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Dynamic Laffer curves

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Abstract

In an endogenous growth model with human capital accumulation, we discuss the possibility of welfare improving changes on the fiscal policy stance in some actual economies. First, we characterize the extent to which the initial fall in revenues produced by a permanent tax cut can be compensated by an increase in the tax base, due to a dynamic Laffer curve effect, showing that there is, in fact, a non-trivial margin for substituting debt for taxes on labor and capital income. Second, we show that the largest feasible reduction in labor income tax rates may easily produce a higher welfare gain than the largest feasible reduction in capital income tax rates. Two qualifications: (a) feasible tax cuts exist only for a relatively high elasticity of intertemporal substitution of consumption, and (b) the preference for the largest feasible tax cut on labor income rather than that on capital income reverses for a low appreciation for leisure, relative to consumption, in the preferences of the representative agent.

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1. Introduction

The object of this paper is to analyze the possible welfare gains from substituting debt for taxes in deficit management. Under endogenous growth,

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a reduction in a tax rate will generally have a positive and permanent impact on the growth rate of the economy, through the incentives created for savings and investment in either type of capital [King and Rebelo (1990), Stokey and Rebelo (1995), Pecorino (1993, 1995), Devereux and Love (1995), and Milesi-Ferretti and Roubini (1998) discuss the effects of taxes on long-run growth in endogenous growth models]. The tax base will eventually increase, and it might be possible to design a deficit financing policy that reduces a tax rate while maintaining other taxes unchanged, under which the present value of future revenues is higher than that of future expenditures. We then say that the tax cut is *feasible*. Although in a non-monetary economy it is necessary to issue some debt to finance the initial deficit produced by a feasible tax cut, the government will be able to eventually retire it, due to this described *dynamic Laffer effect*.

Following Uzawa (1965) and Lucas (1988), we consider a non-monetary, endogenous growth model with two sectors, for physical and human capital, and no uncertainty. Human capital is accumulated with some intervention from physical capital, while the consumption commodity is produced out of both types of capital. The technology exhibits constant returns to scale in both sectors. The government follows an exogenously given expenditure path, which grows initially over time at the same rate as the economy. Public consumption is in the form of the government retiring some output from the economy and returning it to the consumers/workers in the form of transfers, that they take as given. Public expenditures do not affect the production technology or the marginal utility of consumers. Returning the units of good purchased by the government to the consumers implies that a consumption tax could also have an effect on long-run growth. However, for reasonable parameterizations, the effect is so small that the implied increase in the tax base is minimum, and there is no possibility of ever substituting debt for consumption taxes. In this case, there is no dynamic Laffer effect, and we focus in this paper on analyzing the possibility of substituting debt for taxes on labor and capital income. We interpret human capital as education, for which there is no market, so the inputs used in its accumulation are not subject to factor income taxation.

Dynamic Laffer effects have already been studied by Ireland (1994) and Pecorino (1995). Ireland (1994) considers an AK technology and a single tax on output, finding a non-trivial range of feasible tax cuts. As in his work, we show that feasible permanent tax cuts exist in our economy, and characterize how the margin for reduction depends on the initial tax rates and the structural parameters. However, a human capital accumulation economy allows us to generalize Ireland's analysis along some interesting lines. First, a non-trivial transition between balanced growth paths allows us to distinguish between the short- and long-run effects of a tax cut. Second, by considering different tax rates on labor and capital income, we can characterize the maximum feasible reduction in either one. Besides, we can discuss the normative issue of which tax cut is preferred from the point of view of consumers' welfare.

In a setup very similar to the one in this paper, Pecorino (1995) examines the values of the tax rates on human capital income, physical capital income and consumption leading to the maximum level of revenues, which amounts to characterizing the position of the peak in Laffer's curve. Alternatively, as in Ireland (1994), we look at a different point of the curve, that corresponding to the minimum tax rate which is able to support the exogenous stream of Government expenditures.

