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The effects of alternative fiscal policies on the intertemporal government budget constraint

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Abstract

This article presents the effects of alternative fiscal policies on the intertemporal government budget constraint when the time horizon of the policy maker varies. I show that the wealth effect associated with cuts in the skill-adjusted labor income tax rate improves the intertemporal budget balance, whereas the intertemporal substitution effect associated with the physical capital income tax rate deteriorates the intertemporal budget. Under plausible parameter values, the tax rate on skill-adjusted labor income cannot by itself balance the intertemporal budget at all horizons. © 2000 Elsevier Science Inc. All rights reserved.

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1. Introduction

This article addresses intertemporal budget issues relating to government expenditure and several distortionary taxes allowing for alternative time horizons for the policy maker. We use an endogenous growth sectoral model of physical and human capital accumulation along the lines of Stokey and Rebelo (1995) and Pecorino (1993) with the inclusion of government debt. This allows me to focus on intertemporal budget balance along the stationary balanced growth path. Three recent contributions by Ireland (1994), Bruce and Turnovsky (1999), and Pecorino (1995) pursue a similar line of analysis using a different framework. The first two papers do not include human

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capital and labor-leisure choice as is done in this paper, whereas Pecorino (1995) does.¹ The differences in results are important. Including human capital and labor-leisure choice makes a physical capital income tax cut *increase* the long run budget imbalance, contrary to the results of Ireland (1994) and Bruce and Turnovsky (1999). Second, extending Pecorino's (1995) analysis I am interested in a quantitative assessment of the extent to which the horizon of the policy maker affects the design of alternative fiscal policies. In Ireland (1994), Bruce and Turnovsky (1999), and Pecorino (1995), the intertemporal budget constraint balances at the infinite horizon, whereas I consider alternative horizons and obtain a richer set of steady state balanced growth comparisons regarding the merits of each tax and/or government spending policy.

In general, I show that the wealth effect of human capital accumulation induced by neutral technical progress to the hours worked, discussed by Ben-Porath (1967) and Heckman (1976) among others, remains intact at the aggregate level, even though the stocks of physical and human capital vary across sectors. This is shown to be the main determinant of a possible improvement in the intertemporal government budget, independently of Laffer style effects on the tax revenues and intertemporal substitution effects in consumption.²

In addition, I show that the shorter the horizon of the policy maker, the larger the government spending cut needed to balance the intertemporal budget. Policies to balance the intertemporal budget only based on tax rate cuts yield unrealistically high rates. In particular, it is shown that, under plausible parameter values, changes in the tax rate on skill-adjusted labor income cannot by itself balance the intertemporal budget. This result arises because of the interaction between worked hours and the economy-wide human-physical capital intensity, which basically determines the sectoral human-physical capital allocations. Thus, decreasing the skill-adjusted labor income tax rate leads to an improvement of the intertemporal budget. The issue of tax incidence arises naturally in this framework. The physical capital income tax shifts the burden to skill-adjusted labor more heavily than vice-versa.

Another result of this paper is that a cut in government spending reduces the intertemporal budget imbalance more effectively relative to other alternatives. This can be coupled with a cut in the physical capital income tax, the skill-adjusted labor income tax, or the consumption tax, as long as it creates a "primary" surplus along the balanced growth path. But, the main ingredient is the cut in (net) non-utility enhancing government spending.

The article is organized as follows: section 2 presents the basic multi-sector model with physical and human capital accumulation; section 3 presents the intertemporal government budget constraint together with the measure of fiscal imbalance, the revenues from the productive factors, and its associated saving rate; section 4 presents the quantitative analysis, while section 5 concludes.

2. Macroeconomic model

The model is embedded in a perfect foresight framework with infinitely lived identical consumers, firms, and government. It is a three sector model with production

of a consumption good, physical and human capital accumulation, and constant point-in-time returns to scale technologies. There is one nonreproducible factor input, the hours worked in market activities. The model is closely related to those in Stokey and Rebelo (1995) and Pecorino (1993) with the addition of government borrowing and lending as in Ireland (1994), Bruce and Turnovsky (1999), and Pecorino (1995). Since the framework is mostly standard, the presentation is brief.

The representative household solves the intertemporal problem [Eq. (1)]

$$\begin{aligned} & \text{Max } \int_0^\infty U(c, \ell) e^{-\rho t} dt \\ & \{c, \ell, k, h, b\} \end{aligned} \quad (1)$$

subject to the budget constraint [Eq. (1a)]

$$\begin{aligned} & (1 + \tau_c) c + P_k(\dot{k} + \delta_k k) + P_h(\dot{h} + \delta_h h) + \dot{b} \\ & \leq (1 - \ell)P_h h w (1 - \tau_h) + P_k k r (1 - \tau_k) + b r_b - T \end{aligned} \quad (1a)$$

and given initial holdings [Eq. (1b)]

$$k_0 > 0, h_0 > 0, b_0 > 0, \quad (1b)$$

where all variables are in real terms, c is private consumption, ℓ is leisure, $\rho > 0$ is the consumer subjective rate of time preference, k is the stock of physical capital held by the consumer with δ_k denoting its rate of depreciation, h is the stock of human capital held by the consumer with δ_h denoting its rate of depreciation, b is the stock of domestic short bonds issued by the government and held by the consumer, P_k is the price of physical capital relative to the consumption good, which is taken as the numeraire, P_h is as well the relative price of human capital, w is the wage rate, r is the rental rate of physical capital, r_b is the return on government bonds, and T is a lump-sum tax-rebate. In addition, agents face a set of flat tax rates τ_i , $i = c, k, h$, on consumption, physical capital income, and wages. The instantaneous utility function $U(c, \ell)$ is a well-defined concave function with partials $U_c > 0$, $U_{cc} < 0$, $U_\ell > 0$.

The first order conditions for an interior solution to this problem are given by

$$U_c(c, \ell) = \lambda (1 + \tau_c) \quad (2a)$$

$$U_\ell(c, \ell) = \lambda P_h h w (1 - \tau_h) \quad (2b)$$

$$r(1 - \tau_k) - \delta_k = (\dot{P}_k/P_k) + \rho - (\dot{\lambda}/\lambda) \quad (2c)$$

$$(1 - \ell)w(1 - \tau_h) - \delta_h = (\dot{P}_h/P_h) + \rho - (\dot{\lambda}/\lambda) \quad (2d)$$

$$r_b = \rho - (\dot{\lambda}/\lambda) \quad (2e)$$

together with the transversality conditions

$$\lim_{t \rightarrow \infty} \lambda k e^{-\rho t} = 0; \quad \lim_{t \rightarrow \infty} \lambda h e^{-\rho t} = 0; \quad \lim_{t \rightarrow \infty} \lambda b e^{-\rho t} = 0 \quad (2f)$$

where λ , the Lagrange multiplier associated with the accumulation Eq. (1a), is the

marginal utility of wealth of the consumer. Eqs. (2a) and (2b) are marginal conditions for consumption and leisure, while (2c), (2d), and (2e) are arbitrage conditions equating rates of return across holdings of assets and consumption.

The production side of the model consists of three separate constant point-in-time returns to scale production technologies for physical capital, human capital, and consumption using as inputs physical and human capital. Denote by $G(k_k, h_k)$ the production function for the production of physical capital, where k_k is the part of the total physical capital stock used in the production of capital goods and h_k the part of the total human capital also used in the production of capital goods. Likewise, $H(k_h, h_h)$ is the production function for human capital, and $F(k_c, h_c)$ is the production function for consumption goods. Then, profit maximizing behavior by competitive firms implies the following first order conditions

$$P_k G_1(h_k/k_k) = P_h H_1(h_h/k_h) = F_1(h_c/k_c) = r P_k \quad (3a)$$

$$P_k G_2(h_k/k_k) = P_h H_2(h_h/k_h) = F_2(h_c/k_c) = w P_h \quad (3b)$$

where G_1 is the marginal physical product of physical capital in the capital good sector, G_2 is the marginal physical product of human capital in the capital good sector, and so on. Human/physical capital ratios are well defined by the constant returns to scale assumption. In closing the model, the government obeys a flow budget constraint consistent with its capacity to tax and borrow from the private sector, given a path of government consumption expenditure denoted by g . This is given by

$$\dot{b} = r_b b + g - \tau_k r P_k k - \tau_h w P_h h (1 - \ell) - \tau_c c - T. \quad (4)$$

