

**AUTOMATIC STABILIZERS, FISCAL RULES AND
MACROECONOMIC STABILITY**

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Abstract

This paper analyses the effect of the fiscal structure upon the trade-off between inflation and output stabilization in presence of technological shocks in a DGE model with nominal inertia. The model is calibrated to reproduce the main features of European economies and it integrates a rich menu of fiscal variables as well as a target on the debt to output ratio. The main finding is that taxes linked to economic activity worsen the output-inflation variability trade-off as compared with an economy with lump-sum taxes, except when nominal and real rigidities are very large. Aside from the well known supply side channels that explain this result, we find that fiscal rules designed to ensure debt consolidation induce cyclical movements in aggregate demand that also contribute to increase the volatility of output in presence of distortionary taxes.

Keywords: Fiscal rules, macroeconomic stability, distortionary taxes.

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1. Introduction

Recent macroeconomic research has stressed the relevance of the trade-off that the monetary authority faces between inflation and output stability when the economy is hit by supply shocks (Clarida, Galí and Gertler, 1999). In this paper we focus on a potential determinant of that policy trade-off that has received scant attention so far: the fiscal structure. Modern fiscal systems incorporate explicit consolidation rules aimed at reducing the debt to output ratio or, at least, at preventing it from rising further. This is a fundamental change in relation with the eighties, when debt levels increased sharply. Whether these rules allow automatic stabilizers to work or not is a matter of debate. Text-book macroeconomics tells us that continuous budget balances render fiscal policy procyclical, thus aggravating economic fluctuations. King, Plosser and Rebelo (1988) showed that this may also happen in a RBC model, whereas Schmitt-Grohé and Uribe (1997) find that there might be sunspot equilibria if tax rates adjust to achieve budget balance. Thus balanced-budget rules may contribute to enhance macroeconomic instability. However, current fiscal arrangements are not so tight since they are compatible with moderate and long-lasting deviations of the debt to output ratio from target.

A straightforward approach of assessing the impact of automatic stabilizers is to compare the volatility of output in economies with different tax structures. Galí (1994) does that in a RBC model and finds that income taxes generate greater output volatility than lump-sum ones. We address this issue in a more general framework, briefly described in section 2. The model includes a rich menu of fiscal variables such as income and spending taxes, public consumption and investment, transfers, public investment in the production function, government spending rules and public debt targets. It also allows for some Keynesian features such as investment adjustment costs and sticky prices, thus making room for monetary policy. The benchmark model is calibrated to match the most salient long-run and business cycle features of a representative European economy, under the assumption of technology shocks as the only source of fluctuations. The size of the public sector is set to realistic values and it includes a balanced tax structure in which public spending is financed resorting to income and consumption taxes.

Section 3 shows that, regardless of the intensity of monetary policy, lump-sum taxation always generates less output variability than any other tax structure in which revenues are linked to economic activity. This is consistent with Galí's (1994) findings. What is most remarkable is that this result is obtained in a model in which nominal inertia unfolds a demand channel through which automatic stabilizers are expected to exert a moderating influence on output variability. The poorer stabilization performance of distortionary tax structures is compatible with a positive correlation between public surpluses and output.

In section 4 we look in more detail at the mechanisms that explain the main result of the preceding section. To that end, we compute the relative volatility of output under different tax structures in economies that depart from the benchmark in some respect. Both demand and supply channels contribute to affecting the volatility of output under distortionary taxation with respect to an economy with lump-sum taxes. We also find that the gap between the volatility of output under these tax structures narrows as price stickiness and investment adjustment costs increase. Thus, output volatility under distortionary taxes can be lower than under lump-sum taxation for very large nominal and real rigidities. Finally, section 5 concludes.

2. The model

2.1 Firms and households

2.1.1 Price setting: nominal inertia The economy is populated by i intermediate goods producing firms. Each firm faces a downward sloping demand curve for its product (y_i) with finite elasticity ε

$$y_{it} = y_t \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} \quad (1)$$

where $\left[\int_0^1 (y_{it})^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} = y_t$ and $P_t = \left[\int_0^1 (P_{it})^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}$. Following Calvo (1983), each period a measure $1 - \phi$ of firms set their prices, \tilde{P}_{it} , to maximize the present value of future profits,

$$\max_{\tilde{P}_{it}} E_t \sum_{j=0}^{\infty} \rho_{it,t+j} (\beta\phi)^j \left[\tilde{P}_{it} \bar{\pi}^j y_{it+j} - P_{t+j} mc_{it,t+j} (y_{it+j} + \kappa) \right] \quad (2)$$

subject to

$$y_{it+j} = \left(\frac{\tilde{P}_{it} \bar{\pi}}{P_{t+j}} \right)^{-\varepsilon} P_{t+j}^\varepsilon y_{t+j} \quad (3)$$

where $\rho_{t,t+j}$ is a price kernel representing the marginal utility value to the representative household of an additional unit of profits accrued in period $t + j$, β the discount factor, $mc_{t,t+j}$ the marginal cost at $t + j$ of the firm changing prices at t and κ a fixed cost of production. The remaining (ϕ per cent) firms set $P_{it} = \bar{\pi} P_{it-1}$ where $\bar{\pi}$ is the steady-state rate of inflation

2.1.2 Capital and labour demand: cost minimization. The optimal combination of

capital (k) and labour (l) is obtained from the cost minimization process of the firm:

$$\min_{k_{it}, l_{it}} (r_t k_{it} + w_t l_{it}) \quad (4)$$

subject to

$$y_{it} = A_t k_{it}^\alpha l_{it}^{1-\alpha} (g_t^p)^\theta - \kappa \quad (5)$$

where w_t is the real wage and r_t is the rental cost of capital. Notice that, since public investment (g_t^p) enters the production function, there is a potentially powerful channel through which fiscal policy may affect output (Barro, 1990). The variable A_t stands for the total factor productivity.

Aggregating the first order conditions of this problem we obtain the demand for labour (l_t) and capital (k_t),

$$w_t = mc_t (1 - \alpha) A_t k_t^\alpha l_t^{-\alpha} (g_t^p)^\theta \quad (6)$$

$$r_t = mc_t \alpha A_t k_t^{\alpha-1} l_t^{1-\alpha} (g_t^p)^\theta \quad (7)$$

2.1.3 Households The utility function of the representative j_{th} household is non separable in leisure ($1 - l_t$) and consumption (c_t) and separable in public consumption (g_t^c) and investment, as in Baxter and King (1993):

$$U(c_t, 1 - l_t, g_t^c, g_t^p) = \frac{(c_t^\gamma (1 - l_t)^{1-\gamma})^{1-\sigma} - 1}{1 - \sigma} + \Gamma(g_t^c, g_t^p) \quad (8)$$

There is a cash-in-advance constraint that links the money demand (M_t) and current cash transfers (τ_t^m) to consumption,

$$P_t (1 + \tau_t^c) c_t \leq M_t + \tau_t^m \quad (9)$$

Households allocate their income (labour income, capital income, interest payments on bond holdings (B_t), their share of profits of the firms (Ω_{it}), and public transfers ($P_t g_t^s$)) and current cash holdings to buy consumption and investment goods (e_t), and to accumulate savings either in bonds or money holdings for $t + 1$:

$$\begin{aligned} & M_{t+1} + \frac{B_{t+1}}{(1 + i_{t+1})} + P_t (1 + \tau_t^c) c_t + P_t e_t \\ &= P_t (1 - \tau_t^w) w_t l_t + P_t (1 - \tau_t^k) r_t k_t + B_t + M_t + \tau_t^m + P_t g_t^s + \int_0^1 \Omega_{it} di \end{aligned} \quad (10)$$

The tax structure includes taxes on labour income (τ_t^w), capital income (τ_t^k) and consumption (τ_t^c). The accumulation of capital results from the households' investment decisions. Firms face a constant depreciation rate (δ) and due to installation costs $\Phi(e_t/k_t)$ only a proportion of investment spending goes to increase the capital stock

$$k_{t+1} = \Phi\left(\frac{e_t}{k_t}\right) k_t + (1 - \delta)k_t \quad (11)$$

The symmetric monopolistic competition equilibrium is defined as the set of quantities that maximizes the constrained present value of the stream of utility of the representative household and the constrained present value of the profits earned by the representative firm, and the set of prices that clears the goods markets, the labour market and the money, bonds and capital markets. The model is completed with policy rules for the nominal interest rate and public spending. All τ_t^w , τ_t^k and τ_t^c will be assumed constant for all t .

