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Testing the Validity of the Laffer-Curve Hypothesis

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ABSTRACT. – In a simple macromodel of endogenous growth for 13 OECD countries, the effects of deficit financed tax cuts on output and tax revenue are examined and certain widely assumed properties of the Laffer curve are shown to hold for a portion only of the sample countries. The shape of the Laffer curve is shown to be closely associated with both the theoretical underpinnings of the crowding out hypothesis and the literature on the disincentive effects of taxation; i.e., a permanent reduction in average tax rate is strong enough (insufficient) to allow the government debt to be paid off in the long run without the need for subsequent tax increases mainly in highly taxed economies (economies with crowding out performance).

Test de validité de l'hypothèse de la courbe de Laffer

RÉSUMÉ. – Les effets des réductions des impôts, qui aboutissent à la hausse des déficits publics, sur le produit et les revenus fiscaux sont examinés à l'aide d'un modèle de croissance endogène pour un échantillon de 13 pays de l'OCDE. Il apparaît que certaines propriétés de la courbe de Laffer qui sont largement acceptées sont pertinentes pour quelques pays seulement de l'échantillon. Le schéma de la courbe de Laffer apparaît être très étroitement associé tant aux bases théoriques de l'hypothèse « crowding out » qu'à la littérature sur les effets désincitatifs de l'imposition : une réduction permanente du taux moyen de l'imposition est assez résistante (insuffisante) pour permettre le remboursement du déficit public à long terme, à l'absence des hausses postérieures des impôts, surtout dans le cas des économies à haut niveau de prélèvement fiscal (économies en performance « crowding out »).

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1 Introduction

The issue of crowding out has been well known in the literature for a long time. If an increase in government spending, financed either by taxes or by issuing debt, fails to stimulate total economic activity, the private sector is said to have been crowded out by the government action. The mechanism, however, through which such crowding out occurs, if it does, is still being debated and there is no unanimity.

In particular, the Ricardian equivalence theorem states that the substitution of debt for taxes does not affect private consumption or other macroeconomic variables, because financing by debt implies future tax liabilities which are perfectly foreseen and capitalized by economic agents. Thus, debt is not viewed as private wealth, since higher levels of government deficit induce equal offsetting increases in private savings. As a result, debt-financed tax cuts in a Ricardian setting have no effect on the economy and no crowding out effects should be expected from the accumulation of public debt. Those results are clearly at odds with the implications of the traditional (Keynesian) model. Much of the traditional analysis has built on the presumption that government bonds constitute net wealth to individual asset holders, and hence budget deficits exert real macroeconomic effects: increases in government debt, at a given level of government expenditure, stimulate consumption demand, raise interest rates and crowd out private investment [1].

The debate between advocates of the traditional and equivalence views on the public debt effects, i.e., on whether the economy is sensitive to the financing mix between tax and debt–for a given level of government spending–is closely interrelated with the Laffer-curve hypothesis, even though this interconnection has been overlooked in empirical and theoretical work. The idea underlying the Laffer curve that increases in average tax rates lead first to an increase and then to a decrease in tax yields has played a large role in the popular discussion about the size of the government sector. A corollary of the relative concept is that debt-financed tax cuts induce higher tax revenue and lower budget deficits in the long run. It is exactly the existence of a downward sloping portion of the curve which has led to the "supply side" argument that cutting the average tax rate would generate a sufficient increase in the tax base capable of raising total tax revenue.

In academic literature, Beenstock [1979], Buchanan and Lee [1982], Feige and McGee [1983] and Fullerton [1982], among others, have made use of the Laffer curve concept, while Atkinson and Stern [1980], Mirtowski [1982] and Malkomson [1986] have criticized the use that has been made of it.

1. For a detailed description of the traditional and Ricardian views, see Seater [1993].

Prevailing criticisms of the Laffer curve fall into four categories: (i) the assumption that taxation may act to dampen individual incentives to supply factors of production does not seem to be valid, because the magnitudes of known elasticities are not large enough to produce the implied sizes of output contraction on the negatively sloped section of the Laffer curve (with average tax rate on the horizontal axis and tax revenue on the vertical axis); (ii) published quantitative attempts to confront the problem of empiricism, by producing evidence in favour of the established shape of the Laffer curve, are scarce and unreliable; (iii) the theoretical Laffer curve models omit variables and effects that are crucial to any understanding of the macroeconomy (investment, demand, interest rates, balance of trade, fiscal deficits and so on). These models simply postulate one operational exogenous variable–the tax rate–and one line of causality–from tax rate to tax revenue; (iv) the potential of the tax revenue being dependent not only on tax rates but also on the size of the underground economy and the extent of tax evasion are not taken into account.

All those arguments are actually criticisms of the Laffer curve having the shape assumed, since the general shape (convex with endpoints of zero tax revenue at average tax rates of zero and 100 percent) depends on the curve being a continuous function. However, the Laffer curve may not be continuous (for example, working hours need not be a continuous function of the marginal tax rate) and may not have an interior maximum. It could slope upwards at every average tax rate less than 100% with a discontinuity at 100%. Moreover, the assumption of zero tax revenue at an average tax rate of 100% may not be valid, should economic activity go underground, as long as the probability of detection is less than one.

It thus becomes evident that certain properties of the Laffer curve, which are widely assumed to hold, may not in fact hold for some economies, given that the shape of the curve is likely to depend on more than the labour and capital supply functions. What for instance happens to the marginal product of private capital as average tax rates, private and public capital stocks and government deficits change may also be important for the tax base. The interplay of all these influences may result in the response of working hours to an increase in the average tax rate having no effect on, or even an inverse effect on, the revenue gain from the tax increase.

These suggestions highlight the limitations of the assumption that the Laffer curve has the general (convex) shape. The shape of the curve for any real economy must be determined from empirical evidence, not from theory. Similarly, the position of each country on the curve is also an empirical matter. Moreover, empirical work aimed at determining the shape of the Laffer curve needs to use a model sufficiently rich to allow for the effects discussed above. Despite the obvious importance of these issues for fiscal policy, there has been little progress in the direction of estimating the curve using an econometric model. The usual practices are: (i) to use *ad hoc* models, in which total tax revenue is regressed on average tax rates (which determine revenues), on marginal tax rates (which determine incentives) and/or their square (excess burden varies with the square of the tax rate), and (ii) to develop general (or partial) equilibrium taxation models, in order to simulate the effects of different tax rates for a variety of factor supply elasticities.

One line of criticism of these studies is that they concentrate primarily on incentive and supply-side effects, with the result that the Laffer curve largely ignores the actual mechanism by which fiscal policy exerts its biggest and most immediate impact – demand side effects. Another line of criticism is that most of the above studies do not allow for any positive contribution of the government budget. The Laffer curve models do not usually account for the income effect of an efficiency gain that can be associated with correcting market failure by providing public goods. Clearly, there are public goods (e.g., police protection, transportation systems) which act to encourage private production, more than offsetting the adverse effect of the tax wedge.

Closer to capturing the budget effects is the work of IRELAND [1994] and PECORINO [1995]. Both of them analyze the relationship between tax rates and tax revenues in an endogenous growth setting, which gives a wider scope for Latter-type effects than previous studies. Ireland estimates a dynamic Laffer curve in the context of a one-sector endogenous growth model. In his benchmark model, the turning point of the curve occurs at a tax rate of 15%, while his supply-side experiments show that, given the path for government spending, tax rate reductions may lead to large deficits in the short run. In the long run, however, the government debt can be paid off without increases in tax rates, as the economy is likely to face a dynamic Laffer curve; that is, the lower tax rates accelerate the rate of economic growth and, hence, the tax base is sufficiently expanded to generate larger tax revenues at the lower level of the tax burden. On the other hand, Pecorino considers a two-sector model, in which tax treatments differ across sectors (human capital is taxed at a lower rate than physical capital). As a result, the present value of tax revenues is found to be maximized at a significantly higher rate than the corresponding value in Ireland's model.

Ireland's and Pecorino's pioneering works, however, are based on benchmark models that are parameterized to roughly match the U.S. economy. Parameters are chosen to ensure that, under the benchmark specification, the growth rate, tax rates, elasticities of substitution, technology level parameters and the like approximate the corresponding figures in the U.S. It thus becomes evident that, given the uncertainty over the parameter values and over the basic structure of their models, the results of their simulations should only be viewed as both suggestive and concerning the particular economy. Moreover, the actual economy and tax systems are much more complex than the theoretical models.