2.1. Balanced growth path

It is well known that the model presented above sustains endogenous long run growth. Along this balanced growth path, the interest rate and wages, and the relative prices of physical and human capital are constant. Under mild restrictions on preferences, leisure is also constant along the balanced growth path.³ The common endogenous growth rate, denoted by θ , for c , k , h , b , and g along the balanced growth path is given by

$$\theta = (1/\sigma) [(1 - \tau_k) G_1(h_k/k_k) - \delta_k - \rho] \quad (5a)$$

where $0 < (1/\sigma) < \infty$ is the consumer intertemporal elasticity of substitution in consumption. Defining the momentary utility function of the representative consumer to be of the constant elasticity of substitution form,

$$U(c, \ell) = \{[cv(\ell)]^{(1-\sigma)} - 1\}/(1 - \sigma)$$

where $v(\ell)$ is well defined, and combining Eqs. (2), (3a), and (3b) with the equilibrium in the three goods markets yields the general equilibrium balanced growth path for the endogenous variables: (h_k/k_k) , (h_h/k_h) , (h_c/k_c) , ℓ , (c/k) , (h/k) , θ , (k_k/k) , (k_h/k) , (k_c/k) , r , w , P_k , and P_h . Then, Eqs. (2c) and (2e) determine r_b . These variables are solved as implicit functions of the tax rates, government consumption expenditure as a share of the capital stock, and the parameters of utility and technologies.⁴

Along the balanced growth path the lifetime welfare of the representative individual may be computed from Eq. (1), giving the formula

$$W = -\{[c(o)v(\ell)]^{(1-\sigma)}/\{[1-\sigma][\theta(1-\sigma)-\rho]\}\} - [1/\rho(1-\sigma)]. \quad (5b)$$

Lifetime welfare is increasing in the growth rate, θ , and under the usual conditions that make the integral in Eq. (1) well defined, it is increasing in consumption and leisure.

3. The intertemporal government budget constraint

The final equation is the flow government budget constraint (4). Across balanced growth paths, budget deficits are perfectly correlated with the economy-wide growth rate θ . As is usual, lump-sum taxes guarantee the government's intertemporal or long run solvency. Integrating Eq. (4) forward and using the results above one obtains, for every time t , the expression,

$$\begin{aligned} b(t) = & e^{(1-\tau_b)r_b t} \{b_o - [\int_0^t T(s) e^{-(1-\tau_b)r_b s} ds] \\ & + k_o[(g/k) - \tau_k r P_k - \tau_h w P_h(h/k)(1-\ell) - \tau_c(c/k)] \\ & \times [\int_0^t e^{(\theta+\delta_k-r(1-\tau_k)s} ds]\}. \end{aligned} \quad (6)$$

The measure of long run intertemporal solvency that I use is based on the consumer transversality condition given in Eq. (2f). However, I allow the government sector to balance the intertemporal budget at any date T^* in the future, where $0 \leq T^* \leq \infty$. This provides a richer set of choices for several reasons. First, the process of fiscal reform, observed in OECD countries in general and in the U.S. in particular, is always associated with some projected balance at a finite horizon, say T^* periods into the future. Second, as Auerbach (1994) shows, different branches of government have different scenarios for the revenues and expenditures T^* periods into the future, leading to alternative estimates of the imbalances for a finite horizon. Third, $T^* \rightarrow \infty$ may be only considered an upper bound on the long run budget imbalance since in some cases actions can be taken at some $t < \infty$, which change the course of the economy and alter the extent of the intertemporal imbalance. Fourth, a large body of political economy literature (Persson & Svensson, 1989; Chari & Cole, 1993 among others) shows how the timing of policies affects the pattern of government expenditures and its financing alternatives. To sum, allowing the horizon to vary gives me latitude to explore some more interesting fiscal policy choices.

Applying the condition in Eq. (2f) for $t \rightarrow T^*$ and using Eq. (6) gives the formula⁵

$$\begin{aligned} (1/k_o) \{ \int_0^{T^*} T(s) e^{-(1-\tau_b)r_b s} ds \} \equiv V(T^*) = \\ (b_o/k_o) + \{ [(g/k) - \tau_k r P_k - \tau_h w P_h(h/k)(1-\ell) - \tau_c(c/k)] \\ \times (e^{\theta+\delta_k-r(1-\tau_k)T^*} - 1)/(\theta + \delta_k - r(1-\tau_k)) \}. \end{aligned} \quad (7)$$

Eq. (7) is a key expression for the analysis of the intertemporal budget policies in

this paper. The variable $V(T^*)$ is the value of lump-sum taxes as a share of the initial capital stock necessary to balance the intertemporal budget as a function of the time horizon T^* . As long as the implicit discount rate $(\theta + \delta_k - r(1 - \tau_k))$ is strictly negative, when $T^* \rightarrow \infty$ Eq. (7) converges to the usual intertemporal condition that the present discounted value of lump-sum taxes equals the initial stock of debt minus the present discounted value of future primary surpluses. Alternatively, as $T^* \rightarrow 0$, the variable $V(T^*)$ approaches (b_o/k_o) , the initial stock of debt to capital ratio.⁶

The interpretation given to Eq. (7) is that a policy to “balance” the intertemporal budget in $0 \leq T^* \leq \infty$ periods requires that the other taxes— τ_k , τ_h , τ_c , and/or government consumption expenditure as a share of the capital stock, (g/k) —are chosen such that $V(T^*) = 0$. Any other government policy with $V(T^*) > 0$, implies that in net terms some form of lump-sum taxation is necessary to balance the budget for the T^* horizon. Alternatively, a policy that sustains $V(T^*) = 0$, for a T^* horizon, requires that the present discounted value of lump-sum taxes be 0, implying no net disbursements along the horizon.⁷

It is useful to compute the partial derivative of $V(T^*)$ with respect to T^* from Eq. (7), obtaining

$$\partial V(T^*)/\partial T^* = \gamma e^{\theta + \delta_k - r(1 - \tau_k) T^*} \quad (8)$$

where $\gamma \equiv [(g/k) - \tau_k r P_k - \tau_h w P_h (h/k)(1 - \ell) - \tau_c (c/k)]$ is the budget deficit plus lump-sum taxes minus interest payments on outstanding debt, as a share of the physical capital stock [see Eq. (4)]. This is some variant of the “primary” deficit. If this primary deficit is positive, $\gamma > 0$, then $V(T^*)$ is increasing in T^* , $\partial V(T^*)/\partial T^* > 0$, and to minimize the value of $V(T^*)$ it is optimal to set $T^* = 0$. Intuitively in this case, the value of $V(T^*)$ for $0 < T^* \leq \infty$ needed to balance the long run intertemporal budget is greater than the initial stock of debt (b_o/k_o) and the minimum requires $T^* = 0$, or $V(T^*) = (b_o/k_o)$. If this primary deficit is negative, say there is a primary surplus, $\gamma < 0$, and $V(T^*)$ is decreasing in T^* , then $\partial V(T^*)/\partial T^* < 0$. To minimize the value of $V(T^*)$, it is optimal to set $T^* \rightarrow \infty$. In this case, the value of $V(T^*)$ for $0 \leq T^* < \infty$ needed to balance the long run budget is smaller than the initial stock of debt (b_o/k_o) and the minimum requires $T^* \rightarrow \infty$, or $V(T^*) = (b_o/k_o) - \gamma[1/(\theta + \delta_k - r(1 - \tau_k))]$. In the knife edge case, where the measure of primary deficit is 0, $\gamma = 0$, then $\partial V(T^*)/\partial T^* = 0$ independently of the horizon T^* .