With an AK technology, the economy in Ireland (1994) lacks transition between balanced growth paths following a policy intervention. On the other hand, Pecorino (1995) chooses not to consider the transition by characterizing the time evolution of an economy after a change in tax policy, *once* the economy is on the new balanced growth path. There are two crucial reasons not to ignore the transition between the old and the new balanced growth path: (1) Budget and welfare effects immediately following a policy intervention may well differ in size and even in sign from long-run effects. We show that such is the case in this model, and that budget effects are, in fact, different when the transition is taken into account. Hence, ranking alternative policies may depend on whether we perform a long-run analysis, or take into account the transition. (2) Precisely quantifying budget and welfare effects crucially requires knowledge of the *levels* of the relevant variables. That emerges from a full characterization of the transition, which is not easy to make in endogenous growth models.

We focus on fiscal policies being implemented in actual economies, and characterize the welfare implications of a tax cut. In our setup, lower taxes imply higher welfare, so the objective will be to implement the *largest feasible tax cut*. Welfare effects can be important: when our model is calibrated to the US economy, starting from taxes on capital and labor income of 50% and 23%, respectively (as in Cooley and Hansen, 1992), we show that the largest feasible reduction in the labor income tax rate, to 18%, leads to a welfare gain equivalent to that produced by augmenting consumption by 5.1% every period. If we start from capital and labor income tax rates of 50% and 30%, the maximum feasible cut in labor income tax rates, to 15%, produces a welfare gain equivalent to an increase of 14.9% in consumption every period. The impact of capital income tax cuts is not as large: reducing the tax rate to its lowest feasible level of 38% produces in the first case a welfare gain equivalent to increasing consumption by 4.7% every period. In the second case, the lowest feasible level is of 7%, and the compensation in consumption should be of 12.6% every period.

These results show that there may be welfare gains to be made on fiscal policies in actual economies, and that such gains may rely on cutting down labor income taxes, in preference to reducing capital income tax rates.

We describe the model economy in Section 2, while in Section 3 we explain the type of fiscal experiments considered in the paper. In Section 4 we discuss the short- and long-run effects of alternative tax cuts, paying special attention to their impact on welfare. In Section 5 we discuss the sensitivity of our qualitative results to alternative values of the structural parameters. The paper closes with some conclusions.

2. The economy

The economy consists of a government, N_t identical consumers and a single representative firm. The number of consumers alive each period grows at an exogenous gross rate n, $N_t = n^t N_0$. The single consumption commodity is produced through a constant returns to scale technology:

$$Y_t = F(v_t K_t, L_t) = A(v_t K_t)^{\alpha}(u_t H_t)^{1-\alpha} \tag{1}$$

with $0 < \alpha < 1$, where A denotes the constant level of technology and v_t is the proportion of physical capital, K_t, devoted to the production of the consumption commodity. The total available time is normalized to one unit; u_t is the fraction of time each individual allocates to the production of the consumption good, and H_t represents the labor efficiency units of private agents, so that the labor input is $L_t = u_t H_t$.

There is a second sector in the economy, which produces human capital in the form of labor efficiency units. Each individual accumulates human capital h_t as

$$h_{t+1} = B[(1 - v_t)k_t]^{\beta}[(1 - u_t - w_t)h_t]^{1-\beta} + (1 - \delta_h)h_t, \quad t = 0, 1, 2, \ldots \tag{2}$$

with $0 < \beta < 1$, where B is the level of technology in this sector, depreciating at a constant rate $\delta_h \in (0, 1)$. We assume that there is no market for human capital. Effective physical capital stock used in the production of human capital by each individual is $(1 - v_t)k_t$; effective units of labor used in the production of human capital are $(1 - u_t - w_t)h_t$, where w_t denotes the fraction of time that agents devote to leisure. Throughout the paper, except for fractions of time denoted by u_t and w_t, or fractions of capital, like v_t, lower case letters denote per capita variables, while the analog capital letters denote aggregate variables. The produced commodity can either be consumed or accumulated as physical capital, which depreciates at a constant rate $\delta_k \in (0, 1)$. Per capita physical capital accumulates over time according to