This paper proposes an extension of the debate in the direction of estimating empirically the properties of the Laffer curve, in the context of an endogenous growth model accompanied by suitable auxiliary equations, for 13 OECD countries over the post-1964 period. In particular, we incorporate a private-capital productivity function into a constant-returns model of endogenous growth, with a view towards examining whether there is a robust and systematic tendency for budget deficits to be declining as average tax rates are being set at successively lower levels. Moreover, we investigate whether such a tendency, if detected, can be attributed to the differential impact of the tax burden on private-capital productivity and, hence, on the output level. Our method aims at achieving simultaneously two objectives: (a) it tests, via established econometric procedures, the response of fiscal deficit to tax rate changes–at given levels of government spending–for a variety of developed countries, and it traces the position of each of these countries on the Laffer curve, and (b) it broadens the scope of the Laffer curve concept by associating it with the crowding out concept and the Ricardian *vis-a-vis* traditional controversy over the effects of debt-financed tax cuts on economic performance.

2 The Model

The simplest model that generates growth endogenously is one where production per worker, y, is linear in private capital per worker, k, and public services, G, are treated as a productive input for private producers. Following BARRO [1990] and BARRO and MARTIN [1992], public services are envisaged as Samuelson-style non-rival, non-excludable public goods:

$$y = Ak^{\alpha}G^{\beta} \tag{1}$$

where $\alpha + \beta = 1$. Hence, production is subject to diminishing returns with respect to private capital per worker for given government expenditure, but is subject to constant returns with respect to private capital per worker and public services together.

The positive externalities in the production function (1) take the form of government (investment) expenditures in services that enhance productivity in the private sector, thereby increasing the growth rate. The specification of the technology is completed by the resource constraint and the private investment equation, as follows:

$$y_t = c_t + i_t = c_t + k_{t+1} - (1-\delta)k_t \tag{2}$$

$$k_{t+1} = i_t + (1-\delta)k_t \tag{3}$$

where δ denotes the rate of depreciation.

The intertemporal utility function is based on the assumption of identical and infinitely lived representative agents and is given by

$$U = \Sigma_{t=0}^{\infty} b^t[(c_t^{1-\sigma} - 1)/(1-\sigma)] \tag{4}$$

By postulating now that government expenditure is financed by a proportional income tax at rate τ, the representative consumer's budget constraint (2) can be recast in present value terms:

$$\Sigma_{t=0}^{\infty}(1/R)^t[(1-\tau_t)Ak_t^{\alpha}G_t^{\beta} - k_{t+1} + (1-\delta)k_t - c_t] = 0 \tag{5}$$

where R is the real rate of interest.

As is well known, the first-order condition for the maximization of utility in equation (4), subject to the budget constraint in equation (5), requires the growth rate of consumption per person to be

$$c_{t+1}/c_t = (bR)^{1/\sigma} \tag{6}$$

where

$$R = (1 - \tau_{t+1})\,\alpha(y_{t+1}/k_{t+1}) + (1 - \delta) \tag{7}$$

Equation (7) determines the private rate of return to the capital good. The growth rates of (per capita) income and capital can be shown, using the budget constraint and the appropriate transversality conditions, to equal the growth rate of consumption, as the economy is always in a position of constant, steady-state growth.

The validity of the dynamic Laffer-curve hypothesis can be tested empirically by examining whether a debt-financed tax cut can finance a given expenditure stream, without impinging upon the ability of the government to balance the budget in the long run. If a dynamic Laffer curve prevails, fiscal authorities can reduce taxes, have outlays unaltered and still balance the present value budget constraint, without resorting to tax rate increases in the future. As Ireland points out, the net impact on economic performance of a switch from taxes to debt reflects the combination of the adverse direct effect of the lower tax rate on tax revenue, through the tax function, and the indirect stimulative effect of the lower tax rate on capital accumulation, output and the tax base. Ireland's supply-side numerical experiments show that the indirect effects of deficit-financed tax cuts are stronger than the direct effects; thus, a permanent reduction in tax rates can provide for both economic growth and long-run government budget balance.

In terms of econometric methodology, which is adopted in the present text, testing whether the average of government deficits over a long period of time would be continuously declining if the average tax rate [2] were being set at successively lower levels can be best conducted by estimating the following simultaneous equation system:

$$y_t = A\,k_t^{\alpha} G_t^{\beta} \tag{8a}$$

$$\Delta k/k = \delta_0 + \delta_1 MP_t + \delta_2 (MP \cdot \tau)_t \tag{8b}$$

$$MP_t = b_0 + b_1 \tau_t + b_2 (\mathrm{DEF}/Y)_t + b_3 \Delta k_t + b_4 \Delta G_t + b_5 t \tag{8c}$$

2. The use of a single tax rate applied equally to all forms of income (labour income, interest income, profits) is a major abstraction from reality, since tax revenue is simply the tax rate multiplied by national income. With a proportional tax function of this kind, the average tax rate and the marginal tax rate are equal to a constant rate. Moreover, substantial discrepancies in the tax structure across countries are concealed, not to mention that certain forms of taxation are not conductive to Laffer-type effects (e.g., indirect taxes on goods with highly inelastic demand). The payoff to such abstractions, however, is a more precise analysis of the Laffer curve proposition.

(8d) $$\text{DEF}_t = \tau_t Y_t - G_t$$

Equation (8a) replicates the production function (1), while equation (8d) is the fiscal deficit (DEF) identity, where $\tau_t = T_t/Y_t$ is the ratio of total tax revenue (T) to GDP (Y). The private capital growth equation (8b) is derived from the combination of the steady-state equilibrium condition for capital–the analogue of equation (6)–when $\sigma = 1$, and the interest rate equation (7):

(9) $$k_t = [b(1 - \tau_t)MP_t + (1 - \delta)]k_{t-1}$$

after subtracting k_{t-1} from both sides of equation (9) and dividing throughout by k_{t-1}. Note that $\delta_0 = b(1 - \delta) - 1$, $\delta_1 = b$, $\delta_2 = -b$ and MP stands for the marginal product of private capital, $MP = \partial y/\partial k = \alpha(y/k)$.

Finally, the marginal product of capital in equation (8c) is made a function of the average tax rate, the ratio of deficit to GDP, the (annual changes in) private and public capital and the time trend (t). There is no consensus in the literature as to the determinants of the marginal product of private capital. ASCHAUER [1989], for example, finds that the rate of return to private capital responds negatively to the net private capital stock and positively to the net public capital stock, the time trend and the capacity utilization rate [3]. Other researchers shift the emphasis to fiscal variables: EASTERLY and REBELO [1993] argue that the marginal productivity of private capital and, hence, the rate of capital accumulation will decline, if higher deficits today will later be compensated by higher consumption or income taxes, while ROMER [1986] and KING and REBELO [1990] stress the disruptive role of high tax rates on the marginal product of private capital [4].

3 Empirical Results

The present study uses the Generalized Method of Moments (GMM) technique developed by HANSEN [1982], in order to investigate the tax rate-

3. The significantly positive relationship between the rate of return to private capital and public capital points, according to Aschauer, to the distinctive feature of public capital–particularly, infrastructure capital–to bear a complementary relationship to private capital, given that a higher level of public capital is normally expected to raise the marginal productivity of private capital.

4. ROMER [1986] argues that, if the level of investment is chosen by private entrepreneurs in the pursuit of future profits, higher tax rates that reduce the rate of return on investment will negatively affect the rate of investment and thereby the long-run rate of growth; in KING and REBELO's [1990] model, a tax rate on either labour or capital income will adversely affect the incentive to accumulate human and physical capital–through reducing the private returns to accumulation–and the adverse effects of taxation are expected to be reinforced in open economies that have access to international capital markets.

