of TR
Distortionary taxation, case 2. See equation 4, Table 3

Figure 6
OLS Estimates of TR
Distortionary taxation, case 2. See equation 5, Table 3

Figure 7
OLS Estimates of B
Distortionary taxation, case 2. See equation 5, Table 3

Figure 8
OLS Estimates of B
Distortionary taxation, case 2. See equation 6, Table 3

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Figure 9
Fraction of forecast variance of consumption explained
by innovations in technology, government consumption & tax rate

Figure 10
Fraction of forecast variance of consumption
explained by innovations in the tax rate

Figure 11
Fraction of forecast variance of output explained
by innovations in technology, government consumption & tax rate

Figure 12
Fraction of forecast variance of current account
explained by innovations in technology, gov. consumpt & tax rate

Figure 13
Fraction of forecast variance of consumption
explained by innovations in technology, gov. cons & tax rate

Figure 14
Fraction of forecast variance of consumption
explained by innovations in the tax rate

Figure 15
Fraction of forecast variance of output explained
by innovations in technology, government consumption & tax rate

Figure 16
Fraction of forecast variance of current account
explained by innovations in technology, gov. consumpt & tax rate

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Figure 17
Effects of a 1% change in the labor tax rate
on consumption (finite horizon, case 3)

Dashes =) $\gamma = .045$
Short dashes =) $\gamma = .09$
Dots and dashes =) $\gamma = 1.5$

Figure 18
Effects of a 1% change in the labor tax rate
on consumption (finite horizon, case 3)

Dashes =) $\gamma = .045$ (finite horizon)
Short dashes =) $\gamma = .045$ (infinite horizon)

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