2.2 Monetary and fiscal policy

Monetary policy is represented by a standard Taylor rule:

$$i_t = \rho_r i_{t-1} + (1 - \rho_r) \bar{i} + (1 - \rho_r) \rho_\pi (\pi_t - \bar{\pi}) + (1 - \rho_r) \rho_y \hat{y}_t + z_t^i \quad (12)$$

in which the monetary authority sets the interest rate (i_t) to prevent inflation deviating from its steady-state level ($\pi_t - \bar{\pi}$) and to counteract movements in the output gap (\hat{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 .

Provided that ρ_π is above a certain threshold value, 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, Leith and Wren-Lewis, 2000). A simple way of making this requirement operational is to assume that either taxes or public spending respond sufficiently to the level of debt (Canzoneri, Cumby and Diba, 2001). These feedback rules also represent the quantitative deficit and/or debt targets made explicit in most developed countries' fiscal systems nowadays (Corsetti and Roubini, 1996, Bohn, 1998 and Ballabriga and Martinez-Mongay, 2002). In fact, the Stability and Growth Pact can be interpreted as implying such a feedback since a deficit objective in terms of GDP is equivalent in the long run to a target of the debt to output ratio.

The theoretical requirements of a Ricardian policy can be satisfied with a feedback behaviour of either revenues or expenditures, but the empirical evidence indicates that successful consolidations in industrialized countries have been based on spending cuts

Table 1
Calibration of baseline model

σ	β	γ	α	θ	δ	σ_z	ρ_z	ε	κ	Θ	ϕ
2.0	0.9926	0.4453	0.40	0.10	0.021	0.0045	0.80	6.0	0.20	-0.12	0.75
τ^w	τ^k	τ^c	g^c/y	g^s/y	g^p/y	$\alpha_b^c = \alpha_b^p$	α_b^s	ρ_r	ρ_π	π	
0.43	0.21	0.14	0.18	0.16	0.06	0.40	0.0	0.5	2.0	1.02 ^{0.25}	

(see von Hagen, Hallet and Strauch, 2001, Alesina and Perotti, 1997).¹ Therefore, for realistic purposes, 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:

$$\frac{g_t}{\bar{g}} = \left(\frac{b_{t-j} \bar{y}}{y_{t-j} \bar{b}} \right)^{-\alpha_b} \left(\frac{y_t}{\bar{y}} \right)^{-\alpha_y}, \quad \alpha_b, \alpha_y \geq 0 \quad (13)$$

where the bar over the variables indicates steady-state values.

2.3 Calibration

In order to analyse the main implications of our model in terms of the interactions between monetary and fiscal policy, we have obtained a numerical solution of the steady state as well as of the log-linearized system.² Table 1 summarizes the values of the calibrated baseline parameters. The relative risk aversion coefficient (σ) is 2, the discount factor (β) 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), the share of consumption in utility (γ) has been chosen to be 0.4453.

The elasticity of output with respect to private capital (α) is 0.4, as in Cooley and Prescott (1995). The value of the output elasticity to productive public expenditure (θ) is more controversial, as Gramlich (1994) has pointed out, since its estimated value ranges from 0 to 0.39. Nevertheless, Cassou and Lansing (1998) have shown that the observed decline in the US ratio of capital to private capital can be reconciled with optimal fiscal policy when the elasticity of output with respect to g^p is 0.1. The depreciation rate (δ) is equal to 0.021 as estimated by Christiano and Eichenbaum (1992). The standard deviation (σ_z) and the first order autocorrelation coefficient (ρ_z) of the technology shock are set to 0.0043 and 0.8 respectively, whereas the investment ratio elasticity of the price of

¹ Cyclical changes in tax rates are not very realistic and may, under some circumstances, lead to multiple (sunspot) equilibria, thus inducing additional instability (Schmitt-Grohé and Uribe, 1997).

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

capital ($\Theta \equiv \Phi''(\bar{e}/\bar{k})/\Phi'$) is set to -0.12 . These values have been chosen in order to produce GDP cycles that mimic the volatility of output and investment observed in EMU in our baseline model (see Agresti and Mojon, 2001). Following Christiano, Eichenbaum and Evans (1997), the elasticity of demand with respect to price (ε) is set to 6, consistent with a steady-state mark-up, $\varepsilon/(\varepsilon - 1)$, equal to 1.2. The fixed cost in production (κ) is set to 0.2, to produce zero profits in the steady state, where the output has been normalized 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).

Fiscal policy parameters have been calibrated after computing the tax rates for EMU members using the method proposed by Mendoza, Razin and Tesar (1994): 0.43 for labour taxes (τ^w), 0.21 for taxes on capital income (τ^k) and 0.14 for consumption taxes (τ^c). For the same sample of countries and years, government consumption over GDP (\bar{g}^c/\bar{y}) is 0.18, transfers (\bar{s}/\bar{y}) are 0.16 and productive public expenditure (\bar{g}^p/\bar{y}) is 0.06. This calibration yields a public debt of 60 per cent of annual GDP in the steady state, which was the reference level in the Maastricht Treaty. The feedback parameter to public debt in the fiscal rule for government consumption and productive public expenditure (α_b^c and α_b^p) in the baseline model are set to 0.4, whereas α_b^s is equal to zero to avoid transfers becoming procyclical, something at odds with the empirical evidence in EMU since unemployment benefits are countercyclical.

The last set of parameters refers to the interest rate rule. In the baseline model, we set the autocorrelation coefficient of the interest rate (ρ_r) equal to 0.5 and the response to inflation deviations from target (ρ_π) 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 (see, Doménech, Ledo and Taguas, 2002). The steady-state level of gross inflation ($\bar{\pi}$) is set to $1.02^{0.25}$, that is, the target level of the ECB.

The model with supply shocks has been simulated 100 times, producing 200 observations. We take the last 100 observations and compute the steady-state value (\bar{x}), the relative standard deviation to output (σ_x/σ_y , except for GDP which is just σ_y), the first-order autocorrelation (ρ_x) and the contemporaneous correlation with output (ρ_{xy}) of each variable.³ We have also simulated an economy with zero tax rates on consumption, labour and capital incomes, in which public spending is financed using a lump-sum tax such that $\bar{g}^s/\bar{y} = -0.26$, but with otherwise identical fiscal structure as that in the benchmark model ($\bar{g}^c/\bar{y} = 0.18$, $\bar{g}^p/\bar{y} = 0.06$, $\bar{b}/\bar{y} = 0.6$).

The main statistics of these simulations are reported in Table 2. The baseline model reproduces most business-cycle facts of the European economies. The effects of distur-

³ To avoid spurious correlation, we do not filter the simulated data (see Cogley and Nason, 1995).

Table 2
Business cycles statistics

x	Baseline model				Lump-sum taxation model			
	\bar{x}	σ_x/σ_y	ρ_x	ρ_{xy}	\bar{x}	σ_x/σ_y	ρ_x	ρ_{xy}
y	1.00	1.00	0.84	1.00	2.16	0.91	0.82	1.00
c	0.53	0.52	0.88	0.98	1.00	0.54	0.89	0.93
e	0.23	2.61	0.80	0.96	0.64	2.27	0.79	0.99
g^c	0.18	0.74	0.94	0.80	0.39	0.43	0.84	0.99
g^p	0.06	0.74	0.94	0.80	0.13	0.43	0.84	0.99
b	2.40	1.22	0.99	-0.47	5.19	0.09	0.86	-0.90
m	0.60	0.56	0.87	0.99	1.00	0.58	0.88	0.94
mc	0.83	0.22	0.49	-0.81	0.83	0.23	0.37	-0.80
q	1.00	0.31	0.79	0.89	1.00	0.27	0.78	0.94
l	0.31	0.18	0.91	0.93	0.50	0.14	0.91	0.78
i^1	1.24	0.10	0.88	-0.97	1.24	0.08	0.86	-0.99
r^1	3.60	0.59	0.88	0.74	2.84	0.64	0.89	0.80
w	1.94	0.51	0.90	0.98	2.58	0.55	0.90	0.96
π	1.005	0.06	0.66	-0.93	1.005	0.05	0.60	-0.95
pbs	0.018	0.15	0.91	0.81	0.018	0.10	0.84	-0.99

1 In percentage.

tionary taxation on the steady-state values of the main variables are substantial in comparison to the economy with lump-sum taxes (see, for example, Chari and Kehoe, 1999). Interestingly, the standard deviation of output is lower in the economy with lump-sum taxes (0.91 vs. 1). The relative volatilities of public consumption, productive public expenditures and public debt are also larger in the economy with distortionary taxes than in the model with lump-sum taxes. In the next section we take a closer look at this feature.

3. Alternative distortionary taxes versus lump-sum taxation.

In this section, we assess the extent to which automatic stabilizers affect the ability of economic policy to deliver its objectives of low inflation and output volatility in the presence of technological shocks. For this purpose, we compare the position of the inflation-output variance frontier under alternative tax structures. These frontiers are drawn for different values of the interest rate response to the inflation rate (ρ_π), while holding constant the remaining parameters that characterize the economy.