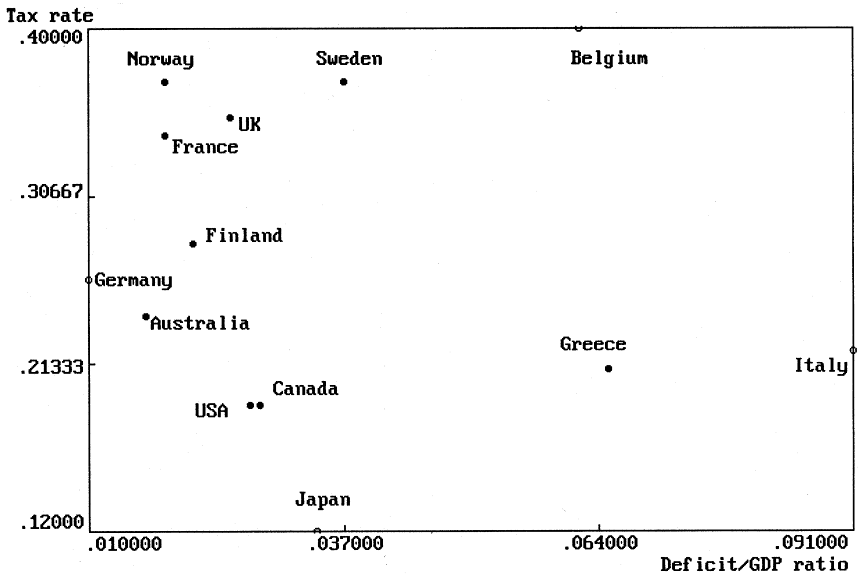
deficit-output relationships out of the equation system (8) [5]. In applying the GMM method, we sacrifice asymptotic efficiency in exchange for not having to specify completely the nature of the serial correlation and/or heteroskedasticity.

The following group was used as the instrumental variables: a constant, private and public capital for two previous periods, tax rate and deficit/GDP ratio for one previous period and interest rate, unemployment rate, population and terms of trade. Annual data for 13 OECD countries (Australia, Belgium, Canada, Finland, France, Germany, Greece, Italy, Japan, Norway, Sweden, the UK, USA) over the period 1964-1994 were used in the regressions. The main reason for choosing this particular sample lies in that reliable data on the real stock of private capital are available from OECD only for these countries (sources and definitions of all variables are reported in the appendix; all variables are expressed at constant prices, local currencies).

As can be readily seen from the scatter diagram 1, the sample countries can be ranked in terms of two distinguishing features: the average tax rate and the average deficit/GDP ratio over the period examined. Roughly speaking, the countries of our sample can be partitioned into three groups: the highly taxed countries (the UK, France, Norway, Sweden), the countries with high deficit/GDP ratios (Italy, Belgium, Greece) and the countries with

FIGURE 1

Scatter plot of the tax rate on the deficit/GDP ratio.



5. A general approach to estimating the matrix of parameters is based on the principle of maximum likelihood. A drawback of this approach is that it requires us to specify the form of the likelihood function. The key advantage of GMM is that it requires specification only of certain moment conditions rather than the full density. This can also be a drawback, in that GMM often does not make efficient use of all the information in the sample.

relatively low average tax rates and low deficit/GDP ratios (Japan, USA, Canada, Australia, Germany). Note that Belgium is characterized by both high average tax rate and high deficit/GDP ratio, whereas Finland comes in between the highly- and low-taxed groups of countries.

Given this classification, it is unlikely that the Laffer curve principle can equally apply to all of the three groups of countries. For example, the "conventional wisdom" presumes that the record budget deficits drive up real interest rates and generate substantial crowding out effects; thus, the combination of lower tax rates and larger budget deficits will tend to deteriorate economic performance in the group of countries with high deficit/GDP ratios and the Laffer curve hypothesis will probably fail to hold. On the other hand, highly taxed countries are more likely to face a dynamic Laffer curve than the low-taxed countries; that is, the location of the highly taxed economies will rather be to the right of the peak of the Laffer curve, where revenue begins to fall as tax rates rise, since the disincentive effects of taxation grow strong enough to generate a percentage reduction in the taxable base which is greater than the percentage increase in tax rates. Notwithstanding these reasonable hypotheses, all drawing from established theoretical frameworks, determining the true relationship between tax rates and tax revenue (or budget deficit) still remains an essentially empirical issue.

Before turning to the empirical results from the estimation of model (8), the time series properties of the variables of interest should be assessed. Two sets of unit root tests were applied, i.e. standard Dickey-Fuller tests and the seminonparametric Phillips-Perron modification of those tests. For the variables y, k, G of the production function, we are unable to reject the unit root hypothesis at even the 10% level. On taking, however, first differences the above three series strongly reject the unit root at the 5% level, thus confirming that the data set contains three I(1) variables (the results of these tests are presented in the appendix, Table A1). The next step of the analysis is to investigate the potential cointegration properties of these data. The results from testing the number of cointegrating vectors, on the basis of JOHANSEN's [1988] maximal eigenvalue and trace test statistics, suggested the existence of at least one cointegrating vector (in all equations and countries) at the 1% or 5% level (10% for France and Denmark). Accordingly, the null hypothesis of no cointegration is rejected.

For the variables of both the capital stock equation (8b) and the marginal product equation (8c), the unit root hypothesis is rejected at standard significance levels, thus implying that these series are integrated of order zero (I(0)).

The results of the GMM estimation of the equation system (8) are reported in Table 1 (details concerning the construction and meaning of the dummy variable (DV) and the multiplicative dummy variables $(DV^*(DEF/Y), DV^*\Delta G)$ are provided below). Consider first the results relating to the marginal product (equation (8c)). The coefficient on the tax rate is statistically significant at 5% level (10% level in Australia, Canada and Japan) and negative in all countries, indicating the overwhelming importance of the lower tax burden in enhancing the productivity of private capital. A one percentage increase in the average tax rate is estimated to lower the

TABLE 1

GMM Estimates of Equation System (8)

	Australia	Belgium	Canada	Finland	France	Germany	Greece	Italy	Japan	Norway	Sweden	UK	USA
							Production function (8a)						
A	3.2	5.6	4.6	764.1	28.9	90.2	31.6	9.8	967.2	80.3	163.1	3.49	455.1
	(2.7)	(1.9)	(1.4)	(3.2)	(5.4)	(3.1)	(2.3)	(2.7)	(4.8)	(2.8)	(3.1)	(3.7)	(2.3)
α	0.527	0.731	0.317	0.376	0.451	0.374	0.497	0.652	0.326	0.415	0.701	0.508	0.521
	(3.2)	(4.6)	(2.8)	(3.6)	(4.9)	(3.3)	(3.4)	(5.3)	(3.2)	(2.9)	(4.7)	(3.4)	(3.2)
β	0.603	0.316	0.516	0.413	0.361	0.563	0.218	0.209	0.464	0.574	0.287	0.565	0.319
	(3.6)	(2.9)	(3.1)	(3.5)	(4.1)	(3.9)	(3.6)	(2.8)	(4.7)	(3.6)	(2.3)	(4.1)	(2.8)
DV	—	–0.89	2.68	—	13.7	17.3	8.3	3.1	—	—	58.3	1.34	97.4
		(2.8)	(2.4)		(3.1)	(2.6)	(2.9)	(2.8)			(2.7)	(2.5)	(3.2)
R^2	0.913	0.876	0.973	0.867	0.989	0.976	0.943	0.951	0.987	0.957	0.891	0.927	0.869
DW	1.68	1.67	1.53	1.64	1.54	1.63	1.64	1.52	1.43	1.73	1.72	1.58	1.89
$Q(14)$	17.4	14.3	18.3	19.7	13.8	12.7	13.4	12.8	20.1	16.9	14.6	18.3	18.2
	(0.31)	(0.22)	(0.2)	(0.3)	(0.4)	(0.27)	(0.2)	(0.2)	(0.1)	(0.3)	(0.3)	(0.3)	(0.2)
P-val.	0.40	0.27	0.32	0.56	0.49	0.41	0.34	0.59	0.63	0.27	0.36	0.41	0.57
							Private capital growth equation (8b)						
δ_0	–0.041	–0.027	–0.032	–0.029	–0.043	–0.043	–0.038	–0.041	–0.033	–0.046	–0.037	–0.038	–0.046
	(2.6)	(1.8)	(2.7)	(2.1)	(4.7)	(2.7)	(2.6)	(3.4)	(2.4)	(3.2)	(2.8)	(2.7)	(2.4)
δ_1	0.53	0.23	0.46	0.59	0.16	0.85	0.59	0.61	0.67	0.79	0.56	0.55	0.31
	(3.1)	(1.2)	(2.6)	(2.9)	(0.7)	(3.8)	(2.9)	(2.3)	(3.2)	(2.7)	(2.6)	(3.2)	(3.2)
δ_2	1.12	–0.89	–0.73	1.17	–0.25	0.94	–0.77	–0.84	1.22	–0.86	–0.76	–1.15	0.91
	(1.7)	(3.3)	(1.2)	(1.9)	(2.3)	(1.6)	(3.4)	(2.5)	(0.9)	(3.4)	(2.1)	(3.1)	(1.5)
DV	—	–0.72	0.06	—	0.017	–0.03	–0.011	–0.011	—	—	–0.09	–0.011	–0.023
		(3.1)	(3.2)		(2.9)	(2.4)	(2.6)	(2.3)			(2.3)	(2.4)	(2.7)
R^2	0.904	0.893	0.953	0.970	0.991	0.971	0.957	0.962	0.991	0.953	0.864	0.976	0.893
DW	1.63	1.57	1.71	1.56	1.55	1.87	1.62	1.43	1.77	1.76	1.51	1.61	1.76
$Q(14)$	17.1	16.7	16.5	13.9	18.5	19.3	17.3	15.1	16.4	12.5	13.6	12.3	10.9
	(0.29)	(0.41)	(0.2)	(0.2)	(0.3)	(0.41)	(0.2)	(0.3)	(0.2)	(0.2)	(0.3)	(0.6)	(0.6)
P-val.	0.58	0.43	0.63	0.76	0.51	0.49	0.57	0.61	0.37	0.44	0.33	0.47	0.39