Studying alternative strategies for a balanced intertemporal budget at the horizon T^* involves the effects of taxes and expenditures on the economy-wide growth rate and possibly the relative effects on the tax bases. These effects are associated with the possibility of “dynamic scoring”: a cut in the physical capital income tax rate stimulates the growth rate, expanding the tax base and improving the long run intertemporal budget balance (see Ireland, 1994; Bruce & Turnovsky, 1999; Pecorino, 1995). On the other hand, along the balanced growth path, an increase in the economy-wide growth rate induces an increase in the *flow* budget deficit in equation (4) because along the balanced growth path, c , k , h , b , and g all grow at the common rate determined by Eq. (5a). Thus, in this model there is no “static” scoring when comparing alternative balanced growth paths.⁸

Table 1

Functional forms and benchmark parameter values

$G(k_k, h_k) = A_k k_k^{\alpha_k} h_k^{(1-\alpha_k)}, A_k > 0, 0 < \alpha_k < 1$
$H(k_h, h_h) = A_h k_h^{\alpha_h} h_h^{(1-\alpha_h)}, A_h > 0, 0 < \alpha_h < 1$
$F(k_c, h_c) = A_c k_c^{\alpha_c} h_c^{(1-\alpha_c)}, A_c > 0, 0 < \alpha_c < 1$
$v(\ell) = \ell^\phi, \phi \geq 0$

$k_o = 1$
$\alpha_k = \alpha_h = \alpha_c = 0.25$
$\delta_k = \delta_h = 0.025$
$A_k = A_c = 1$
$\sigma = 2.0$
$\phi = 0.5$
$\tau_k = \tau_h = 0.30$
$\tau_c = 0$
$(g/k) = 0.07$
$\rho = 0.02$
$A_h = 0.1426$
$b_o = 0.15$

The revenue as a share of total output generated by the tax on the return to physical capital is

$$R_k = P_k r \tau_k / [P_k (\theta + \delta_k) + P_h (h/k)(\theta + \delta_h) + (c/k) + (g/k)] \quad (9a)$$

where total output as a share of the capital stock is defined as

$$Y/k \equiv [P_k (\theta + \delta_k) + P_h (h/k)(\theta + \delta_h) + (c/k) + (g/k)].$$

Similarly, the revenue from the tax on the return to skill-adjusted labor is

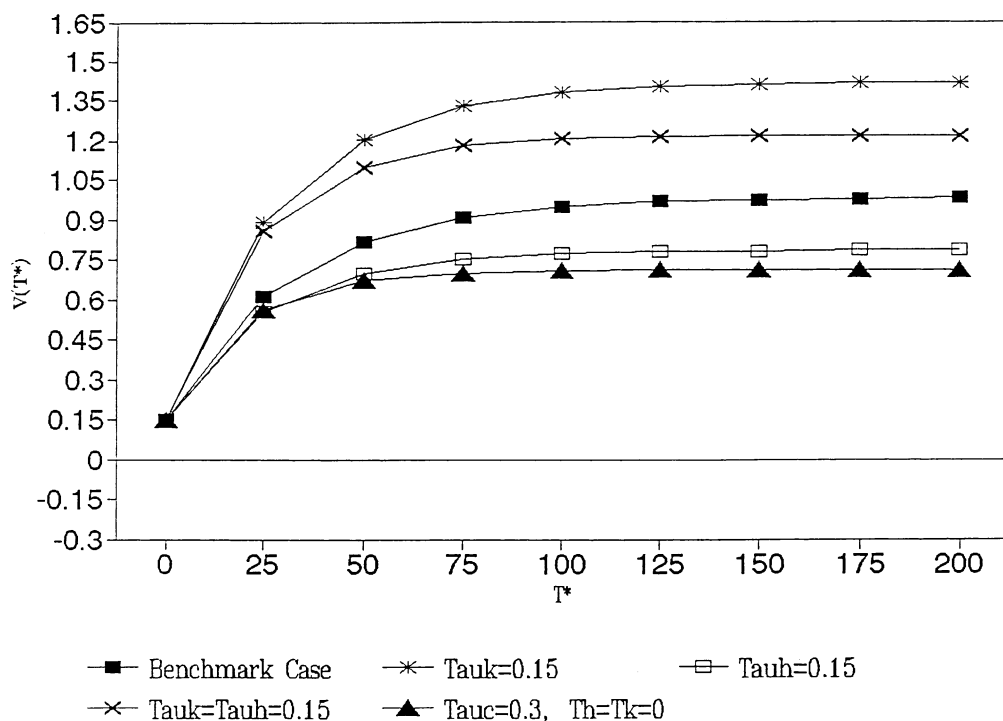
$$R_h = (1 - \ell) P_h (h/k) w \tau_h / [P_k (\theta + \delta_k) + P_h (h/k)(\theta + \delta_h) + (c/k) + (g/k)]. \quad (9b)$$

From Eqs. (9a) and (9b), note that changes in tax rates, government expenditures, and the implied change in interest and wage rates will impact government revenues through the economy-wide growth rate, relative prices, and allocations (h/k) and (c/k).

A closed form analytic solution for the model presented may be only obtained in some special cases.⁹ My analysis compares economies along alternative steady state balanced growth paths thus leaving aside transitional dynamics. I use numerical simulations as has been the norm in the related literature. See Lucas (1990), King and Rebelo 1990, Pecorino (1993, 1994, 1995), Ireland (1994), and Devereux and Love (1994) among others.

4. Quantitative analysis

The functional forms and parameter values used are familiar from the articles by Lucas (1990), Pecorino (1993), Stokey and Rebelo (1995), and others (listed in Table 1). Technology in each sector is of the Cobb-Douglas type with the A's denoting the

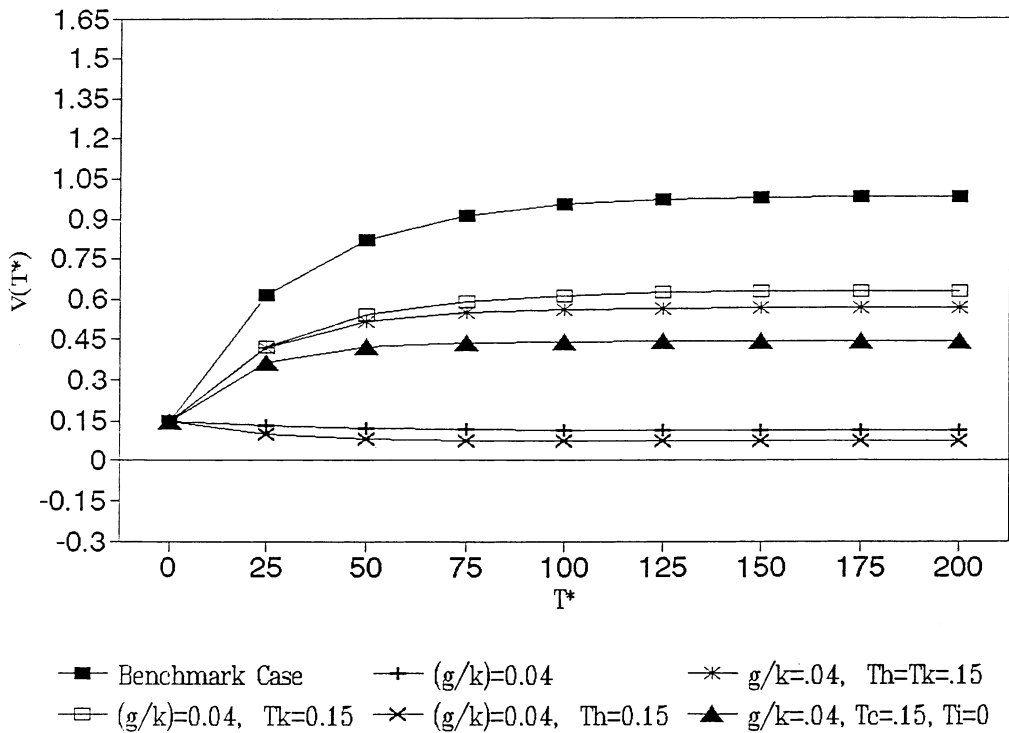
Fig. 1. $V(T^*)$: Tax rate cuts.

level of technology and α 's the physical capital shares. Preferences are CES as defined above and the function $v(\ell)$ for leisure is also of the constant elasticity form, where ϕ determines the consumer preference towards leisure. First, I calibrate the model and solve for a benchmark balanced growth path. Following King and Rebelo (1990), I combine this base parameter set with chosen values for the before-tax real interest rate, $r = 0.10$, and the economy-wide growth rate, $\theta = 0.0125$, and find the implied values for $\rho = 0.02$ and $A_h = 0.1426$ that support this allocation along the balanced growth path. This base set implies that the sectoral human/physical capital ratios are identical, or $(h_k/k_k) = (h_h/k_h) = (h_c/k_c) \equiv z$, and the solution for z reduces to¹⁰

$$z = (h/k) (1 - \ell). \quad (10)$$

The implied output-capital ratio in this benchmark allocation is $Y/k = 0.3133$; thus the initial stock of government debt is set at $b_o = 0.15$ giving a debt-output ratio of about 48%, close to the current level in the U.S. economy.