Figure 1 shows the main result of the paper: when public spending is financed through lump-sum taxes, a given monetary policy is able to deliver less output volatility

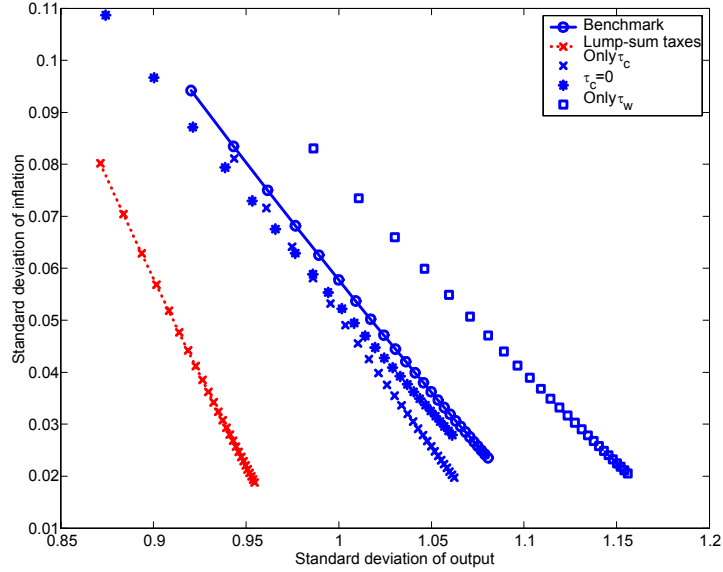


Figure 1: Variance frontier for alternative tax structures.

than any other tax structure; this holds for any value of the standard deviation of the inflation rate. The reduction in σ_y is quite remarkable with respect to the benchmark.

The fact that automatic stabilizers built into the distortionary tax system contribute to destabilizing the economy, compared with an economy with lump-sum taxes, is striking. The mechanisms that generate this result operate both through the demand and the supply side of the model. Income taxes reduce the labour supply and the capital/output ratio in the steady state (Galí, 1994).⁴ In that case a positive shock to total factor productivity leads to a larger percentage change in the use of the two private productive factors, and hence to larger output fluctuations than those that would prevail in a lump-sum tax system. Our model includes these channels along with those related to the response of public spending.

Fiscal revenues and spending are related to economic activity in a variety of ways.

⁴ Using the FOCs, it can be easily shown that the labour supply is more elastic and responsive to shifts in labour demand in the economy with distortionary taxation since the elasticity is a decreasing function of the steady-state labour supply

$$\left. \frac{\partial \hat{l}_t}{\partial \hat{w}_t} \right|_{\bar{c}} = \left(\frac{\bar{l}}{1 + \bar{l}} + \frac{\bar{i}}{1 + \bar{i}} \right)^{-1}$$

Distortionary taxes are linked either to income or to consumption and Ricardian fiscal policies incorporate another channel through which the tax/spending system must be linked to economic activity. In order to prevent public debt from exploding, the budget surplus must react when the level of debt departs from its target. When public revenues are sensitive to the level of economic activity, a positive technological shock causes opposite movements in output and the level of debt, inducing a sharp fall in the debt to output ratio. Thus, public spending must react accordingly, generating an additional shock. The combination of (positive) technology and, current or anticipated, public spending shocks, induces a strong output increase. Thus the standard deviation of output increases relative to that of an economy in which taxes do not respond to the rise in economic activity. In the latter case there is a much more moderate fall in the debt to output ratio that mitigates the response of g_t^c and g_t^p .

The stronger response of public consumption in the economy with distortionary taxes is compatible with the procyclical behaviour of the primary budget balance. In Table 2, the contemporaneous correlation between output and the primary budget surplus (*pbs*) is positive and very high (0.81) in the economy with distortionary taxation, as a consequence of very procyclical fiscal revenues. This correlation is in accordance with the empirical evidence in EMU (0.71).⁵ On the contrary, in the economy with lump-sum taxes the correlation between output and the primary budget surplus is -0.99 , since fiscal revenues are constant whereas public expenditures are procyclical due to fiscal consolidation.

This pattern indicates that correlations between output and public deficits at the business cycle frequencies are not informative about the effectiveness of fiscal stabilizers when different tax structures are compared. This correlation is at the heart of model-based estimates of the strength of fiscal stabilizers (see, among others, Auerbach, 2002) that proceed in two steps, first computing the cyclical response of taxes and then multiplying it by the estimated fiscal multipliers. Since budget surpluses are meant to reduce output, and the empirical evidence is that distortionary taxes are associated with high surpluses in booms, then the implication follows nicely: distortionary taxes help to moderate cyclical fluctuations. Our results do not contradict the evidence, that is, automatic stabilizers exert the expected effect on the budget surplus. However, they are not able to reduce the standard deviation of output below the level that would have been achieved with lump-sum taxes. Procyclical surpluses do not necessarily bring about more output stabilization.

Figure 1 also reveals two additional results. Firstly, alternative structures of the tax

⁵ This correlation is obtained using annual data from 1970 to 2001 and the Hodrick-Prescott filter with a smoothing parameter equal to 10.

system hardly affect the position of the IOF. Compared with the benchmark economy, extreme cases of consumption taxation or income taxation only lead to minor increases in the standard deviation of output for a given standard deviation of inflation. Only in the case in which public spending is fully financed with taxes on labour income ($\tau_w > 0, \tau_k = \tau_c = 0$) does the standard deviation of output rise by a significant amount. This higher volatility is due to the increase in the elasticity of the labour supply which enhances the impact of a technology shock on hours. We also observe that the IOF is hardly affected by changes in τ_k .⁶ The second feature is that the shifts of the IOF's are almost horizontal in most cases. This means that for a given parameter ρ_π , the choice of the tax system does affect the standard deviation of output but leaves that of inflation virtually unaltered. This result confirms that in a monetary regime the level and standard deviation of inflation are mainly determined by monetary policy.⁷

4. Supply and demand effects of fiscal policies.

In this section we assess the importance of the different channels through which income and consumption taxes amplify technology-driven output fluctuations: price inertia, fiscal rules, public investment in the production function, labour supply and private capital accumulation. Supply and demand channels are not easily disentangled since the combination of technological shocks and the induced fiscal responses, shift the aggregate demand around an upward sloping supply curve that also moves as a result of labour and capital fluctuations. To gain some insight into the importance of each channel, we carry out some counterfactual exercises which are summarized in Table 3, where we display the standard deviation of output for the economy with lump-sum (σ_y^l) and with distortionary taxes (σ_y^d) and their ratio when ρ_π is equal to 2.

Let us first focus on the supply channels. Distortionary taxes enhance the procyclical movement of labour supply, capital accumulation and total factor productivity in our model. Taxes on labour income increase the demand for leisure in the steady state, whereas taxes on capital income reduce the steady-state level of the capital/output ratio. Both effects enhance cyclical deviations from the steady state as compared with an econ-

⁶ When $\tau_k = 0$, the capital to output ratio is the same in the economy with distortionary taxation as in the economy in which government spending is financed through lump-sum taxes. As pointed out by Galí (1994), since the output response to technology shocks depends on the response of investment, which is a function of y/k , the small shifts of the IOF when τ_k varies indicate that the importance of this supply channel is smaller than the effects through the labour supply.

⁷ The only exception to this pattern is the structure in which revenues are raised on capital and labour income but not on consumption ($\tau_w, \tau_k > 0, \tau_c = 0$) and ρ_π is relatively small. In this case, there is a sizeable increase in the standard deviation of inflation along with a fall in the standard deviation of output.

Table 3
Sensitivity of σ_y to alternative model parameterizations when $\rho_\pi = 2.0$

Alternative model	lump-sum taxes σ_y^l	distortionary taxes σ_y^d	relative volatility σ_y^d / σ_y^l
Model 1 (<i>benchmark</i>) ($\gamma = 0.45, \theta = 0.1, \alpha_b^c = \alpha_b^p = 0.4, \alpha_b^s = 0$)	0.9119	1.0000	1.0966
Model 2: Inelastic labour supply ($\gamma \simeq 1$)	0.8375	0.8769	1.0470
Model 3: TFP independent of g^p ($\theta = 0$)	0.8583	0.9289	1.0823
Model 4: Consolidation effort ($\alpha_b^c = \alpha_b^p = 0.2, \alpha_b^s = 0$)	0.8800	0.9158	1.0407
Model 5: Delayed consolidation ($\alpha_b^c = \alpha_b^p = 0.4, \alpha_b^s = 0, j = 8$)	0.8707	0.9205	1.0572
Model 6: Fiscal rule in transfers ($\alpha_b^c = \alpha_b^p = 0, \alpha_b^s = 0.4$)	0.8416	0.8564	1.0176
Model 7: Model 2+Model 3+Model 6. ($\gamma \simeq 1.0, \theta = \alpha_b^c = \alpha_b^p = 0, \alpha_b^s = 0.4$)	0.7948	0.8069	1.0152
Model 8: Flexible prices ($\phi \simeq 0$)	0.9892	1.1559	1.1685

omy with lump-sum taxation. We have made total factor productivity dependent on the amount of public investment, which moves along with public revenues according to the fiscal rules in the model.