TABLE 1 (continued)

	Australia	Belgium	Canada	Finland	France	Germany	Greece	Italy	Japan	Norway	Sweden	UK	USA
					Marginal product of private capital equation (8c)								
b_0	0.33	0.87	0.14	0.93	0.67	0.24	0.83	1.27	0.96	0.68	1.06	0.28	0.295
	(3.6)	(2.1)	(0.7)	(3.7)	(5.3)	(5.6)	(3.4)	(3.9)	(6.4)	(2.8)	(2.8)	(6.7)	(6.4)
b_1	–0.03	–0.05	–0.028	–0.14	–0.043	–0.05	–0.06	–0.08	–0.02	–0.06	–0.06	–0.09	–0.079
	(1.7)	(3.1)	(1.4)	(2.3)	(3.4)	(3.1)	(2.7)	(2.5)	(1.4)	(2.8)	(2.3)	(4.5)	(2.6)
b_2	0.013	–0.16	0.06	0.05	0.017	–0.07	–0.15	–0.18	0.04	0.05	–0.13	–0.047	–0.072
	(1.5)	(3.9)	(1.3)	(2.2)	(1.3)	(2.5)	(3.1)	(4.2)	(1.2)	(1.1)	(0.9)	(1.2)	(3.1)
b_3	–0.7 E-4	–0.5 E-4	–0.3 E-5	–0.9 E-6	–0.2 E-5	–0.6 E-6	–0.3 E-4	–0.2 E-5	–0.5 E-7	–0.7 E-5	–0.8 E-4	–0.1 E-5	–0.13 E-5
	(3.7)	(1.4)	(3.6)	(2.6)	(4.7)	(7.4)	(0.8)	(0.3)	(2.9)	(5.6)	(2.4)	(4.8)	(6.2)
b_4	–0.3 E-4	–0.1 E-4	0.14 E-4	–0.5 E-7	–0.13 E-5	0.46 E-6	–0.8 E-5	–0.5 E-4	0.63 E-7	0.8 E-5	–0.1 E-4	–0.7 E-5	0.26 E-5
	(1.1)	(3.4)	(2.3)	(2.3)	(0.7)	(2.2)	(3.2)	(4.1)	(2.4)	(3.1)	(3.5)	(1.9)	(2.8)
b_5	0.002	0.03	0.009	0.017	0.012	0.003	0.02	0.04	0.04	0.004	–0.05	–0.001	0.004
	(3.2)	(3.1)	(5.9)	(3.6)	(2.2)	(4.7)	(3.1)	(5.3)	(4.2)	(2.9)	(3.7)	(2.5)	(3.9)
DV	—	–0.61	0.28	—	0.26	0.11	0.33	0.45	—	—	0.31	0.13	0.104
		(2.3)	(2.7)		(3.2)	(3.4)	(3.3)	(2.7)			(2.4)	(2.8)	(2.1)
$DV.(DEF/Y)$	—	0.06	—	—	—	—	—	0.05	—	—	—	—	—
		(2.6)						(2.7)					
$DV \cdot \Delta G$	—	—	—	—	—	—	–0.19 E-5	—	—	—	0.04 E-5	0.2 E-5	—
							(2.5)				(2.8)	(2.5)	
R^2	0.847	0.863	0.827	0.834	0.531	0.963	0.887	0.981	0.986	0.914	0.889	0.973	0.976
DW	1.67	1.75	1.77	1.57	1.81	1.58	1.73	1.82	1.34	1.46	1.86	1.42	1.83
$Q(14)$	17.4	13.6	16.5	16.9	12.8	20.2	21.4	17.9	18.1	13.6	14.5	22.1	13.1
	(0.23)	(0.19)	(0.3)	(0.2)	(0.6)	(0.1)	(0.5)	(0.3)	(0.2)	(0.2)	(0.2)	(0.1)	(0.5)
P-val.	0.28	0.39	0.32	0.46	0.52	0.38	0.47	0.68	0.53	0.41	0.38	0.27	0.60

Note : The t—ratios appear in parentheses. Q is the Box-Leung Q-statistic. DW is Durbin-Watson's test statistic for serial correlation in the residuals. P-val. is the probability value of the J-test which is distributed as χ^2 and analyzes the goodness-of-fit of the model. The results show that the overidentifying restrictions are satisfied. The dummy variable DV and the multiplicative dummy variable $DV^*(DEF/Y)$ and $DV^*\Delta G$ cover the periods 1993-1994 (Belgium, France, Germany, Italy), 1982–1990 (Canada, USA), 1987–1992 (Greece), 1992 (Sweden), 1980–1990 (the UK).

return to private capital by anything between 14 basis points (in Finland) and 2 basis points (in Japan). Similarly, the rate of return to private capital responds negatively to an increase in net private capital stock per worker. In the U.S., for example, a one standard deviation increase in the latter variable (13345 dollars) induces roughly a one and one third standard deviation decline in the marginal product of capital. The corresponding figures for the decline in the marginal product of private capital range from 3.6 (in France) to 0.4 (in Italy). Note, however, that the coefficient on (changes in) private capital stock is insignificantly different from zero in the three countries (Italy, Belgium, Greece) with high deficit/GDP ratios.

The rate of return to private capital appears to respond positively to (changes in) public capital stock in five countries (USA, Germany, Norway, Japan, Canada) and negatively in six other countries (Belgium, Finland, Greece, Sweden, the UK and Italy) [6], whereas (changes in) the stock of public capital has no statistically discernible impact on the productivity of private capital in Australia and France. A different pattern of results appears with respect to the deficit variable. The negative and significantly different from zero estimates on the deficit/GDP ratio in Belgium, Germany, Greece, USA and Italy indicate that deficit financing leads to lower rates of return to private capital in these countries [7]. In contrast, the coefficient on the deficit/GDP ratio is significantly positive in Finland and insignificant (positive or negative) in Australia, Canada, France, Japan, Norway, Sweden and the UK.

It is interesting to note that the estimated rate-of-return equation includes a positive and statistically significant time trend in all countries, except Sweden and the UK. There has been a concern in the literature about a "falling rate of profit" in the 1970s and 1980s. Our findings, however, would lead one to conclude that the rate of return to private capital has trended upward throughout the post-1964 period and an apparent slump in the profitability of private capital has occurred solely in Sweden and the UK.

The statistically insignificant point estimates of the impact of the tax rate, public capital changes and budget deficit on the productivity of private capital in Australia lends support to the Ricardian equivalence theorem: private agents are assumed to be fully aware of the future tax implications of debt financing; thus, any increase in fiscal deficits would be matched by an equal increase in current savings, with no impact on domestic interest rates and, hence, on the productivity of private capital.

In direct contrast to the results obtained for Australia, the coefficient values of the fiscal variables in the countries with high deficit/GDP ratios are more in line with the crowding out hypothesis of the traditional view. Indeed, the coefficients on deficit, tax rates and public capital in Belgium, Italy and Greece are always negative, of substantial magnitude and significantly different from zero. The negative role for government deficits and public

6. Note that the results for Sweden, the UK and Greece do not change significantly after allowing for the effects of the multiplicative dummy variable $DV^{*}\Delta G$ in the corresponding periods.