Fig. 1 and 2 present the function $V(T^*)$ evaluated at the base set and some alternative values for taxes and government expenditure. At the benchmark balanced growth path, $\gamma = 0.0272 > 0$, or the primary deficit is some 2.7% of the capital stock. Thus, $V(T^*)$ is increasing in the horizon T^* with a half-life of about 8.6 periods (years, for example). In this case, the shorter the time horizon T^* , the smaller the net disbursement $V(T^*)$. At $T^* = 0$, $V(T^*) = 0.15$, the initial debt-capital ratio. As $T^* \rightarrow \infty$, $V(T^*) =$

Fig. 2. $V(T^*)$: Government expenditure and tax cuts.

0.9857 or about 99% of the capital stock.¹¹ Tables 2 and 3 show percentage point changes from the benchmark allocations under alternative tax and government expenditure combinations.

4.1. Tax rate cuts

If the physical capital income tax is cut in half to $\tau_k = 0.15$ and all the other parameters are unchanged, Table 2 shows that the primary deficit, γ , increases by about 1.8%, and as $T^* \rightarrow \infty$, $V(T^*)$ increases by 43.2% to about 142% of the capital stock. There is no dynamic scoring as can be seen in Fig. 1 because $V(T^*)$ is above the benchmark level for all T^* . Alternatively, if the skill-adjusted labor tax is cut in half to $\tau_h = 0.15$ and all other parameters are unchanged, the primary deficit, γ , decreases by about 0.2%, and as $T^* \rightarrow \infty$ $V(T^*)$ decreases by 19.7% to about 79% of the capital stock. In this case, there is dynamic scoring in the sense that the present discounted value of lump sum taxes, as a share of the capital stock, decreases. The important result, seen in Fig. 1, is that, when $\tau_h = 0.15$, $V(T^*)$ is below the benchmark case for all $T^* > 0$.¹²

The key to understanding these results is the effect on the economy-wide human/physical capital intensity, h/k , and the sectoral human/physical capital intensities, z , from Eq. (10). When τ_k decreases, leisure decreases by 3.3%, h/k decreases by 7.6%,

Table 2

Tax rate cuts: Percentage points from benchmark values

	$\tau_k = 0.15$	$\tau_h = 0.15$	$\tau_k = 0.15$ $\tau_h = 0.15$	$\tau_c = 0.30$ $\tau_k = 0$ $\tau_h = 0$
c/k	-4.5	3.1	-2.3	-5.7
h/k	-7.6	9.2	0	0
Y/k	-4.3	4.6	-0.7	-12.7
z	-4.1	8.9	3.4	4.5
k_c/k	-4.9	-5.2	-10.4	-19.3
k_h/k	2.2	5.3	7.8	14.5
k_k/k	2.7	-0.1	2.6	4.8
h_c/h	-1.4	-0.7	-2.8	-8.5
h_h/h	2.4	5.2	8.1	14.3
h_k/h	2.3	0.4	2.7	4.8
ℓ	-3.3	-4.9	-7.9	-10.5
r	-1.1	2.2	0.9	1.1
$(1 - \tau_k)r$	0.6	1.5	2.2	4.1
w	0.5	-0.9	-0.4	-0.5
$(1 - \tau_h)w$	0.4	1.4	1.8	3.8
θ	0.3	0.8	1.1	2.1
$V(T^* \rightarrow \infty)$	43.2	-19.7	23.5	-27.0
γ	1.8	-0.2	1.9	0.3
$ \theta + \delta_k - r(1 - \tau_k) $	0.3	0.8	1.1	2.1
R_k	-4.7	0.6	-4.2	—
R_h	-1.2	-6.8	-7.5	—
W	-31.9	29.1	2.1	-8.6

The ratios h_i/h , for $i = c, h$, and k , are computed from the table as $h_i/h = (1 - \ell) (k_i/k)$.

and z decreases by 4.1%. Thus, the negative impact on h/k is greater than the positive impact of more hours worked, and the sectoral intensities z fall. This leads to an increase in the primary deficit, γ , by 1.8% and a consequent deterioration of the intertemporal budget. When τ_h decreases, leisure decreases by 4.9%, but h/k increases by 9.2%, and the sectoral intensities z increase by 8.9%. In this case, the positive impact on h/k adds to the positive impact of more hours worked and z increases. This leads to a fall in the primary deficit of 0.2% and an improvement of the intertemporal budget. Note also that when τ_k decreases, physical capital moves evenly from the consumption sector to the physical and human capital sectors, -4.9%, 2.7%, and 2.2%, respectively. Alternatively, when τ_h decreases, physical capital moves from the consumption and physical capital sectors to the human capital sector, -5.2%, -0.1%, and 5.3%, respectively. This asymmetry implies that the capital income tax cut makes the physical and human capital sectors less substitutes and more complements. However, the human capital tax cut leads to a battle of the sectors as physical and human capital sectors become more substitutes and less complements.¹³

In this general equilibrium framework, lifetime welfare is increasing in the growth rate and in consumption and leisure, e.g., Eq. (5b). When τ_k decreases, the positive

Table 3

Government expenditure and tax cuts: Percentage points from benchmark values

	$g/k = 0.04$	$g/k = 0.04$ $\tau_k = 0.15$	$g/k = 0.04$ $\tau_h = 0.15$	$g/k = 0.04$ $\tau_k = 0.15$ $\tau_h = 0.15$	$g/k = 0.04$ $\tau_k = \tau_h = 0$ $\tau_c = 0.15$
c/k	2.4	-1.9	5.8	0.5	-2.6
h/k	0	-7.5	9.2	0	0
Y/k	-0.7	-5.0	4.1	-1.1	-2.8
z	-1.5	-5.6	7.3	1.9	3.8
k_c/k	1.3	-3.1	-4.2	-8.9	-18.4
k_h/k	-1.0	0.9	4.5	6.7	13.8
k_k/k	-0.3	2.2	-0.3	2.2	4.6
h_c/h	-1.5	-2.9	-1.6	-3.7	-8.6
h_h/h	-1.6	0.3	3.7	6.0	13.1
h_k/h	-0.5	1.4	-0.1	2.0	4.4
ℓ	3.6	1.2	-2.0	-4.4	-8.8
r	-0.3	-1.5	1.8	0.5	1.0
$(1 - \tau_k)r$	-0.2	0.3	1.3	1.9	4.0
w	0.2	0.8	-0.8	-0.2	-0.4
$(1 - \tau_h)w$	0.1	0.1	1.5	1.9	3.9
θ	-0.1	0.1	0.6	0.9	2.0
$V(T^* \rightarrow \infty)$	-87.3	-35.5	-91.4	-41.8	-54.0
γ	-2.8	-1.1	-3.0	-1.0	-1.2
$ \theta + \delta_k - r(1 - \tau_k) $	-0.1	0.1	0.6	1.0	2.0
R_k	-0.2	-4.7	0.4	-4.3	—
R_h	8.1	6.4	-2.6	-3.4	—
W	15.1	-5.8	40.7	22.6	17.7

The ratios h_i/h , for $i = c, h$, and k , are computed from the table as $h_i/h = (1 - \ell) (k_i/k)$.

effect on the growth rate is too small to offset the loss in consumption and leisure, and lifetime welfare falls by some 32%. When τ_h decreases, consumption and the growth rate increase, thus offsetting the loss from the decline in leisure, and welfare rises by some 29%.¹⁴

The economic mechanism behind the effects of a cut in τ_k centers on the consumer intertemporal substitution parameter. The implied moderate increase in the after-tax real return on physical capital induces the consumer to postpone current consumption by increasing the saving rate on physical capital.¹⁵ Alternatively, a cut in τ_h leads to a relatively larger increase in the after-tax real return on skill-adjusted labor and an increase in the sectoral intensities, z . It has been pointed out, as early as Ben-Porath (1967) and later by Heckman (1976), that human capital can operate as endogenous neutral technical progress by enhancing the productivity of hours worked. Thus, a cut in τ_h functions very much like an outward shift in the economy-wide production possibilities surface, having little to do with intertemporal substitution in consumption and more to do with aggregate wealth effects. As Table 2 shows, z increases when τ_h is cut leading to aggregate neutral technical progress.