The standard deviation of output in Model 2 is obtained under the assumption of an (almost) inelastic labour supply ($\gamma \approx 1$), which makes the economy more stable, regardless of the tax structure. The gap between economies with lump-sum taxation and those with distortionary taxes also narrows significantly; roughly half of the additional destabilizing effect associated with distortionary taxation is explained by fluctuations in the labour supply. Setting $\theta = 0$ in our production function (or alternatively when $\alpha_b^p = 0$), as in Model 3, also reduces the volatility of output, although the ratio σ_y^d / σ_y^l is barely affected, which indicates that this channel not very important.

Next we assess the importance of alternative definitions of the fiscal consolidation rule. Neither a strong feedback (high α_b) nor an immediate response to the movements in the debt to output ratio ($j = 0$) is necessary to obtain a unique equilibrium. A Ricardian fiscal rule could be characterized by low and slow responses to deviations of the debt to output ratio from its target and still be sufficient to guarantee existence and

uniqueness. Model 4 in Table 3 differs from the benchmark in the intensity of fiscal consolidation. We set α_b to 0.2, which is in some sense too low, since it implies that it takes a very long time before the real debt returns to its steady-state value after a technological shock. The relative volatility falls in this case to 1.04.

Alternatively, it can be argued that instantaneous stabilization is far too strict, and that even the more demanding fiscal programmes allow for a delayed response of the public surplus, and thus to a slower adjustment of the debt/output ratio. This can be represented in our model setting $j > 0$ in equation (13). Large values of j introduce an important change in the time pattern of the response of public spending to changes in public revenues. A delayed reaction of public spending makes the budget surplus more procyclical mitigating the cyclical effect of fiscal consolidation. In particular, Model 5 allows for 8 lags in the time elapsed before the fiscal variables respond to the deviation of debt from its steady state after a technological shock. As in the previous exercise, slower consolidation reduces the relative volatility associated with both tax structures, but it still remains significantly above 1 ($\sigma_y^d/\sigma_y^l = 1.06$).

Not surprisingly, the most important reduction in the relative volatility of output between both economies occurs when only transfers are used to stabilize the debt to output ratio. In Model 6 we have set $\alpha_b^c = \alpha_b^p = 0$ and $\alpha_b^s = 0.4$. When this alternative policy is implemented the volatility of output in the economy with distortionary taxes is just 1.8 per cent above the one in the economy with lump-sum taxes. This is an interesting case for comparative purposes.⁸ In the economy with distortionary taxes, transfers can also be interpreted as a negative lump-sum tax. These transfers only enter the economy through the household budget constraint and exactly compensate the wealth effect of current bond holdings. In this case, the fiscal rule avoids the transitory distortionary effects that the changes in public spending may have on the decisions of private agents. Consolidation through transfers eliminates the wealth effect and the additional demand impulse associated with the rule, also affecting the response of the labour supply.⁹ The fact that the relative volatility of output falls now indicates that consolidation through government spending explains a sizeable part of the relative volatility observed in the

⁸ Nonetheless, this exercise lacks empirical relevance since lump-sum transfers are not a fiscal instrument used in industrialized countries. Although, the evidence shows that fiscal consolidations through transfers reductions have a high probability of being successful (see Von Hagen, Hallet and Strauch, 2001, Alesina and Perotti, 1997), it is important to notice that these kinds of transfers are not lump-sum, an assumption crucial to our results.

⁹ In this case, all variables with the exception of transfers and public debt are independent of the value of α_b^s and j in the fiscal rule. Since public transfers do not appear in the overall resource constraint and public consumption and investment are independent of public debt ($\alpha_b^c = \alpha_b^p = 0$), the log-linearized dynamic model is block-recursive.

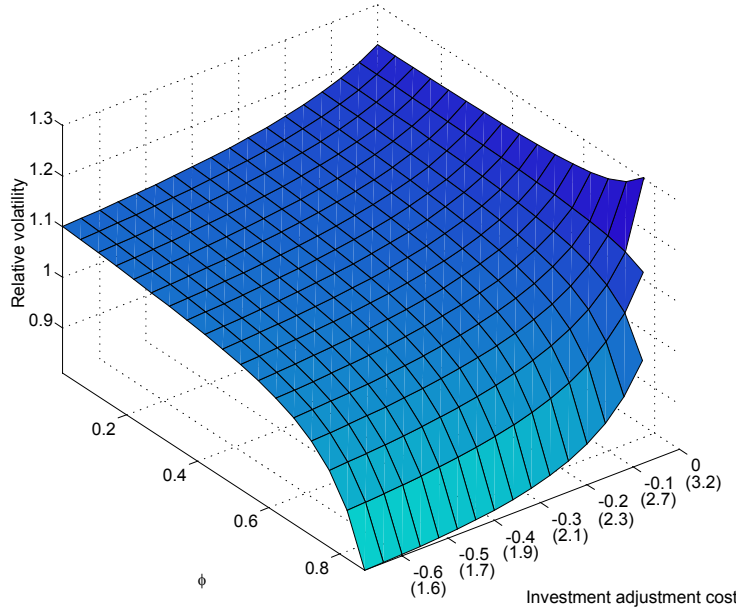


Figure 2: Relative volatility of output (σ_y^d/σ_y^l) for different combinations of price stickiness and investment adjustment costs. Numbers in brackets are the relative volatility of investment to output for different values of the adjustment costs when $\phi = 0.75$.

benchmark model. Taking the exercises in Models 4, 5 and 6 together indicates that the presence of price inertia allows for a demand effect that may be more or less powerful depending on the component of public spending that is used to achieve fiscal consolidation as well as on the intensity of the consolidation effort.

Model 7 in Table 3 incorporates the features of models 2, 3 and 6. As expected, this calibration reduces the destabilizing effects of distortionary taxation to a minimum. In this extreme case, the differences in standard deviation are virtually negligible (relative volatility 1.015), although the standard deviation is still smaller with lump-sum taxes.

Finally, we assess the role played by both nominal and real inertia as regards the relative volatility of output. Price inertia is a key feature of the model. A positive shock associated with falling prices leads to a smaller real wage increase the slower the adjustment of prices. This weakens the response of labour and hence reduces the strength of the supply channel. Model 8 compares the relative volatility of output under both tax structures for a model close to flexible prices ($\phi \simeq 0$); this ratio is significantly higher than the one in the benchmark case ($\phi \simeq 0.75$).

A more general assessment of the role played by nominal and real rigidities is carried out in Figure 2, which depicts how the relative output volatility evolves as we move from the standard RBC model towards a model with Keynesian features.¹⁰ Output volatility under distortionary taxes relative to the economy with lump-sum taxes is very high when both price inertia and investment adjustment costs are absent. This is consistent with Gali's (1994) results that are conditioned on $\phi = \Theta = 0$. High price inertia and capital adjustment costs reduce this ratio. In fact, these two features reinforce each other, but it takes extreme values of these two parameters ($\phi = 0.9$, $\Theta = -0.6$) to generate values of this ratio significantly below one. This extreme economy is not very realistic though, since it implies that firms change prices every 10 quarters (i.e. the Phillips curve is almost flat in the short run) and that the volatility of investment relative to output is 1.5, well below that observed in EMU (2.7).

5. Concluding remarks

The main result of this paper is that the standard deviation of output in an economy hit by technology shocks does not vary greatly across alternative distortionary tax structures, but it is significantly higher than in an otherwise identical economy in which taxes are lump-sum. Although distortionary taxes induce a positive contemporaneous correlation between output and the budget surplus, they do in fact contribute to worsen the output-inflation variance trade-off, as compared with an economy in which public spending is financed through lump-sum taxes. This is a robust result in an economy which reproduces some empirical facts of European countries and departs from a standard RBC model in many respects, therefore generalizing previous findings in the literature.