7. Note again that the results for Belgium and Italy are qualitatively the same when the effects of $DV^{*}(DEF/Y)$ are taken into account.

capital in these countries means in essence that a bond financed increase in government investment may directly raise aggregate demand (the direct fiscal impact), but the accompanying increase in the supply of bonds exerts upward pressure on interest rates, lowers the profitability of private capital stock and discourages private investment activity (direct portfolio impact). Another common feature of the group of countries with high deficit/GDP ratios is that private investment never appears to play a substantial role in the regression, as the marginal product of private capital is mostly insensitive to the expected path of private capital changes.

Estimates of the deficit coefficient in the highly taxed countries portray a quite different picture of the relation between fiscal variables and the marginal productivity of private capital. Indeed, changes in the ratio of deficit to GDP result in negligible effects on the return to private capital in France, Norway, Sweden and the UK, as they fail to signal to agents changes in future fiscal policies which might have an adverse impact on incentives. Under such circumstances, the replacement of current taxes with a package of debt and concomitant future taxes may give rise to results favourable to the Laffer curve proposition: the reduction in tax rates will tend to raise the marginal product of private capital, whereas the increase in the deficit/GDP ratio will leave the marginal product almost unaltered.

The remaining countries (Canada, Finland, Germany, Japan, USA) fall in the group of the low-taxed countries with low deficit/GDP ratios. The effects of fiscal policy actions in this group tend to appear weaker than those observed in the highly-taxed group; that is, the effects of fiscal variables on the marginal product of private capital are shown to be statistically insignificant and/or to cancel out. For example, simply altering the means the government uses to finance its expenditure will not affect the return to private capital in Canada and Japan, as the coefficients on both the average tax rate and the deficit/GDP ratio are not significantly different from zero, even though public investment appears to exert a strong positive influence. In Germany and USA, the combined effect on the return to private capital of substituting debt for taxes is rather neutral, as the coefficients on both the average tax rate and the deficit/GDP ratio are significantly negative, implying that the favourable impact of reducing the tax rate is offset by the adverse effect of increasing the deficit/GDP ratio; there is, however, a clear-cut evidence of a positive relationship between public investment and the return to private capital. Lastly, in Finland the switch from taxes to debt will exert a favourable impact on the productivity of private capital (significantly negative coefficient on tax rate and significantly positive coefficient on deficit/GDP ratio) but public capital formation appears to play a substantial negative role in the regression.

Inspection of the parameter estimates of the production function (8a) in Table 1 reveals that output per worker rises in response to higher levels of both private capital per worker and total public capital (for the definition of public capital, see the appendix). The effect of private capital is stronger in Belgium, Sweden, Italy and Australia and weaker in Finland, Japan, Germany and Canada. In particular, the point estimate of the impact of private capital on output ranges from 0.32 to 0.73, with the highest value attained in Belgium and the lowest in Canada. The corresponding values for public capital are 0.21 (Italy) and 0.60 (Australia).

Examination of the estimated capital stock equation (8b) points to depreciation rates ranging from 3.5 to 5.4 percent. In addition, the coefficients of capital productivity are always positive, of substantial magnitude and significantly different from zero (except France and Belgium). As to the coefficient on the interaction term, we note that it is statistically significant at 1% level and negative in the UK, France, Norway, Sweden, Greece, Belgium and Italy, indicating a strong positive relation between capital growth and capital productivity when average tax rates fall. In contrast, there is a clear-cut evidence of a positive relationship between the rate of growth of private capital and the interaction term in Finland, whereas the interaction variable does not pass a t-statistic test at the 5% level of significance in Australia, Canada, Germany, Japan and USA.

The "appropriateness" of the estimated equations summarized in Table 1 was assessed in two ways. First, the autocorrelation functions of the residuals were examined and Box-Leung Q-statistics calculated at lags of 14 periods to ascertain whether these residuals were white noise or exhibited serial correlation. None of the χ^2-tests based on the Box-Leung Q-statistics rejected the hypothesis of uncorrelated residuals in any of the estimated equations.

Second, the estimated equations (8a), (8b) and (8c) were subjected to tests of structural stability to determine whether separate structures exist. In most studies, the Chow test is used to ascertain whether the structures are significantly different. However, the Chow test does not pinpoint which coefficients differ; moreover, when the subsamples have small numbers of observations, as it happens in our case, the likelihood of multicollinearity rises, and this can potentially affect estimation performance; lastly, the Chow test does not indicate the exact location at which structural differences occur, so that the researcher has to postulate one or more likely conditions, such as structural shifts in monetary and fiscal policies. To deal with these problems, we opted for Hafer and Hein's procedure [8] to determine where structural differences occur.

8. A detailed description of Hafer and Hein's method can be found in LARDARO [1993]. In the context of the present analysis, each of the three equations (8a, 8b, 8c) for each of the sample countries was estimated both in its original form and in first difference form, omitting the intercept. If the intercept in the original equation has shifted at one or more points, the pattern of residuals from the first difference form should reflect these changes by registering increases in the magnitude of residuals at each shift. Large residuals relative to the equation standard error (outliers) indicate time periods corresponding to possible intercept shifts. Similarly, substantially different slope coefficients in the first difference form from those in the original equation indicate possible structural shifts. The next step is to divide the sample into two or more nonoverlapping periods based on the location of outliers and to create a dummy variable for each of these periods. The number of statistically significant dummy variables determines the number of potential structural shifts. The relationship to be estimated includes the significant dummy variable(s) along with multiplicative dummies for any explanatory variable, whose first-difference coefficient differs substantially from its value in the original equation, and the significantly different terms for each structure are chosen.

The initial step of Hafer and Hein's technique involves estimating the first difference form with no intercept of the relationships

$$d\ln y_t = \alpha\, d\ln k_t + \beta\, d\ln G_t$$
$$d(\Delta k/k) = \delta_1 d(MP)_t + \delta_2 d(MP \cdot \top)_t$$
$$d(MP)_t = b_1\, d\top_t + b_2\, d(DEF/Y)_t + b_3 d(\Delta k)_t + b_4\, d(\Delta G)_t$$

After running these regressions, we observed outliers for 1982 and 1991 (USA), for 1982 and 1993 (Germany), for 1993 (France, Italy), for 1980 and 1991 (the UK), for 1982 and 1991 (Canada), for 1991 (Australia), for 1981 and 1993 (Belgium), for 1991 and 1992 (Finland), for 1987 and 1993 (Greece), for 1992 and 1993 (Sweden). Also, the coefficients on $d(DEF/Y)$ for Italy and Belgium and the coefficients on $d(\Delta G)$ for the UK, Sweden and Greece were substantially different from those in the original equation. This raises the possibility that a slope shift has also occurred in these countries.

We next constructed dummy variables for the different subperiods. For example, using 1964 to 1981 as our comparison period for USA (so we only need to create two dummy variables) the following dummies were created: $D1 = 1$ from 1982 to 1990, 0 otherwise; and $D2 = 1$ from 1991 to 1994, 0 otherwise; and so on with the remaining sample countries. Using these dummy variables in the original regression equations, we obtained the results that are presented in the appendix (Table A2).

As becomes evident from the inspection of Table A2, the statistically significant dummies are those referring to the years 1982 (USA), 1993 (Germany, France, Belgium, Italy), 1980 (the UK), 1982 (Canada), 1987 (Greece) and 1992 (Sweden). We will include these dummy variables in our final estimated equation, along with the multiplicative dummy variables $DV^*(DEF/Y)$ for Italy and Belgium and $DV^*\Delta G$ for the UK, Sweden and Greece. The results are reported in Table 1.

4 Simulation Results

To evaluate the implications of the estimates in Table 1 for the tax rate-fiscal deficit-output relationships, it will be useful to analyse in more detail the influence of tax rates on per capita income and budget deficits. It should be stressed, however, that there is no single tax rate for any household, much less any economy (see also footnote 2); and if the horizontal axis of the Laffer curve is intended to represent some aggregate of rates, then the whole concept gives rise to problems of differential tax responses and their appropriate method of aggregation. In particular, comparisons among the sample countries are made in terms of the tax burden expressed as a proportion of GDP, which is a crude measure since it does not discriminate either between marginal and average tax rates or between direct and indirect taxes. The correlation between marginal and average tax rates over time in a single country with a given tax structure seems to be quite plausible. However, the same consideration cannot apply across countries with different tax structures, since a given tax burden may well be associated with different marginal tax rates. Since disincentive effects occur at the margin, the average tax rate makes an insecure basis for international comparisons. In addition, a given percentage burden is likely to weight more heavily on a poor country than on a rich country (just as a rich household should pay proportionately more tax than the poor).