The third column of Table 2 shows the case when the two taxes are cut symmetrically,

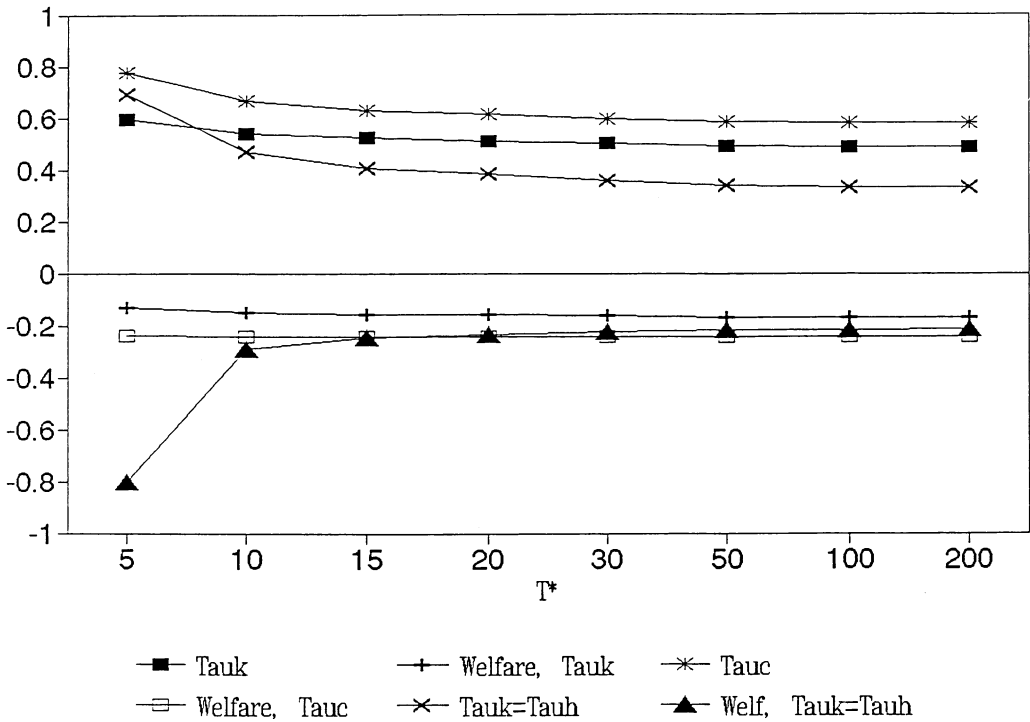
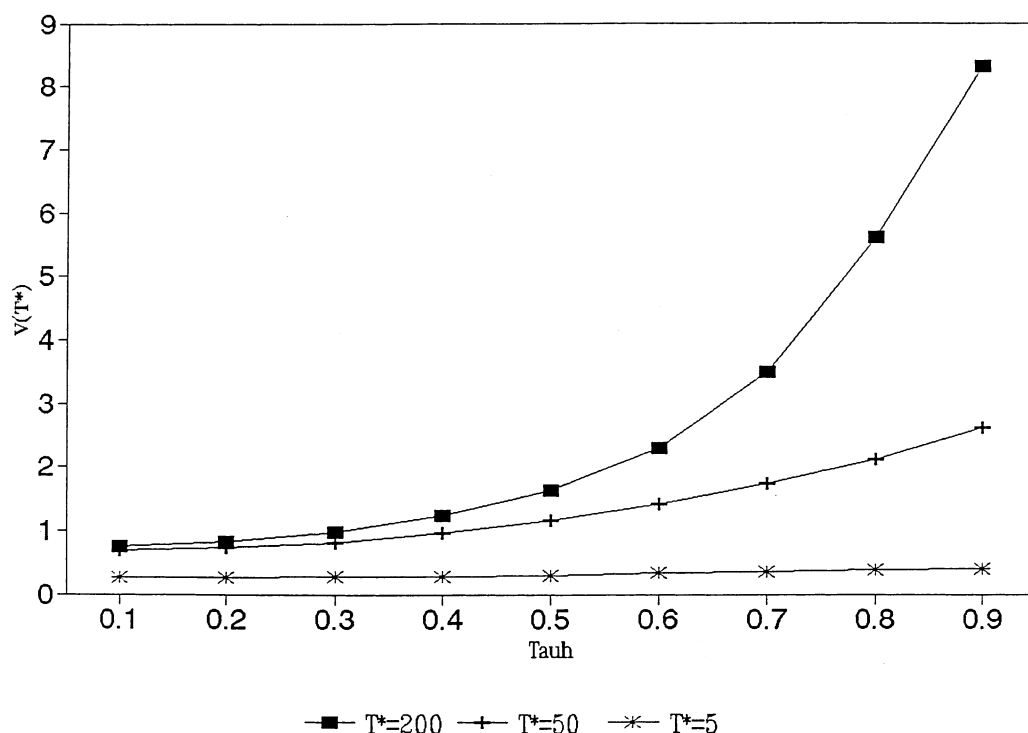


Fig. 3. $V(T^*) = 0$ with endogenous tax rates.

$\tau_k = \tau_h = 0.15$. Fig. 1 shows that there is no dynamic scoring, and the final impact on $V(T^*)$ is intermediate between τ_k and τ_h . The economic rationale is that the intertemporal substitution effect associated with τ_k dominates the wealth effect associated with τ_h . The last column presents the case where the two rates are set to 0, $\tau_k = \tau_h = 0$, and replaced by a flat consumption tax, $\tau_c = 0.30$. Because of the endogenous labor-leisure choice, these two scenarios are obviously opposites. In fact, leisure falls by 10.5%, and a combination of higher discount on future deficits, $|\theta + \delta_k - r(1 - \tau_k)|$ increases by 2.1%, and a minor increase in the primary deficit, up by 0.3%, leads to the best scenario for improved intertemporal budget balance in the class of tax rate alternatives. However, the general equilibrium effect on lifetime welfare is negative; the fall in consumption and leisure more than offsets the increase in the growth rate, and welfare falls by 8.6%.

4.2. Government expenditure and tax cuts

Fig. 2 and Table 3 present cases where government expenditure is cut, cases where government expenditure and tax rates are cut simultaneously, and a case where government expenditure is cut and a consumption tax replaces the two other tax rates. Comparing Figs. 1 and 2, it is clear that cutting government expenditure improves the intertemporal balance much more effectively and more rapidly than cutting tax

Fig. 4. $V(T^*)$ and τ_h .

rates only, at all horizons T^* . In the first column, g/k is cut by 3 percentage points, representing an approximate 9% drop in government expenditure as a share of output. This is very effective in reverting the primary deficit into a primary “surplus,” since γ decreases by 2.8%. As $T^* \rightarrow \infty$, $V(T^*)$ decreases by 87.3% to about 11% of the capital stock. In this case, as Fig. 2 shows, the longer the time horizon T^* , the smaller the net disbursement $V(T^*)$. Lifetime welfare, W , increases by some 15%, but there is more private consumption and less private saving. There is a clear substitution of government consumption for private consumption; c/k increases by 2.4%.