Other findings may be summarized as follows. First, the supply channels account for a significant proportion of the destabilizing effects of distortionary taxes. Second, and most remarkable, automatic stabilizers operating through the demand side of the economy do not compensate the procyclical movements in aggregate supply; on the contrary, they tend to increase the size of economic fluctuations associated with distortionary taxes. Finally, allowing for nominal and real inertia in the economy may compensate the destabilizing effects of distortionary taxes, but only for a very high degree of price stickiness and large investment adjustment costs.

¹⁰ The numbers in parentheses below the values of Θ (the investment adjustment cost) are the relative volatility of investment to output.

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1. Introduction

Recent macroeconomic research has stressed the relevance of the trade-off that the monetary authority faces between inflation and output stability when the economy is hit by supply shocks (Clarida, Galí and Gertler, 1999). In this paper we focus on a potential determinant of that policy trade-off that has received scant attention so far: the fiscal structure. Modern fiscal systems incorporate explicit consolidation rules aimed at reducing the debt to output ratio or, at least, at preventing it from rising further. This is a fundamental change in relation with the eighties, when debt levels increased sharply. Whether these rules allow automatic stabilizers to work or not is a matter of debate. Text-book macroeconomics tells us that continuous budget balances render fiscal policy procyclical, thus aggravating economic fluctuations. King, Plosser and Rebelo (1988) showed that this may also happen in a RBC model, whereas Schmitt-Grohé and Uribe (1997) find that there might be sunspot equilibria if tax rates adjust to achieve budget balance. Thus balanced-budget rules may contribute to enhance macroeconomic instability. However, current fiscal arrangements are not so tight since they are compatible with moderate and long-lasting deviations of the debt to output ratio from target.

A straightforward approach of assessing the impact of automatic stabilizers is to compare the volatility of output in economies with different tax structures. Galí (1994) does that in a RBC model and finds that income taxes generate greater output volatility than lump-sum ones. We address this issue in a more general framework, briefly described in section 2. The model includes a rich menu of fiscal variables such as income and spending taxes, public consumption and investment, transfers, public investment in the production function, government spending rules and public debt targets. It also allows for some Keynesian features such as investment adjustment costs and sticky prices, thus making room for monetary policy. The benchmark model is calibrated to match the most salient long-run and business cycle features of a representative European economy, under the assumption of technology shocks as the only source of fluctuations. The size of the public sector is set to realistic values and it includes a balanced tax structure in which public spending is financed resorting to income and consumption taxes.

Section 3 shows that, regardless of the intensity of monetary policy, lump-sum taxation always generates less output variability than any other tax structure in which revenues are linked to economic activity. This is consistent with Galí's (1994) findings. What is most remarkable is that this result is obtained in a model in which nominal inertia unfolds a demand channel through which automatic stabilizers are expected to exert a moderating influence on output variability. The poorer stabilization performance of distortionary tax structures is compatible with a positive correlation between public surpluses and output.

In section 4 we look in more detail at the mechanisms that explain the main result of the preceding section. To that end, we compute the relative volatility of output under different tax structures in economies that depart from the benchmark in some respect. Both demand and supply channels contribute to affecting the volatility of output under distortionary taxation with respect to an economy with lump-sum taxes. We also find that the gap between the volatility of output under these tax structures narrows as price stickiness and investment adjustment costs increase. Thus, output volatility under distortionary taxes can be lower than under lump-sum taxation for very large nominal and real rigidities. Finally, section 5 concludes.

2. The model

2.1 Firms and households

2.1.1 Price setting: nominal inertia The economy is populated by i intermediate goods producing firms. Each firm faces a downward sloping demand curve for its product (y_i) with finite elasticity ε

$$y_{it} = y_t \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} \quad (1)$$

where $\left[\int_0^1 (y_{it})^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} = y_t$ and $P_t = \left[\int_0^1 (P_{it})^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}$. Following Calvo (1983), each period a measure $1 - \phi$ of firms set their prices, \tilde{P}_{it} , to maximize the present value of future profits,

$$\max_{\tilde{P}_{it}} E_t \sum_{j=0}^{\infty} \rho_{it,t+j} (\beta\phi)^j \left[\tilde{P}_{it} \bar{\pi}^j y_{it+j} - P_{t+j} mc_{it,t+j} (y_{it+j} + \kappa) \right] \quad (2)$$

subject to

$$y_{it+j} = \left(\frac{\tilde{P}_{it} \bar{\pi}}{P_{t+j}} \right)^{-\varepsilon} P_{t+j}^\varepsilon y_{t+j} \quad (3)$$

where $\rho_{t,t+j}$ is a price kernel representing the marginal utility value to the representative household of an additional unit of profits accrued in period $t + j$, β the discount factor, $mc_{t,t+j}$ the marginal cost at $t + j$ of the firm changing prices at t and κ a fixed cost of production. The remaining (ϕ per cent) firms set $P_{it} = \bar{\pi} P_{it-1}$ where $\bar{\pi}$ is the steady-state rate of inflation

2.1.2 Capital and labour demand: cost minimization. The optimal combination of

capital (k) and labour (l) is obtained from the cost minimization process of the firm:

$$\min_{k_{it}, l_{it}} (r_t k_{it} + w_t l_{it}) \quad (4)$$

subject to

$$y_{it} = A_t k_{it}^\alpha l_{it}^{1-\alpha} (g_t^p)^\theta - \kappa \quad (5)$$

where w_t is the real wage and r_t is the rental cost of capital. Notice that, since public investment (g_t^p) enters the production function, there is a potentially powerful channel through which fiscal policy may affect output (Barro, 1990). The variable A_t stands for the total factor productivity.

Aggregating the first order conditions of this problem we obtain the demand for labour (l_t) and capital (k_t),

$$w_t = mc_t (1 - \alpha) A_t k_t^\alpha l_t^{-\alpha} (g_t^p)^\theta \quad (6)$$

$$r_t = mc_t \alpha A_t k_t^{\alpha-1} l_t^{1-\alpha} (g_t^p)^\theta \quad (7)$$

2.1.3 Households The utility function of the representative j_{th} household is non separable in leisure ($1 - l_t$) and consumption (c_t) and separable in public consumption (g_t^c) and investment, as in Baxter and King (1993):

$$U(c_t, 1 - l_t, g_t^c, g_t^p) = \frac{(c_t^\gamma (1 - l_t)^{1-\gamma})^{1-\sigma} - 1}{1 - \sigma} + \Gamma(g_t^c, g_t^p) \quad (8)$$

There is a cash-in-advance constraint that links the money demand (M_t) and current cash transfers (τ_t^m) to consumption,

$$P_t (1 + \tau_t^c) c_t \leq M_t + \tau_t^m \quad (9)$$

Households allocate their income (labour income, capital income, interest payments on bond holdings (B_t), their share of profits of the firms (Ω_{it}), and public transfers ($P_t g_t^s$)) and current cash holdings to buy consumption and investment goods (e_t), and to accumulate savings either in bonds or money holdings for $t + 1$:

$$\begin{aligned} & M_{t+1} + \frac{B_{t+1}}{(1 + i_{t+1})} + P_t (1 + \tau_t^c) c_t + P_t e_t \\ &= P_t (1 - \tau_t^w) w_t l_t + P_t (1 - \tau_t^k) r_t k_t + B_t + M_t + \tau_t^m + P_t g_t^s + \int_0^1 \Omega_{it} di \end{aligned} \quad (10)$$

The tax structure includes taxes on labour income (τ_t^w), capital income (τ_t^k) and consumption (τ_t^c). The accumulation of capital results from the households' investment decisions. Firms face a constant depreciation rate (δ) and due to installation costs $\Phi(e_t/k_t)$ only a proportion of investment spending goes to increase the capital stock

$$k_{t+1} = \Phi\left(\frac{e_t}{k_t}\right) k_t + (1 - \delta)k_t \quad (11)$$

The symmetric monopolistic competition equilibrium is defined as the set of quantities that maximizes the constrained present value of the stream of utility of the representative household and the constrained present value of the profits earned by the representative firm, and the set of prices that clears the goods markets, the labour market and the money, bonds and capital markets. The model is completed with policy rules for the nominal interest rate and public spending. All τ_t^w , τ_t^k and τ_t^c will be assumed constant for all t .

2.2 Monetary and fiscal policy

Monetary policy is represented by a standard Taylor rule:

$$i_t = \rho_r i_{t-1} + (1 - \rho_r) \bar{i} + (1 - \rho_r) \rho_\pi (\pi_t - \bar{\pi}) + (1 - \rho_r) \rho_y \hat{y}_t + z_t^i \quad (12)$$

in which the monetary authority sets the interest rate (i_t) to prevent inflation deviating from its steady-state level ($\pi_t - \bar{\pi}$) and to counteract movements in the output gap (\hat{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 .