On similar grounds, simply shifting the burden of taxation from direct to indirect taxation does not change real disposable income for the average household, provided that indirect taxes are fully passed on. However, the extent to which indirect tax increases are reflected in higher prices may differ substantially across countries, thus affecting the incentives to work, save and consume in a variety of ways.

Lastly, the tax base may shrink as taxes rise because the scope of tax evasion increases as the benefits from evading taxes rise with tax rates, and not because labour and capital services are withdrawn from the market. The nontax rate influences on tax evasion (public morality, attitude toward government penalties and so on) mean that the Laffer curve depends on a complex set of political and sociological factors.

Even though the dependence of tax revenues on tax rates appears to be oversimplified in standard macroeconomic theory to deal with the effects of tax rates on economic performance, simulations of the highly aggregated supply side model (8) can remedy to some extent these deficiences and elucidate some of the main issues involved. Table 2 reports the effects of successive two-percentage point reductions in the average tax rate over the sample period on the means of deficit and per capita income in each of the 13 countries considered. Eight separate dynamic simulations for each country (six for Japan) were run and compared with the control solution.

The closeness of the deficit and output values and the corresponding estimations recovered by the simulation iteration at the prevailing tax rates is measured by Theil's inequality coefficient, U. Theil's U statistic for output starts in the range of 0.75-0.90 for the first forecast step and decreases as the number of forecast steps increases. In the neighborhood of 9-10 forecast steps, U drops to below 0.32 (a zero value of U indicates that the actual and recovered series are exactly equal). The corresponding figures for deficit are 0.36-0.53 for the first forecast step and 0.11-0.18 for the last step. Thus, it is clear that the model performs well in spite of its small size and it can be reliably used to perform policy experiments involving tax instruments.

The simulations of the model for the UK illustrate the effects of successively lowering the average (over the sample period) tax rate by two percentage points in each iteration, from the prevailing level of 35% to 21%. As can be readily seen from the coefficient values of the marginal product equation for the UK in Table 1, the immediate effect of the lower tax rate is to increase the marginal product of capital by nearly 0.09 percentage points for each one-percentage point reduction in the average tax rate (while the effect of the higher deficit is negligible). The higher capital productivity will then accelerate the growth rate of private capital–in the capital stock equation–in two ways: (i) directly, by 0.55 percentage points for each one-

TABLE 2

Simulations of the Model (8).

Australia			Belgium			Canada			Finland			France		
t	def(bil.)	y	t	def(bil.)	y(th.)	t	def(bil.)	y	t	def(bil.)	y	t	def(bil.)	y(th.)
0.238*	−4.16	43385	0.396*	−339.2	1405	0.191*	−12.1	39330	0.28*	−9.33	165227	0.369*	−52.57	125.7
0.238	−4.2	42967	0.396	−338.0	1403	0.191	−12.8	39590	0.28	−9.1	167536	0.369	−53.1	125.3
0.218	−4.0	42845	0.376	−342.0	1440	0.171	−12.7	39605	0.26	−8.9	168642	0.349	−51.6	128.6
0.198	−4.1	42876	0.356	−367.1	1483	0.151	−12.5	39715	0.24	−8.6	169743	0.329	−48.7	132.1
0.178	−3.9	43768	0.336	−386.7	1506	0.131	−12.6	39669	0.22	−8.5	169967	0.309	−45.6	135.7
0.158	−4.0	43949	0.316	−399.5	1557	0.111	−12.8	39573	0.20	−8.1	170536	0.289	−42.8	140.3
0.138	−4.2	44157	0.296	−432.3	1597	0.091	−12.3	38658	0.18	−8.0	171016	0.269	−43.3	141.2
0.118	−4.1	44283	0.276	−457.7	1610	0.071	−12.6	39701	0.16	−8.1	171657	0.249	−44.1	142.9
0.098	−4.2	44456	0.256	−483.8	1632	0.051	−12.5	39650	0.14	−8.2	171983	0.229	−44.5	143.5

Germany			Greece			Italy			Japan			Norway		
t	def(bil.)	y	t	def(bil.)	y(th.)	t	def(tril.)	y(th.)	t	def(tril.)	y(th.)	t	def(bil.)	y
0.257*	−20.16	73328	0.213*	−759.8	2979	0.222*	−228.5	34234	0.116*	−8.99	4540	0.366*	−9.25	299187
0.257	−21.3	73286	0.213	−753	2982	0.222	−227.0	34567	0.116	−8.7	4576	0.366	−9.7	301063
0.237	−21.7	73949	0.193	−789	2995	0.202	−229.0	34973	0.096	−8.6	4593	0.346	−9.2	302167
0.217	−21.6	73565	0.173	−802	3013	0.182	−231.0	35269	0.076	−8.8	4527	0.326	−8.6	302969
0.197	−21.3	73193	0.153	−836	3038	0.162	−236.0	35391	0.056	−8.9	4547	0.306	−8.4	303261
0.177	−21.2	73713	0.133	−897	3063	0.142	−248.0	36011	0.036	−8.8	4568	0.286	−8.1	304013
0.157	−21.7	73369	0.113	−919	3102	0.122	−264.0	36406	—	—	—	0.266	−7.7	304861
0.137	−21.5	73878	0.093	−956	3136	0.102	−260.0	37113	—	—	—	0.246	−7.2	305361
0.117	−21.4	73356	0.073	−997	3187	0.082	−257.0	37604	—	—	—	0.226	−7.1	305901

TABLE 2 (continued).

Sweden			UK			USA		
t	def(bil.)	y	t	def(bil.)	y	t	def(bil.)	y
0.367*	–43.8	267381	0.35*	–7.84	13074	0.19*	–112	38547
0.367	–43.5	267402	0.35	–8.3	12315	0.19	–115	38204
0.347	–41.6	269509	0.33	–8.0	13003	0.17	–114	38163
0.327	–37.4	275693	0.31	–7.7	13873	0.15	–112	37847
0.307	–33.6	279705	0.29	–7.5	14589	0.13	–113	37305
0.287	–28.7	288623	0.27	–7.1	15210	0.11	–111	37409
0.267	–27.3	294796	0.25	–7.4	16608	0.09	–114	37868
0.247	–28.6	293356	0.23	–7.6	16927	0.07	–116	38264
0.227	–31.4	290667	0.21	–7.9	17303	0.05	–113	38973

Note: * indicates actual average (over the sample period) aggregates. t, def and y stand for the average tax rate, average fiscal deficit and average per capita income over the sample period.

percentage point increase in capital productivity, and (ii) indirectly, via the significantly negative coefficient on the interaction variable; that is, the favourable effects on capital growth of the increasing marginal product of capital are accentuated by the sign and magnitude of the coefficient on the interaction variable $(\delta_2 = -1.15)$ [9].

Furthermore, the tax-induced higher rates of private capital accumulation are normally expected to raise output per worker in the production function. The resulting higher levels of output tend to offset in the long run–through broadening the taxable base–the tendency of fiscal deficits to expand in the short run as a result of fixing the average tax rate at lower levels. The net effect on deficits, at a given stream of government expenditure, is indicated by the deficit column for the UK in Table 2: for tax rates as low as 27%, deficits decline, whereas the opposite is true when tax rates drop below 27%. Therefore, the preceding simulations constitute an impressive piece of evidence validating the dynamic Laffer-curve hypothesis for the UK, as lower tax rates (up to 27%) generate a percentage increase in the taxable base that is greater than the percentage reduction in tax rates, with consequential effects on revenue.

A similar pattern of results emerges in simulations pertaining to France, Norway and Sweden. In France, for instance, the rise in simulated output per worker over the actual sample (mean) output reaches nearly 12% at an average tax rate of 29% and continues to rise gradually over the remainder of the simulation. At the lowest simulated rate of 23%, it implies a long run multiplier of 1.14 (14.2% increase in income). The reduction in deficit reaches a peak of FRF 42.8 bil. at an average rate of 29% and then remains below FRF 44.5 bil., thus lowering the actual sample (mean) deficit by

9. Indeed, the meaning of the interaction term $(t * MP)$ is that the influence of the marginal product on the growth rate of capital depends upon the level of the tax burden: as the average tax rate decreases, successively higher levels of capital productivity tend to result in higher rates of capital growth.