A cut in government expenditure coupled with a cut in τ_k decreases the primary deficit but does not produce a primary surplus since γ falls only by 1.1%. As $T^* \rightarrow \infty$, $V(T^*)$ decreases by 35.5%, but the longer the time horizon T^* , the larger the net disbursement $V(T^*)$. Lifetime welfare, W , decreases by 5.8%, with less private consumption and more private saving due to the intertemporal substitution mechanism. When τ_h is cut, the battle of the sectors and wealth effects discussed above are again observed. There is a primary surplus, γ decreases by 3.0%, and as $T^* \rightarrow \infty$, $V(T^*)$ decreases by 91.4% to about 7% of the capital stock. This is seen in Fig. 2 to be the best scenario in terms of long run budget balance. Lifetime welfare, W , increases by 40.7% with more private consumption. The two last columns present the cases where government expenditure is cut along with (a) cuts in the two tax rates and (b) the

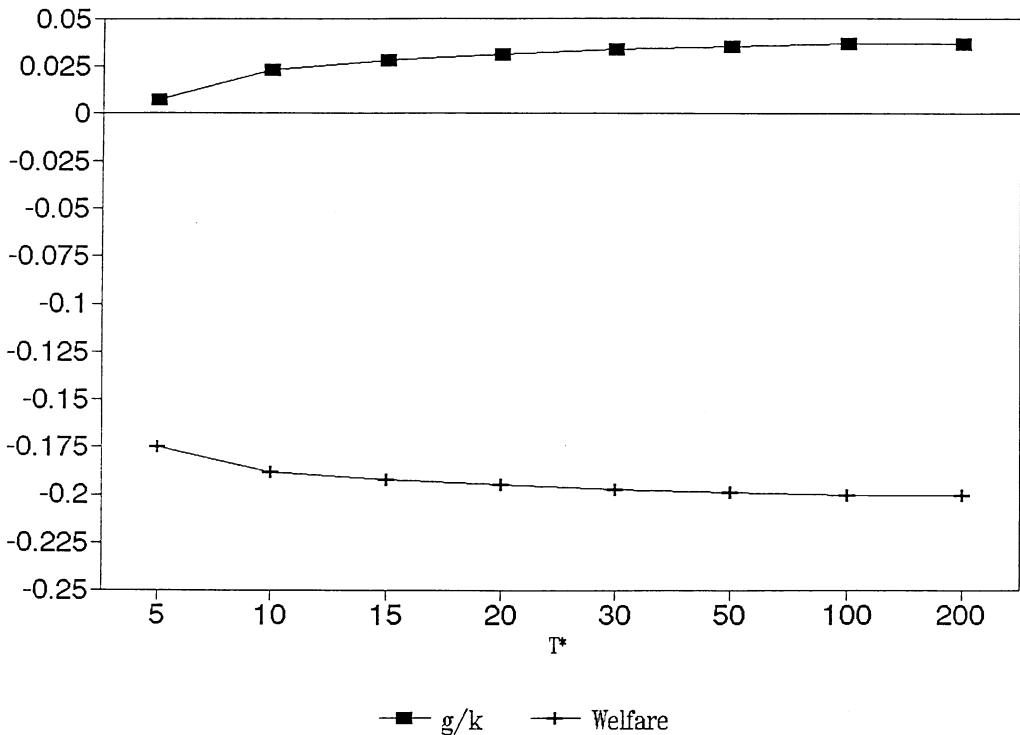


Fig. 5. $V(T^*) = 0$ with endogenous g/k .

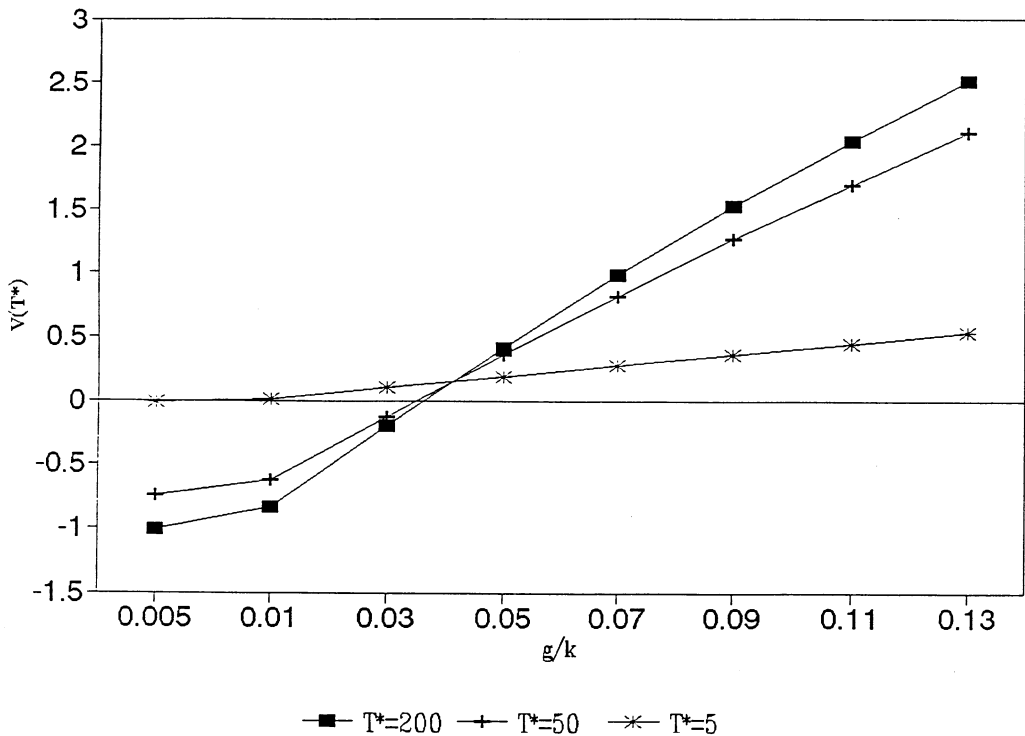
two tax rates are substituted by a consumption tax. These two cases are somewhat similar except for the effects on private consumption that are obviously diametrically opposed.

To sum up, within the long run intertemporal balance dimension, cutting government expenditure is the most effective tool. Given the neutral technical improvement generated by human capital accumulation, a cut in government expenditure coupled with a cut in the skill-adjusted labor income tax rate provides the best policy choice for improving the intertemporal budget.

4.3. Policies to balance the intertemporal budget

The balanced intertemporal budget concept introduced above is a situation where $V(T^*) = 0$ along the balanced growth path. In this case, a surplus is generated that pays the interest on the outstanding debt. Fig. 3 shows tax rates and welfare at different horizons T^* for the cases where (a) τ_k is set endogenously for $V(T^*) = 0$; (b) τ_c is set endogenously for $V(T^*) = 0$ while $\tau_k = \tau_h = 0$; and (c) $\tau_k = \tau_h$ are set endogenously for $V(T^*) = 0$.

In all cases, balancing at a shorter horizon requires a higher tax rate, and as the horizon gets longer the tax rates fall monotonically. The tax rates range from $\tau_c = 77\%$ at $T^* = 5$ to $\tau_k = \tau_h = 33\%$ at $T^* = 200$. Welfare is decreasing with the horizon

Fig. 6. $V(T^*)$ and g/k .

T^* in cases a and b but not in case c because the symmetric skill-adjusted labor tax induces higher consumption of leisure and goods as T^* increases. The tax on skill-adjusted labor income, τ_h , cannot by itself sustain a balanced budget with $V(T^*) = 0$ along a balanced growth path under the base parameter set. The reason for this result is depicted in Fig. 4, where it is shown that τ_h is increasing in $V(T^*)$ for all horizons T^* and more importantly, $V(T^*) > 0$ for all τ_h at all horizons T^* . In turn, there is no value of τ_h that can bring the quantity $V(T^*)$ below its initial level equal to the initial stock of government debt. The economics of this result are associated with the negative wealth effect implied by the higher tax rate, τ_h .

Fig. 5 and 6 show the case where government expenditure is chosen to make $V(T^*) = 0$ and the relationship between $V(T^*)$ and g/k for alternative horizons T^* . In Fig. 5, the values of g/k range from 0.07% of the capital stock at $T^* = 5$ to 3.6% at $T^* = 200$. Welfare decreases with T^* , but the levels are comparable to the tax rate cases. In Fig. 6, it is shown that $V(T^*)$ is increasing in g/k for all T^* , but $V(T^*) < 0$ for a wide range of g/k values at different horizons, allowing government expenditure to be consistent with $V(T^*) = 0$. The figure also shows that whether the government has a short horizon or a long horizon makes a difference for the change in $V(T^*)$. A change in g/k at the short horizon induces a very small change in $V(T^*)$; the curve is less steep. At the long horizon it induces a much larger effect; the curves at $T^* = 50$