Provided that ρ_π is above a certain threshold value, 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, Leith and Wren-Lewis, 2000). A simple way of making this requirement operational is to assume that either taxes or public spending respond sufficiently to the level of debt (Canzoneri, Cumby and Diba, 2001). These feedback rules also represent the quantitative deficit and/or debt targets made explicit in most developed countries' fiscal systems nowadays (Corsetti and Roubini, 1996, Bohn, 1998 and Ballabriga and Martinez-Mongay, 2002). In fact, the Stability and Growth Pact can be interpreted as implying such a feedback since a deficit objective in terms of GDP is equivalent in the long run to a target of the debt to output ratio.

The theoretical requirements of a Ricardian policy can be satisfied with a feedback behaviour of either revenues or expenditures, but the empirical evidence indicates that successful consolidations in industrialized countries have been based on spending cuts

Table 1
Calibration of baseline model

σ	β	γ	α	θ	δ	σ_z	ρ_z	ε	κ	Θ	ϕ
2.0	0.9926	0.4453	0.40	0.10	0.021	0.0045	0.80	6.0	0.20	-0.12	0.75
τ^w	τ^k	τ^c	g^c/y	g^s/y	g^p/y	$\alpha_b^c = \alpha_b^p$	α_b^s	ρ_r	ρ_π	π	
0.43	0.21	0.14	0.18	0.16	0.06	0.40	0.0	0.5	2.0	1.02 ^{0.25}	

(see von Hagen, Hallet and Strauch, 2001, Alesina and Perotti, 1997).¹ Therefore, for realistic purposes, 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:

$$\frac{g_t}{\bar{g}} = \left(\frac{b_{t-j} \bar{y}}{y_{t-j} \bar{b}} \right)^{-\alpha_b} \left(\frac{y_t}{\bar{y}} \right)^{-\alpha_y}, \quad \alpha_b, \alpha_y \geq 0 \quad (13)$$

where the bar over the variables indicates steady-state values.

2.3 Calibration

In order to analyse the main implications of our model in terms of the interactions between monetary and fiscal policy, we have obtained a numerical solution of the steady state as well as of the log-linearized system.² Table 1 summarizes the values of the calibrated baseline parameters. The relative risk aversion coefficient (σ) is 2, the discount factor (β) 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), the share of consumption in utility (γ) has been chosen to be 0.4453.

The elasticity of output with respect to private capital (α) is 0.4, as in Cooley and Prescott (1995). The value of the output elasticity to productive public expenditure (θ) is more controversial, as Gramlich (1994) has pointed out, since its estimated value ranges from 0 to 0.39. Nevertheless, Cassou and Lansing (1998) have shown that the observed decline in the US ratio of capital to private capital can be reconciled with optimal fiscal policy when the elasticity of output with respect to g^p is 0.1. The depreciation rate (δ) is equal to 0.021 as estimated by Christiano and Eichenbaum (1992). The standard deviation (σ_z) and the first order autocorrelation coefficient (ρ_z) of the technology shock are set to 0.0043 and 0.8 respectively, whereas the investment ratio elasticity of the price of

¹ Cyclical changes in tax rates are not very realistic and may, under some circumstances, lead to multiple (sunspot) equilibria, thus inducing additional instability (Schmitt-Grohé and Uribe, 1997).

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

capital ($\Theta \equiv \Phi''(\bar{e}/\bar{k})/\Phi'$) is set to -0.12 . These values have been chosen in order to produce GDP cycles that mimic the volatility of output and investment observed in EMU in our baseline model (see Agresti and Mojon, 2001). Following Christiano, Eichenbaum and Evans (1997), the elasticity of demand with respect to price (ε) is set to 6, consistent with a steady-state mark-up, $\varepsilon/(\varepsilon - 1)$, equal to 1.2. The fixed cost in production (κ) is set to 0.2, to produce zero profits in the steady state, where the output has been normalized 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).

Fiscal policy parameters have been calibrated after computing the tax rates for EMU members using the method proposed by Mendoza, Razin and Tesar (1994): 0.43 for labour taxes (τ^w), 0.21 for taxes on capital income (τ^k) and 0.14 for consumption taxes (τ^c). For the same sample of countries and years, government consumption over GDP (\bar{g}^c/\bar{y}) is 0.18, transfers (\bar{s}/\bar{y}) are 0.16 and productive public expenditure (\bar{g}^p/\bar{y}) is 0.06. This calibration yields a public debt of 60 per cent of annual GDP in the steady state, which was the reference level in the Maastricht Treaty. The feedback parameter to public debt in the fiscal rule for government consumption and productive public expenditure (α_b^c and α_b^p) in the baseline model are set to 0.4, whereas α_b^s is equal to zero to avoid transfers becoming procyclical, something at odds with the empirical evidence in EMU since unemployment benefits are countercyclical.

The last set of parameters refers to the interest rate rule. In the baseline model, we set the autocorrelation coefficient of the interest rate (ρ_r) equal to 0.5 and the response to inflation deviations from target (ρ_π) 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 (see, Doménech, Ledo and Taguas, 2002). The steady-state level of gross inflation ($\bar{\pi}$) is set to $1.02^{0.25}$, that is, the target level of the ECB.

The model with supply shocks has been simulated 100 times, producing 200 observations. We take the last 100 observations and compute the steady-state value (\bar{x}), the relative standard deviation to output (σ_x/σ_y , except for GDP which is just σ_y), the first-order autocorrelation (ρ_x) and the contemporaneous correlation with output (ρ_{xy}) of each variable.³ We have also simulated an economy with zero tax rates on consumption, labour and capital incomes, in which public spending is financed using a lump-sum tax such that $\bar{g}^s/\bar{y} = -0.26$, but with otherwise identical fiscal structure as that in the benchmark model ($\bar{g}^c/\bar{y} = 0.18$, $\bar{g}^p/\bar{y} = 0.06$, $\bar{b}/\bar{y} = 0.6$).

The main statistics of these simulations are reported in Table 2. The baseline model reproduces most business-cycle facts of the European economies. The effects of distur-

³ To avoid spurious correlation, we do not filter the simulated data (see Cogley and Nason, 1995).

Table 2
Business cycles statistics

x	Baseline model				Lump-sum taxation model			
	\bar{x}	σ_x/σ_y	ρ_x	ρ_{xy}	\bar{x}	σ_x/σ_y	ρ_x	ρ_{xy}
y	1.00	1.00	0.84	1.00	2.16	0.91	0.82	1.00
c	0.53	0.52	0.88	0.98	1.00	0.54	0.89	0.93
e	0.23	2.61	0.80	0.96	0.64	2.27	0.79	0.99
g^c	0.18	0.74	0.94	0.80	0.39	0.43	0.84	0.99
g^p	0.06	0.74	0.94	0.80	0.13	0.43	0.84	0.99
b	2.40	1.22	0.99	-0.47	5.19	0.09	0.86	-0.90
m	0.60	0.56	0.87	0.99	1.00	0.58	0.88	0.94
mc	0.83	0.22	0.49	-0.81	0.83	0.23	0.37	-0.80
q	1.00	0.31	0.79	0.89	1.00	0.27	0.78	0.94
l	0.31	0.18	0.91	0.93	0.50	0.14	0.91	0.78
i^1	1.24	0.10	0.88	-0.97	1.24	0.08	0.86	-0.99
r^1	3.60	0.59	0.88	0.74	2.84	0.64	0.89	0.80
w	1.94	0.51	0.90	0.98	2.58	0.55	0.90	0.96
π	1.005	0.06	0.66	-0.93	1.005	0.05	0.60	-0.95
pbs	0.018	0.15	0.91	0.81	0.018	0.10	0.84	-0.99

1 In percentage.

tionary taxation on the steady-state values of the main variables are substantial in comparison to the economy with lump-sum taxes (see, for example, Chari and Kehoe, 1999). Interestingly, the standard deviation of output is lower in the economy with lump-sum taxes (0.91 vs. 1). The relative volatilities of public consumption, productive public expenditures and public debt are also larger in the economy with distortionary taxes than in the model with lump-sum taxes. In the next section we take a closer look at this feature.

3. Alternative distortionary taxes versus lump-sum taxation.

In this section, we assess the extent to which automatic stabilizers affect the ability of economic policy to deliver its objectives of low inflation and output volatility in the presence of technological shocks. For this purpose, we compare the position of the inflation-output variance frontier under alternative tax structures. These frontiers are drawn for different values of the interest rate response to the inflation rate (ρ_π), while holding constant the remaining parameters that characterize the economy.