15.4% at the end of the simulation process. Accordingly, the impact of fiscal expansion is stronger on deficit than output.

The above countries with decreasing tax-induced deficits have been shown in Section 3 to comprise the group of highly taxed economies. A completely different picture is obtained, however, when we turn to the group of countries with crowding out features (Belgium, Italy, Greece). The results in Table 2 for the latter countries are not supportive at all of the dynamic Laffer-curve formulation, as the policy of reducing tax rates–i.e., the switch from tax finance to bond finance of a given level of government purchases and the concomitant debt creation–has detrimental effects which offset the favourable effects of tax burden alleviation on capital productivity. As a result, the fiscal expansions examined here do not have a major impact on income, while the combination of lower tax rates and smaller taxable base contributes to the gradual escalation of budget deficits.

The results of the simulations for Italy provide a benchmark for comparing the highly taxed with the crowding out group of countries. The projections for Italy show output per worker growing slower than deficit, allowing a move towards virtual destabilization of the public debt. In particular, deficit rises to a peak of ITL 264 tril. or 16% at an average tax rate of 12.2%, relative to the base run (tax rate equal to 22.2%), before falling slightly to about ITL 257 tril. at lower tax rates. The corresponding increase in output is less marked: output goes up solely by 8.8% relative to the base run as the tax rate falls to 8.2%.

The simulation results for Belgium and Greece are similar in many respects to those obtained for Italy. The projections imply a slight increase in output, generated by the fall in average tax rate. While government spending is maintained at the average (over the sample period) level, output increases act to broaden the taxable base to a lesser extent than tax rates fall, so causing the budget deficits to rise.

The third group of countries (Australia, Canada, Germany, Japan, USA and possibly Finland) cannot be ranked in terms of either the crowding out or the highly taxed setups, as the Laffer curve appears to have been replaced by an almost straight line which is horizontal to the tax-rate axis. In the U.S., for example, output per worker is shown to fall at the start of the simulation process, bottoming out at the average tax rate of 13%, from where it rises steadily, though slightly, until the end of the simulation. During the whole simulation process, output only grows by 1.1%, while deficits flatten out at around USD 2.5 bil. above the actual outrun (for the tax rate of 19%) of USD 112 bil., throughout the simulation process.

5 Conclusions

The conclusions regarding the shape of the Laffer curve generated by the relatively simple analytical framework and the highly aggregated model employed in this paper are in general consistent with the basic theoretical principles relating to the crowding out and the disincentive effects of heavy taxation. In empirically investigating the properties of the Laffer curve for 13 OECD countries over the last 30-year period, it was shown that certain attributes of this curve which are widely assumed to hold cannot be accepted for some economies.

The empirical evidence presented in this study highlights the limitations of the assumption that the Laffer curve has the familiar convex shape. In particular, the simulations using the results from the estimated three-equation model demonstrate that a permanent decrease in tax rates is capable of generating larger tax revenues and smaller deficits–at a given path of government spending–in the long run for the highly taxed countries alone. These countries face a dynamic Laffer curve: tax rate reductions have strong effects on the marginal return to capital and aggregate output, thus generating a sufficient expansion of the tax base to offset the decline in revenue resulting from the lower tax rates. In other words, the alleviation of the average tax burden proves to moderate the disincentive effects of taxation and, hence, to mitigate the impact of public-sector malfunctioning on the private investment rate, the output and the tax base. In contrast, the analysis suggests that a permanent reduction in average tax rates can result in increasing long-run government budget deficits in economies with crowding out characteristics, thus providing a strong refutation of the dynamic Laffer-curve proposition. Lastly, deficits are insensitive to tax rate changes in low taxed countries with low deficit/GDP ratios.

Given the limited number of countries considered, our inferences must be taken with caution. The conclusions reached are necessarily tentative and serious reservations may be put forward about the reasonability of using the same econometric model for the economies of the thirteen OECD countries. However, the study provides useful insight into the controversy over the shape of the Laffer curve and may help policy makers to choose the best mix of tax and deficit policies, in order to stimulate economic activity and maximize tax revenues.

Descriptions and Sources

Y = Gross domestic product at constant prices. Source: IMF's International Financial Statistics Yearbook (line 99b.c).

y = real gross domestic product per worker. Data for civilian employment are taken from OECD's Labour Force Statistics.

k = real gross stock of private capital per worker. Source: OECD's Flows and Stocks of Fixed Capital.

G = real government expenditure. Source: IMF's International Financial Statistics Yearbook (lines 82 and 83).

T = real government revenue. Source: IMF's International Financial Statistics Yearbook (line 81).

DEF = real government deficit or surplus. Source: IMF's International Financial Statistics Yearbook (line 80).

IG = real government total gross capital formation. Source: OECD's National Accounts Statistics.

Problems would arise in using the aggregate quantity of government purchases as a proxy for the aggregate of public services, G, in the set of explanatory variables, as suggested by BARRO and MARTIN [1992]. In doing this, the underlying production function relation would be disturbed, because the level of output would be related to both stocks (private capital) and flows (government outlays). To avoid spurious relationships, public capital stock, KG, which is defined here as beginning of period stock, was calculated from government investment expenditure, IG, based on the perpetual inventory model. According to the perpetual inventory method, we have: $KG_t = (1-\delta)KG_{t-1} + IG_{t-1}$. The benchmark for KG was calculated following the procedure suggested by COE and HELPMAN [1995], as $KG_0 = IG_0/(g+\delta)$ where g is the average annual logarithmic growth of government investment spending over the sample period, IG_0 is the first year for which the data were available and KG_0 is the benchmark for the beginning of the year.

Deflation of nominal aggregates is by the GDP deflator from IMF's International Financial Statistics Yearbook (line 99bir).

TABLE A1

Dickey-Fuller and Phillips-Perron Unit Root Test Results.

	Dickey-Fuller (a)						Phillips-Perron (b)					
	y		k		G		y		k		G	
	level	difference	level	difference	level	difference	level	difference	level	difference	level	difference
Australia	–0.62	–3.6*	–1.71	–3.6*	–1.18	–3.8*	–0.40	–5.64	–2.27	–4.06	–0.71	–4.42
Belgium	–1.13	–3.6*	–1.96	–3.9*	–0.72	–3.7*	–1.59	–3.54	–1.84	–4.02	–1.48	–4.67
Canada	–1.18	–4.3*	–1.14	–3.7*	–1.69	–3.9*	–0.98	–3.14	–1.60	–3.14	–2.30	–4.81
Finland	–1.73	–4.1*	–1.48	–4.2*	–0.47	–3.6*	–1.62	–4.26	–1.83	–4.28	–0.66	–5.09
France	–0.83	–3.9*	–0.28	–3.8*	–1.76	–4.0*	–1.23	–4.60	–0.35	–3.63	–2.12	–5.41
Germany	–1.98	–3.6*	–0.76	–3.5*	–1.53	–3.8*	–2.38	–4.46	–0.67	–3.41	–1.36	–6.42
Greece	–0.65	–4.2*	–0.14	–4.1*	–0.84	–4.2*	–0.96	–3.71	–0.35	–3.71	–1.09	–5.87
Italy	–1.45	–3.9*	–1.87	–4.5*	–0.17	–4.6*	–1.68	–4.91	–2.19	–5.05	–0.44	–6.18
Japan	–1.12	–4.8*	–1.24	–4.3*	–1.49	–3.7*	–1.26	–3.80	–1.69	–3.05	–2.16	–4.36
Norway	–0.48	–4.7*	–1.52	–4.6*	–1.94	–4.3*	–0.64	–4.13	–1.07	–3.11	–1.67	–5.17
Sweden	–0.86	–3.7*	–0.74	–3.7*	–0.57	–3.9*	–1.20	–4.22	–0.98	–3.98	–0.68	–5.43
UK	–1.65	–3.5*	–1.62	–3.6*	–0.41	–4.5*	–1.76	–3.25	–2.19	–3.51	–0.97	–5.19
USA	–1.44	–4.0*	–0.89	–4.3*	–1.24	–4.4*	–1.68	–3.68	–1.23	–4.28	–1.47	–4.96

(a) $\Delta X_t = a_0 + a_1 t + a_2 X_{t-1} + \Sigma_{i=1}^{k} b_i \Delta X_{t-i}$. Optimal number of lags is chosen by Akaike's final prediction error criterion. The values shown in the Table denote the t-statistics of X_{t-1}.