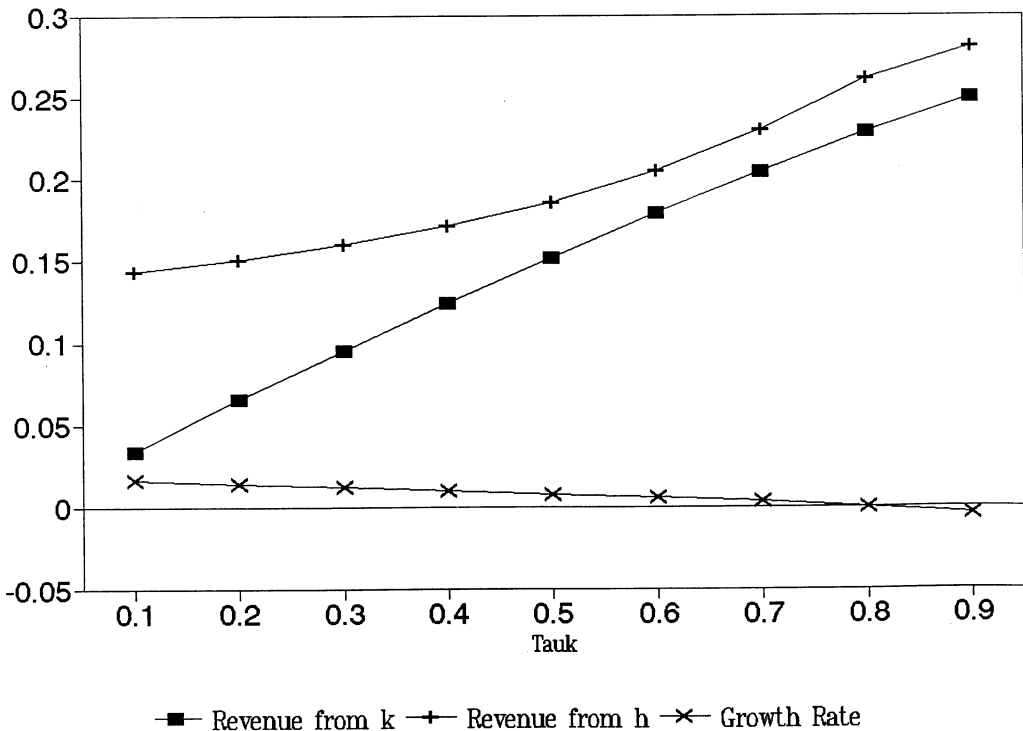


Fig. 7. Physical capital tax rate: Revenues and growth rate.

or 200 are much steeper. Thus, cutting g/k with the conjecture that the long run intertemporal budget balances in a shorter horizon is shown to be incorrect.

4.4. Tax rates, tax bases, and the growth rate

Figs. 7–9 present simulations of alternative tax rates and the implied values for the factor revenues from Eqs. (9a) and (9b) and the economy-wide growth rate from Eq. (5a).

Fig. 7 shows that increasing the physical capital income tax rate, τ_k , induces gains in the revenue from that factor. This is because the intertemporal substitution channel yields lower saving (capital) and thus a higher return, which coupled with the higher tax rate yields more revenue. The revenue on the other reproducible factor, human capital, also increases. It is important to note that there is an incidence issue here. Increasing the physical capital income tax rate shifts a lot of the burden to the other reproducible factor. This is one additional factor that explains why cutting the physical capital income tax rate leads to deterioration of the intertemporal budget. The growth rate decreases only very slightly and turns negative at $\tau_k = 80\%$.¹⁶ Fig. 8 shows the case of the skill-adjusted labor income tax rate, τ_h . The important differences are (a) the revenue from skill-adjusted labor income first increases, and after about τ_h close to 50% it decreases. There are Laffer style effects in taxing this factor, but not in taxing the other reproducible factor as Fig. 7 shows; and (b) the revenue from physical

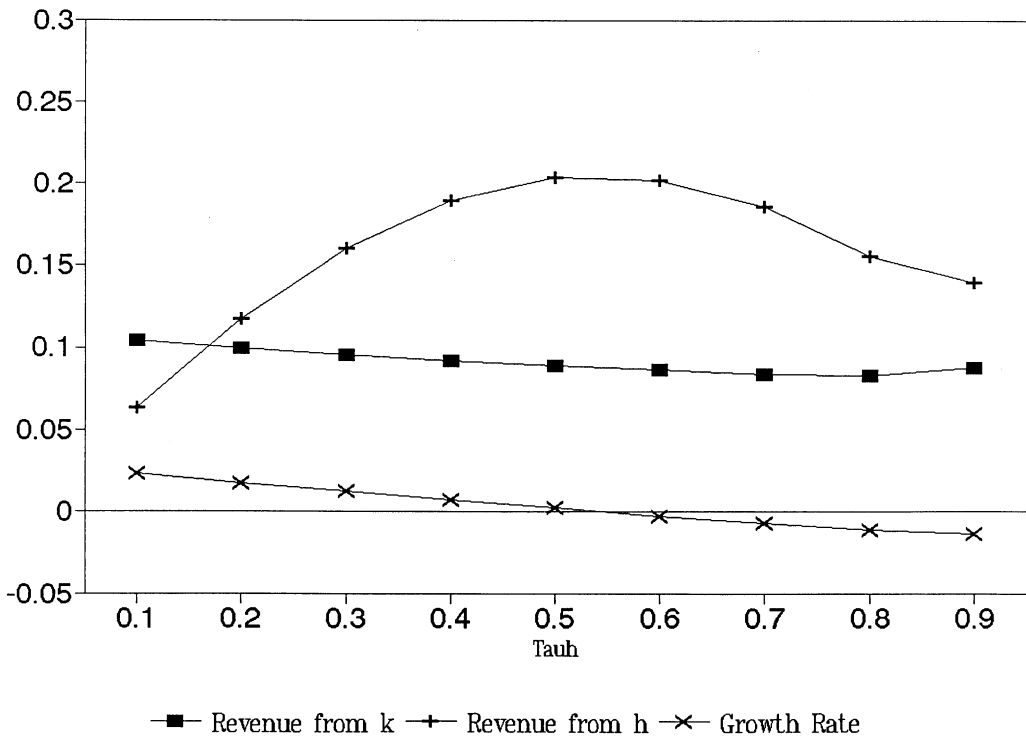


Fig. 8. Skill-adjusted labor tax rate: Revenues and growth rate.

capital income is decreasing in the human capital income tax rate, and there is no shift of the tax burden to the other reproducible factor at least for τ_h in the range 0–50%. In the range where $\tau_h > 50\%$, the revenue from skill-adjusted labor income decreases because of the Laffer style effects, and at $\tau_h = 80\%$, the revenue from physical capital income starts to increase. Thus, for $\tau_h > 50\%$, the burden shifts mildly from skill-adjusted labor to physical capital. Both private saving rates decrease up to $\tau_h = 80\%$, increasing slightly afterwards. The growth rate decreases and turns negative at about $\tau_h = 55\%$. Fig. 9 presents the symmetric case where $\tau_k = \tau_h$. Again, the revenue from human capital first increases, and after about τ_h close to 70% it decreases. The growth rate decreases and turns negative at about $\tau_k = \tau_h = 50\%$.

The important result when Figs. 1, 4, and 8 are compared is that cutting the skill-adjusted labor income tax rate induces dynamic scoring independently of the Laffer style effects on the revenues from this factor—in other words, regardless of the level of the tax rate. From Fig. 8 one would expect that cutting τ_h in the range $0.5 < \tau_h < 0.9$ would lead to dynamic scoring but not in the range $0 < \tau_h < 0.5$. However, Fig. 4 shows that dynamic scoring occurs at all rates. Fig. 9 and Table 2 confirm this independence result since dynamic scoring does not occur at plausible symmetric rates, independently of the Laffer effects in the revenue from skill-adjusted labor. Another result from Figs. 7–9 is that the growth effects of the alternative tax rates