$$nk_{t+1} = i_t + (1 - \delta_k)k_t, \quad t = 0, 1, 2, \ldots , \tag{3}$$

where i_t denotes the per capita resources devoted in the economy to gross investment, i.e., the units of output which are not consumed:

$$c_t + [nk_{t+1} - (1 - \delta_k)k_t] = A(v_t k_t)^{\alpha}(u_t h_t)^{1-\alpha}, \tag{4}$$

where c_t denotes per capita private consumption. This is the global constraint of resources in the economy.

Each individual in the economy derives utility from consuming c_t units of the single physical commodity, as well as from enjoying leisure time, w_t. Preferences are characterized by a constant relative risk aversion utility function

$$U(c_t, w_t) = \frac{(c_t^p w_t^{1-p})^{1-\sigma} - 1}{1 - \sigma}, \quad \sigma > 0, \ 0 < p < 1.$$

Interpreting the product inside the bracket as a single, composite commodity, the coefficient of relative risk aversion is equal to σ and the elasticity of intertemporal substitution of consumption of the composite good is $1/\sigma$. Together with the constant returns to scale technologies assumed in the two sectors, this utility function satisfies the conditions for endogenous growth in King et al. (1988).

The representative consumer can save in the form of physical capital or government debt, b_t. He/she takes tax rates, government transfers, factor rental prices, and the real return on bonds as given, and chooses sequences for $\{c_t, u_t, v_t, w_t, k_{t+1}, h_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ to maximize discounted time aggregate utility. He/she faces the sequence of single period budget constraints

$$\begin{aligned} &nk_{t+1} + n\frac{b_{t+1}}{R_t} + c_t + (r_t - \delta_k)\tau_t^r v_t k_t + \tau_t^{\omega}\omega_t u_t h_t \\ &\quad \leq r_t v_t k_t + \omega_t u_t h_t + (1 - \delta_k)k_t + b_t + g_t, \quad t = 1, 2, 3, \ldots, \end{aligned} \tag{5}$$

which includes $r_t v_t k_t$ as income received from renting physical capital to the firms producing the consumption commodity, where r_t is the rental price of capital, as well as $\omega_t u_t h_t$, as income from supplying efficient units of labor at a salary ω_t. His/her stock of human capital, h_t, has been accumulated over time by devoting part of his time and physical capital to the educational sector. He/she receives transfers from the government, g_t, as well as the return from the discount bonds, b_t, which were bought the previous period. This total income is used to purchase c_t units of the consumption commodity, $nk_{t+1} - (1 - \delta_k)k_t$ units of physical capital, and nb_{t+1}/R_t discount bonds at a price $1/R_t$, which pay a certain return R_t in the next period. He/she also pays $(r_t - \delta)\tau_t^r v_t k_t + \tau_t^{\omega}\omega_t u_t h_t$ as taxes, where τ^{ω}, τ^r denote, respectively, the tax rates on income from effective labor and income from renting the stock of physical capital, where we allow for depreciation allowances. We take the initial stocks of debt, physical and human capital, b_0, k_0, h_0, as given.

The utility maximization problem of an infinitely lived dynasty is

$$\underset{\{c_t,u_t,v_t,w_t,k_{t+1},h_{t+1},b_{t+1}\}}{\mathrm{MAX}} \sum_{t=0}^{\infty} \rho^t \frac{(c_t^p w_t^{1-p})^{1-\sigma} - 1}{1-\sigma} N_t, \quad \sigma > 0, \;\; 0 < \rho < 1 \tag{6}$$

subject to (2) and (5), given h_0, k_0, b_0, with $k_t, c_t, h_t \geq 0$, $v_t, u_t, w_t \in (0,1)$ and $u_t + w_t \in (0,1)$ for all t, with $0 < \rho < 1$ being the time discount factor.