Figure 1 shows the main result of the paper: when public spending is financed through lump-sum taxes, a given monetary policy is able to deliver less output volatility

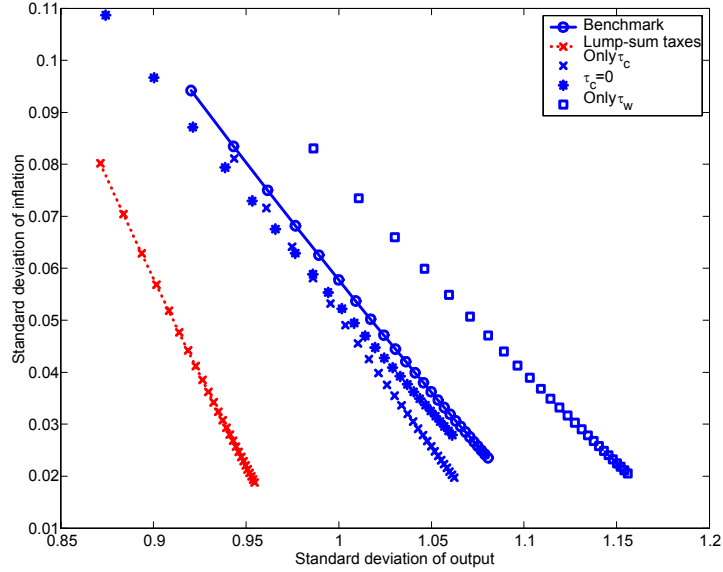


Figure 1: Variance frontier for alternative tax structures.

than any other tax structure; this holds for any value of the standard deviation of the inflation rate. The reduction in σ_y is quite remarkable with respect to the benchmark.

The fact that automatic stabilizers built into the distortionary tax system contribute to destabilizing the economy, compared with an economy with lump-sum taxes, is striking. The mechanisms that generate this result operate both through the demand and the supply side of the model. Income taxes reduce the labour supply and the capital/output ratio in the steady state (Galí, 1994).⁴ In that case a positive shock to total factor productivity leads to a larger percentage change in the use of the two private productive factors, and hence to larger output fluctuations than those that would prevail in a lump-sum tax system. Our model includes these channels along with those related to the response of public spending.

Fiscal revenues and spending are related to economic activity in a variety of ways.

⁴ Using the FOCs, it can be easily shown that the labour supply is more elastic and responsive to shifts in labour demand in the economy with distortionary taxation since the elasticity is a decreasing function of the steady-state labour supply

$$\left. \frac{\partial \hat{l}_t}{\partial \hat{w}_t} \right|_{\bar{c}} = \left(\frac{\bar{l}}{1 + \bar{l}} + \frac{\bar{i}}{1 + \bar{i}} \right)^{-1}$$

Distortionary taxes are linked either to income or to consumption and Ricardian fiscal policies incorporate another channel through which the tax/spending system must be linked to economic activity. In order to prevent public debt from exploding, the budget surplus must react when the level of debt departs from its target. When public revenues are sensitive to the level of economic activity, a positive technological shock causes opposite movements in output and the level of debt, inducing a sharp fall in the debt to output ratio. Thus, public spending must react accordingly, generating an additional shock. The combination of (positive) technology and, current or anticipated, public spending shocks, induces a strong output increase. Thus the standard deviation of output increases relative to that of an economy in which taxes do not respond to the rise in economic activity. In the latter case there is a much more moderate fall in the debt to output ratio that mitigates the response of g_t^c and g_t^p .

The stronger response of public consumption in the economy with distortionary taxes is compatible with the procyclical behaviour of the primary budget balance. In Table 2, the contemporaneous correlation between output and the primary budget surplus (*pbs*) is positive and very high (0.81) in the economy with distortionary taxation, as a consequence of very procyclical fiscal revenues. This correlation is in accordance with the empirical evidence in EMU (0.71).⁵ On the contrary, in the economy with lump-sum taxes the correlation between output and the primary budget surplus is -0.99 , since fiscal revenues are constant whereas public expenditures are procyclical due to fiscal consolidation.

This pattern indicates that correlations between output and public deficits at the business cycle frequencies are not informative about the effectiveness of fiscal stabilizers when different tax structures are compared. This correlation is at the heart of model-based estimates of the strength of fiscal stabilizers (see, among others, Auerbach, 2002) that proceed in two steps, first computing the cyclical response of taxes and then multiplying it by the estimated fiscal multipliers. Since budget surpluses are meant to reduce output, and the empirical evidence is that distortionary taxes are associated with high surpluses in booms, then the implication follows nicely: distortionary taxes help to moderate cyclical fluctuations. Our results do not contradict the evidence, that is, automatic stabilizers exert the expected effect on the budget surplus. However, they are not able to reduce the standard deviation of output below the level that would have been achieved with lump-sum taxes. Procyclical surpluses do not necessarily bring about more output stabilization.

Figure 1 also reveals two additional results. Firstly, alternative structures of the tax

⁵ This correlation is obtained using annual data from 1970 to 2001 and the Hodrick-Prescott filter with a smoothing parameter equal to 10.

system hardly affect the position of the IOF. Compared with the benchmark economy, extreme cases of consumption taxation or income taxation only lead to minor increases in the standard deviation of output for a given standard deviation of inflation. Only in the case in which public spending is fully financed with taxes on labour income ($\tau_w > 0, \tau_k = \tau_c = 0$) does the standard deviation of output rise by a significant amount. This higher volatility is due to the increase in the elasticity of the labour supply which enhances the impact of a technology shock on hours. We also observe that the IOF is hardly affected by changes in τ_k .⁶ The second feature is that the shifts of the IOF's are almost horizontal in most cases. This means that for a given parameter ρ_π , the choice of the tax system does affect the standard deviation of output but leaves that of inflation virtually unaltered. This result confirms that in a monetary regime the level and standard deviation of inflation are mainly determined by monetary policy.⁷

4. Supply and demand effects of fiscal policies.

In this section we assess the importance of the different channels through which income and consumption taxes amplify technology-driven output fluctuations: price inertia, fiscal rules, public investment in the production function, labour supply and private capital accumulation. Supply and demand channels are not easily disentangled since the combination of technological shocks and the induced fiscal responses, shift the aggregate demand around an upward sloping supply curve that also moves as a result of labour and capital fluctuations. To gain some insight into the importance of each channel, we carry out some counterfactual exercises which are summarized in Table 3, where we display the standard deviation of output for the economy with lump-sum (σ_y^l) and with distortionary taxes (σ_y^d) and their ratio when ρ_π is equal to 2.

Let us first focus on the supply channels. Distortionary taxes enhance the procyclical movement of labour supply, capital accumulation and total factor productivity in our model. Taxes on labour income increase the demand for leisure in the steady state, whereas taxes on capital income reduce the steady-state level of the capital/output ratio. Both effects enhance cyclical deviations from the steady state as compared with an econ-

⁶ When $\tau_k = 0$, the capital to output ratio is the same in the economy with distortionary taxation as in the economy in which government spending is financed through lump-sum taxes. As pointed out by Galí (1994), since the output response to technology shocks depends on the response of investment, which is a function of y/k , the small shifts of the IOF when τ_k varies indicate that the importance of this supply channel is smaller than the effects through the labour supply.

⁷ The only exception to this pattern is the structure in which revenues are raised on capital and labour income but not on consumption ($\tau_w, \tau_k > 0, \tau_c = 0$) and ρ_π is relatively small. In this case, there is a sizeable increase in the standard deviation of inflation along with a fall in the standard deviation of output.

Table 3
Sensitivity of σ_y to alternative model parameterizations when $\rho_\pi = 2.0$

Alternative model	lump-sum taxes σ_y^l	distortionary taxes σ_y^d	relative volatility σ_y^d/σ_y^l
Model 1 (<i>benchmark</i>) ($\gamma = 0.45, \theta = 0.1, \alpha_b^c = \alpha_b^p = 0.4, \alpha_b^s = 0$)	0.9119	1.0000	1.0966
Model 2: Inelastic labour supply ($\gamma \simeq 1$)	0.8375	0.8769	1.0470
Model 3: TFP independent of g^p ($\theta = 0$)	0.8583	0.9289	1.0823
Model 4: Consolidation effort ($\alpha_b^c = \alpha_b^p = 0.2, \alpha_b^s = 0$)	0.8800	0.9158	1.0407
Model 5: Delayed consolidation ($\alpha_b^c = \alpha_b^p = 0.4, \alpha_b^s = 0, j = 8$)	0.8707	0.9205	1.0572
Model 6: Fiscal rule in transfers ($\alpha_b^c = \alpha_b^p = 0, \alpha_b^s = 0.4$)	0.8416	0.8564	1.0176
Model 7: Model 2+Model 3+Model 6. ($\gamma \simeq 1.0, \theta = \alpha_b^c = \alpha_b^p = 0, \alpha_b^s = 0.4$)	0.7948	0.8069	1.0152
Model 8: Flexible prices ($\phi \simeq 0$)	0.9892	1.1559	1.1685

omy with lump-sum taxation. We have made total factor productivity dependent on the amount of public investment, which moves along with public revenues according to the fiscal rules in the model.