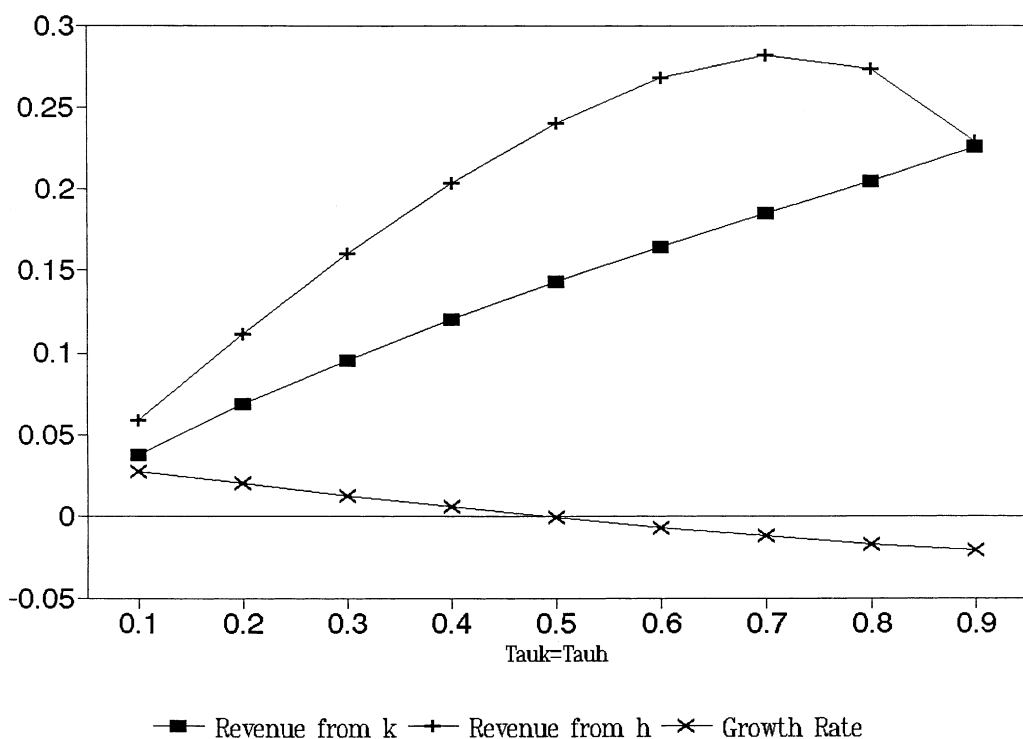


Fig. 9. Symmetric rates, $\tau_k = \tau_h$: Revenues and growth rate.

are small. This is shared by many previous authors, including Lucas (1990), King and Rebelo (1990), Pecorino (1993), and Stokey and Rebelo (1995).

5. Concluding remarks

If a balanced intertemporal budget plan includes a cut in government spending, the smaller the horizon of the policy maker the larger the necessary spending cut. Similarly, if the balanced intertemporal budget plan includes only distortionary tax rates, the smaller the horizon, the larger the level of the tax rate. In the more realistic class of policies designed not to completely balance the intertemporal budget, but just to improve it across steady growth paths, as long as a primary surplus along the balanced growth path is created, the longer the horizon the lower the net disbursement in lump-sum taxes. However, if a primary deficit along the balanced growth path remains, a shorter horizon grossly underestimates the size of the intertemporal imbalance. The wealth effect of human capital accumulation induced by neutral technical progress to the hours worked discussed by Ben-Porath (1967) and Heckman (1976) remains intact at the aggregate level, even though the stocks of physical and human capital vary across sectors. This is shown to be the main determinant of dynamic scoring of the

intertemporal government budget, independently of Laffer style effects on the tax revenues and intertemporal substitution effects in consumption in this model.

A natural extension to this analysis is the quantitative consideration of transitional dynamics. When transitional dynamics are implemented, it breaks the perfect correlation between the flow budget deficit and the economy-wide growth rate. Then, one may distinguish between dynamic scoring and static scoring in this framework.

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Notes

1. Ireland (1994) considers a convex one-sector growth model, whereas in Bruce and Turnovsky's (1999) one-sector model the source of endogenous growth is government expenditure that enters the production function.
2. The endogenous labor-leisure choice is important because asymmetries in the effects of taxing physical versus human capital will arise in this case. See Pecorino (1993), Devereux and Love (1994), and Pecorino (1995) for a discussion.
3. Leisure is constant along the balanced growth path as long as preferences guarantee that as income grows, substitution and wealth effects cancel out (see Lucas, 1990; Pecorino, 1993, 1995).
4. The balanced growth path is attained from arbitrary initial conditions for k_0 , h_0 , b_0 , and g_0 . It is well known that in the multi-sector endogenous growth model in this paper, the arbitrary initial ratio (h_0/k_0) may not be the same as the constant ratio along the balanced growth path. If this is the case, a period of transitional dynamics, where h and k grow at different rates, leads the economy to the balanced growth path, and government policy may distort this adjustment (see for example Caballe and Santos, 1993; Mulligan and Sala-i-Martin, 1993; Jones et al., 1993; Faig, 1995; Devereux & Love, 1994). In this paper, I follow Lucas (1990), King and Rebelo (1990), Pecorino (1993, 1995), Stokey and Rebelo (1995), and abstract from transitional dynamics, restricting the analysis to the long run balanced growth path. This is done by assuming that h_0 is chosen endogenously to guarantee that the economy is in the balanced growth path. Thus, there are no issues of time consistency of policy in this paper.
5. Technically, applying the transversality condition for $t \rightarrow T^*$ is consistent with consumer optimality to the infinite horizon (see for example Benveniste & Scheinkman, 1982).
6. Along the balanced growth path this model is Ricardian in the sense that the

consumer is indifferent between debt and lump-sum taxes given the path of distortionary tax rates.

7. Bruce and Turnovsky (1999) analyze V for the case where $T^* \rightarrow \infty$ and interpret it as a measure of sustainability of fiscal policy. Blanchard et al. (1990) present an alternative but related measure of sustainability of fiscal policy also used by Auerbach (1994).
8. Bruce and Turnovsky (1999) introduced the concepts of dynamic versus static scoring in their framework. Fullerton (1982), in a different framework, focused on the (uncompensated) elasticity of the labor supply with respect to changes in wages as a crucial parameter determining the possibility of static scoring. See also Pecorino (1995).
9. For example, if leisure is exogenously determined, under the restriction that the share of human capital in technology is the same across sectors, the model satisfies the dynamic nonsubstitution theorem of Mirrlees (1969). That is, the production possibilities surface is a linear plane, and there are no transitional dynamics across steady states. However, when leisure is endogenous the dynamic nonsubstitution theorem fails, the production possibilities surface is strictly concave, and parameter changes can lead to transitional dynamics. See also Devereux and Love (1994).
10. In this case the relative prices are the same, that is $P_k = P_h = 1$.
11. In a different, nonoptimizing, model, Tobin (1986) shows that following the U.S. economy path of the early 1980's, the nation's capital stock would be depleted in about 11 to 12 years.
12. The dynamic scoring result for τ_h is sensitive to the parameter of the leisure function, ϕ . For example, if $\phi = 2$, the implied uncompensated labor supply elasticity falls, and there is no dynamic scoring. However, for a plausible range of ϕ , it is shown below that $V(T^*)$ is monotonically increasing in τ_h and $V(T^*)$ is strictly greater than zero for all τ_h at different horizons T^* . This compromises the use of τ_h to achieve an intertemporal balance with $V(T^*) = 0$.
13. In the paper by Devereux and Love (1994), transitional dynamics are considered for the case where $\sigma = 1$. In that model there are small long run effects in the sectoral allocations and large transitional effects. In my model there are no transitional dynamics; thus the variations in h_0 that guarantee that the economy is in the balanced growth path lead to large sectoral reallocations.
14. In Lucas (1990), the results are different because the production of human capital only requires human capital per se. In this paper, the production of the three goods require all reproducible and nonreproducible factors. Pecorino (1993) has the same production structure as the one used here, but assumes that all government expenditures are returned as lump sum to the consumer; thus the tax reforms are fully compensated. Note also that the effects of the wage tax cuts would be less dramatic if human capital were a partially, instead of fully, taxed activity. See also Jones et al. (1993), and Stokey and Rebelo (1995).
15. In the paper by Bruce and Turnovsky (1999), there are only one sector and

one capital income tax rate; thus they show that if the elasticity of intertemporal substitution is large, say $\sigma < 1$ [$(1/\sigma) > 1$], then there is dynamic scoring in their case. In Ireland's (1994) convex one-sector model, there is also dynamic scoring arising from Laffer style effects in the tax bases. In my multi-sector model with human capital accumulation, there is no dynamic scoring, independent of σ .

16. The tax burdens mentioned are across steady state balanced growth paths and are uncompensated. The issue of tax incidence is discussed by Kotlikoff and Summers (1979) in a two-period model with human capital. However, their production function for human capital only requires raw hours as an input. See also Bernheim (1981) and Turnovsky (1982) for alternative dynamic analyses of tax incidence.

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