* The null hypothesis of the unit root is rejected at 5% level of significance. Critical values are taken from GUILKEY and SCHMIDT [1989].

(b) Critical values (at 95%)=2.93.

TABLE A2

Hafer-Hein's Test Results (Intermediate Estimated Equation with all Dummies).

	Australia	Belgium	Canada	Finland	France	Germany	Greece	Italy	Japan	Norway	Sweden	UK	USA
						Production function (8a)							
A	2.7	4.8	4.1	414.0	28.9	81.6	25.7	9.8	967.2	80.3	124.5	2.64	347.1
	(2.2)	(1.7)	(0.9)	(2.8)	(3.4)	(2.8)	(2.1)	(2.7)	(4.8)	(2.8)	(2.7)	(2.7)	(2.1)
α	0.48	0.693	0.306	0.354	0.451	0.361	0.473	0.652	0.326	0.415	0.683	0.523	0.504
	(2.9)	(3.7)	(2.7)	(3.2)	(4.9)	(3.1)	(3.2)	(5.3)	(3.2)	(2.9)	(4.3)	(3.4)	(3.1)
β	0.54	0.289	0.489	0.402	0.361	0.547	0.203	0.209	0.464	0.574	0.294	0.554	0.327
	(3.3)	(2.7)	(2.7)	(3.0)	(4.1)	(3.5)	(3.1)	(2.8)	(4.7)	(3.6)	(2.3)	(3.5)	(2.7)
$D1$	−0.60	−0.24	1.34	10.6	13.7	−1.4	7.4	3.1	—	—	56.4	1.14	116.3
	(1.5)	(1.4)	(3.4)	(0.7)	(3.1)	(0.7)	(3.6)	(2.8)			(2.3)	(2.8)	(2.8)
$D2$	—	0.63	−0.27	25.4	—	18.7	1.2	—	—	—	8.7	0.26	17.4
		(2.8)	(1.3)	(0.9)		(2.7)	(1.4)				(0.7)	(0.8)	(0.9)
R^2	0.915	0.894	0.991	0.871	0.989	0.981	0.948	0.951	0.987	0.957	0.894	0.938	0.873
DW	1.72	1.72	1.62	1.68	1.54	1.64	1.67	1.52	1.43	1.73	1.75	1.63	1.92
						Private capital growth equation (8b)							
δ_0	−0.036	−0.021	−0.02	−0.013	−0.043	−0.035	−0.029	−0.041	−0.033	−0.046	−0.026	−0.024	−0.037
	(2.4)	(1.6)	(1.8)	(1.8)	(4.7)	(2.5)	(2.3)	(3.4)	(2.4)	(3.2)	(2.5)	(2.5)	(2.2)
δ_1	0.51	0.19	0.44	0.57	0.16	0.82	0.57	0.61	0.67	0.79	0.53	0.57	0.33
	(2.8)	(1.1)	(2.5)	(2.6)	(0.7)	(3.4)	(2.8)	(2.3)	(3.2)	(2.7)	(2.6)	(3.1)	(3.4)
δ_2	1.07	−0.74	−0.71	1.15	−0.25	0.87	−0.79	−0.84	1.22	−0.86	−0.78	−1.12	0.88
	(1.6)	(2.8)	(1.1)	(1.9)	(2.3)	(1.4)	(3.3)	(2.5)	(0.9)	(3.4)	(2.2)	(2.9)	(1.4)
$D1$	−0.40	−0.20	1.17	−0.002	0.017	0.007	−0.013	−0.011	—	—	−0.01	−0.013	−0.016
	(1.2)	(1.1)	(3.1)	(0.4)	(2.9)	(0.7)	(2.6)	(2.3)			(2.7)	(2.9)	(3.1)
$D2$	—	0.76	−0.35	0.005	—	−0.02	0.003	—	—	—	0.003	0.006	0.004
		(2.8)	(1.2)	(0.7)		(2.3)	(0.7)				(1.3)	(1.2)	(0.5)
R^2	0.913	0.901	0.964	0.976	0.991	0.982	0.964	0.962	0.991	0.953	0.866	0.983	0.896
DW	1.65	1.62	1.75	1.57	1.55	1.89	1.64	1.43	1.77	1.76	1.54	1.64	1.79

TABLE A2 (continued).

	Australia	Belgium	Canada	Finland	France	Germany	Greece	Italy	Japan	Norway	Sweden	UK	USA
					Marginal product of private capital equation (8c)								
b_0	0.27	0.76	0.12	0.87	0.67	0.19	0.79	1.27	0.96	0.68	0.91	0.24	0.206
	(3.1)	(1.8)	(0.6)	(3.4)	(5.3)	(3.8)	(3.1)	(3.9)	(6.4)	(2.8)	(2.7)	(4.3)	(3.7)
b_1	−0.03	−0.04	−0.021	−0.13	−0.043	−0.04	−0.05	−0.08	−0.02	−0.06	−0.07	−0.08	−0.084
	(1.5)	(2.9)	(1.3)	(2.2)	(3.4)	(3.0)	(2.6)	(2.5)	(1.4)	(2.8)	(2.3)	(3.7)	(2.7)
b_2	0.011	−0.17	0.05	0.05	0.017	−0.08	−0.16	−0.18	0.04	0.05	−0.12	−0.053	−0.065
	(1.4)	(3.4)	(1.2)	(2.1)	(1.3)	(2.6)	(3.2)	(4.2)	(1.2)	(1.1)	(0.9)	(1.4)	(2.9)
b_3	−0.6 E-4	−0.57 E-4	−0.3 E-5	−0.9 E-6	−0.2 E-5	−0.7 E-6	−0.2 E-4	−0.2 E-5	−0.5 E-7	−0.7 E-5	−0.9 E-4	−0.2 E-5	−0.24 E-5
	(3.2)	(1.3)	(3.16)	(2.5)	(4.7)	(5.3)	(0.8)	(0.3)	(2.9)	(5.6)	(2.6)	(3.8)	(4.6)
b_4	−0.25 E-4	−0.2 E-4	0.12 E-4	−0.5 E-7	−0.13 E-5	0.5 E-6	−0.9 E-5	−0.5 E-4	0.63 E-7	0.8 E-5	−0.2 E-4	−0.8 E-5	0.21 E-5
	(1.4)	(3.2)	(2.2)	(2.4)	(0.7)	(2.3)	(3.2)	(4.1)	(2.4)	(3.1)	(3.7)	(2.1)	(2.7)
b_5	0.0026	0.024	0.007	0.016	0.012	0.004	0.02	0.04	0.04	0.004	−0.04	−0.003	0.003
	(3.3)	(2.7)	(4.3)	(3.4)	(2.2)	(4.8)	(3.4)	(5.3)	(4.2)	(2.9)	(2.9)	(2.6)	(2.9)
$D1$	−0.9	−0.43	1.23	0.17	0.26	0.02	0.24	0.45	—	—	0.32	0.12	0.097
	(1.3)	(1.6)	(3.6)	(0.8)	(3.2)	(1.2)	(2.6)	(2.7)			(2.3)	(2.7)	(3.4)
$D2$	—	0.85	−0.62	−0.15	—	0.09	0.07	—	—	—	0.06	0.03	0.009
		(2.4)	(1.7)	(0.6)		(2.8)	(1.2)				(0.8)	(0.8)	(1.1)
R^2	0.853	0.892	0.832	0.836	0.531	0.972	0.893	0.981	0.986	0.914	0.894	0.986	0.988
DW	1.72	1.84	1.79	1.59	1.81	1.61	1.74	1.82	1.34	1.46	1.89	1.45	1.86

Note: The dummy variable $D1$ covers the following periods: 1991-1994 (Australia), 1981-1992 (Belgium), 1982-1990 (Canada, USA), 1991 (Finland), 1993-1994 (France, Italy), 1982-1992 (Germany), 1987-1992 (Greece), 1992 (Sweden), 1980-1990 (the UK). The dummy variable $D2$ covers the following periods: 1992-1994 (Finland), 1993-1994 (Belgium, Germany, Greece, Sweden), 1991-1994 (Canada, the UK, USA).

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