The standard deviation of output in Model 2 is obtained under the assumption of an (almost) inelastic labour supply ($\gamma \approx 1$), which makes the economy more stable, regardless of the tax structure. The gap between economies with lump-sum taxation and those with distortionary taxes also narrows significantly; roughly half of the additional destabilizing effect associated with distortionary taxation is explained by fluctuations in the labour supply. Setting $\theta = 0$ in our production function (or alternatively when $\alpha_b^p = 0$), as in Model 3, also reduces the volatility of output, although the ratio σ_y^d/σ_y^l is barely affected, which indicates that this channel not very important.

Next we assess the importance of alternative definitions of the fiscal consolidation rule. Neither a strong feedback (high α_b) nor an immediate response to the movements in the debt to output ratio ($j = 0$) is necessary to obtain a unique equilibrium. A Ricardian fiscal rule could be characterized by low and slow responses to deviations of the debt to output ratio from its target and still be sufficient to guarantee existence and

uniqueness. Model 4 in Table 3 differs from the benchmark in the intensity of fiscal consolidation. We set α_b to 0.2, which is in some sense too low, since it implies that it takes a very long time before the real debt returns to its steady-state value after a technological shock. The relative volatility falls in this case to 1.04.

Alternatively, it can be argued that instantaneous stabilization is far too strict, and that even the more demanding fiscal programmes allow for a delayed response of the public surplus, and thus to a slower adjustment of the debt/output ratio. This can be represented in our model setting $j > 0$ in equation (13). Large values of j introduce an important change in the time pattern of the response of public spending to changes in public revenues. A delayed reaction of public spending makes the budget surplus more procyclical mitigating the cyclical effect of fiscal consolidation. In particular, Model 5 allows for 8 lags in the time elapsed before the fiscal variables respond to the deviation of debt from its steady state after a technological shock. As in the previous exercise, slower consolidation reduces the relative volatility associated with both tax structures, but it still remains significantly above 1 ($\sigma_y^d/\sigma_y^l = 1.06$).

Not surprisingly, the most important reduction in the relative volatility of output between both economies occurs when only transfers are used to stabilize the debt to output ratio. In Model 6 we have set $\alpha_b^c = \alpha_b^p = 0$ and $\alpha_b^s = 0.4$. When this alternative policy is implemented the volatility of output in the economy with distortionary taxes is just 1.8 per cent above the one in the economy with lump-sum taxes. This is an interesting case for comparative purposes.⁸ In the economy with distortionary taxes, transfers can also be interpreted as a negative lump-sum tax. These transfers only enter the economy through the household budget constraint and exactly compensate the wealth effect of current bond holdings. In this case, the fiscal rule avoids the transitory distortionary effects that the changes in public spending may have on the decisions of private agents. Consolidation through transfers eliminates the wealth effect and the additional demand impulse associated with the rule, also affecting the response of the labour supply.⁹ The fact that the relative volatility of output falls now indicates that consolidation through government spending explains a sizeable part of the relative volatility observed in the

⁸ Nonetheless, this exercise lacks empirical relevance since lump-sum transfers are not a fiscal instrument used in industrialized countries. Although, the evidence shows that fiscal consolidations through transfers reductions have a high probability of being successful (see Von Hagen, Hallet and Strauch, 2001, Alesina and Perotti, 1997), it is important to notice that these kinds of transfers are not lump-sum, an assumption crucial to our results.

⁹ In this case, all variables with the exception of transfers and public debt are independent of the value of α_b^s and j in the fiscal rule. Since public transfers do not appear in the overall resource constraint and public consumption and investment are independent of public debt ($\alpha_b^c = \alpha_b^p = 0$), the log-linearized dynamic model is block-recursive.

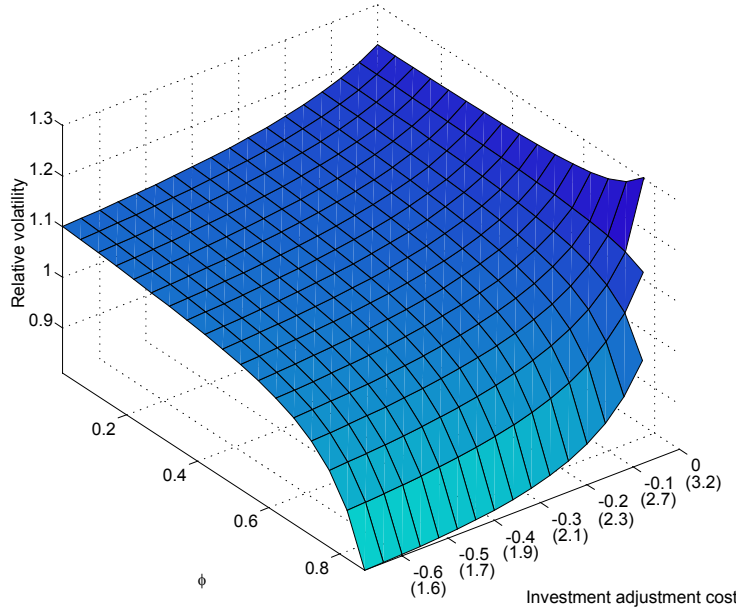


Figure 2: Relative volatility of output (σ_y^d/σ_y^l) for different combinations of price stickiness and investment adjustment costs. Numbers in brackets are the relative volatility of investment to output for different values of the adjustment costs when $\phi = 0.75$.

benchmark model. Taking the exercises in Models 4, 5 and 6 together indicates that the presence of price inertia allows for a demand effect that may be more or less powerful depending on the component of public spending that is used to achieve fiscal consolidation as well as on the intensity of the consolidation effort.

Model 7 in Table 3 incorporates the features of models 2, 3 and 6. As expected, this calibration reduces the destabilizing effects of distortionary taxation to a minimum. In this extreme case, the differences in standard deviation are virtually negligible (relative volatility 1.015), although the standard deviation is still smaller with lump-sum taxes.

Finally, we assess the role played by both nominal and real inertia as regards the relative volatility of output. Price inertia is a key feature of the model. A positive shock associated with falling prices leads to a smaller real wage increase the slower the adjustment of prices. This weakens the response of labour and hence reduces the strength of the supply channel. Model 8 compares the relative volatility of output under both tax structures for a model close to flexible prices ($\phi \simeq 0$); this ratio is significantly higher than the one in the benchmark case ($\phi \simeq 0.75$).

A more general assessment of the role played by nominal and real rigidities is carried out in Figure 2, which depicts how the relative output volatility evolves as we move from the standard RBC model towards a model with Keynesian features.¹⁰ Output volatility under distortionary taxes relative to the economy with lump-sum taxes is very high when both price inertia and investment adjustment costs are absent. This is consistent with Gali's (1994) results that are conditioned on $\phi = \Theta = 0$. High price inertia and capital adjustment costs reduce this ratio. In fact, these two features reinforce each other, but it takes extreme values of these two parameters ($\phi = 0.9$, $\Theta = -0.6$) to generate values of this ratio significantly below one. This extreme economy is not very realistic though, since it implies that firms change prices every 10 quarters (i.e. the Phillips curve is almost flat in the short run) and that the volatility of investment relative to output is 1.5, well below that observed in EMU (2.7).

5. Concluding remarks

The main result of this paper is that the standard deviation of output in an economy hit by technology shocks does not vary greatly across alternative distortionary tax structures, but it is significantly higher than in an otherwise identical economy in which taxes are lump-sum. Although distortionary taxes induce a positive contemporaneous correlation between output and the budget surplus, they do in fact contribute to worsen the output-inflation variance trade-off, as compared with an economy in which public spending is financed through lump-sum taxes. This is a robust result in an economy which reproduces some empirical facts of European countries and departs from a standard RBC model in many respects, therefore generalizing previous findings in the literature.

Other findings may be summarized as follows. First, the supply channels account for a significant proportion of the destabilizing effects of distortionary taxes. Second, and most remarkable, automatic stabilizers operating through the demand side of the economy do not compensate the procyclical movements in aggregate supply; on the contrary, they tend to increase the size of economic fluctuations associated with distortionary taxes. Finally, allowing for nominal and real inertia in the economy may compensate the destabilizing effects of distortionary taxes, but only for a very high degree of price stickiness and large investment adjustment costs.

¹⁰ The numbers in parentheses below the values of Θ (the investment adjustment cost) are the relative volatility of investment to output.

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