First order conditions for this problem are, for each $t = 0, 1, 2, 3, \ldots,$

$$\frac{(1-\tau_t^{\omega})\omega_t}{(1-\tau_t^r)r_t + \tau_t^r \delta_k} = \frac{1-\beta}{\beta} \frac{1-v_t}{1-u_t-w_t} \frac{k_t}{h_t}, \tag{7}$$

$$\frac{p}{1-p} w_t = \frac{1}{(1-\tau_t^{\omega})\omega_t} \frac{c_t}{h_t}, \tag{8}$$

$$c_t^{p(1-\sigma)-1} w_t^{(1-\sigma)(1-p)} = \rho c_{t+1}^{p(1-\sigma)-1} w_{t+1}^{(1-p)(1-\sigma)} [(1-\tau_{t+1}^r)(r_{t+1} - \delta_k) + 1], \tag{9}$$

$$\begin{aligned} &\frac{c_t^{p(1-\sigma)-1} w_t^{(1-p)(1-\sigma)}}{(1-v_t)^{\beta}(1-u_t-w_t)^{-\beta}(k_t/h_t)^{\beta}} (1-\tau_t^{\omega})\omega_t \\ &\quad = \rho n \frac{c_{t+1}^{p(1-\sigma)-1} w_{t+1}^{(1-p)(1-\sigma)}}{(1-v_{t+1})^{\beta}(1-u_{t+1}-w_{t+1})^{-\beta}(k_{t+1}/h_{t+1})^{\beta}} \\ &\qquad \times (1-\tau_{t+1}^{\omega})\omega_{t+1}[(1-\beta)B(1-v_{t+1})^{\beta}(1-u_{t+1}-w_{t+1})^{-\beta} \\ &\qquad \times (k_{t+1}/h_{t+1})^{\beta}(1-w_{t+1}) + 1 - \delta_h], \end{aligned} \tag{10}$$

$$c_t^{p(1-\sigma)-1} w_t^{(1-\sigma)(1-p)} = \rho c_{t+1}^{p(1-\sigma)-1} w_{t+1}^{(1-p)(1-\sigma)} R_t, \tag{11}$$

together with (5) and the transversality conditions

$$\lim_{t\to\infty} n^t \frac{k_{t+1} + b_{t+1}/R_t}{\prod_{s=0}^{t-1} R_s} = 0, \quad \lim_{t\to\infty} \mu_t h_{t+1} = 0, \tag{12}$$

where μ_t is the Lagrange multiplier associated to (2), with the standard interpretation of setting after-tax marginal rates of substitution and transformation equal to relative prices. According to (12), the aggregate stocks of physical capital and debt do not accumulate over time at a rate faster than R_t/n. From (9) and (11), the equilibrium rate of return on bonds is

$$R_t = (1-\tau_{t+1}^r)r_{t+1} + [1 - \delta_k(1-\tau_{t+1}^r)], \tag{13}$$

which implies that the discount rate at which bonds are issued is equal, in equilibrium, to the rental rate on physical capital paid by the firm to the consumers, net of taxes and depreciation.

The single firm producing the consumption good operates in perfectly competitive markets for its product, as well as for the two production factors, labor and physical capital. Profit-maximizing behavior leads to paying each factor its marginal product:

$$\omega_t = F_{L_t}(t) = (1-\alpha)A(u_t h_t)^{-\alpha}(v_t k_t)^{\alpha}, \quad t = 0, 1, 2, 3, \dots, \tag{14}$$

$$r_t = F_{K_t}(t) = \alpha A(u_t h_t)^{1-\alpha}(v_t k_t)^{\alpha-1}, \quad t = 0, 1, 2, 3, \dots. \tag{15}$$

The government gives each period an income transfer g_t to each consumer, which is financed by taxes on labor and capital income, as well as by issuing debt. These transfers do not have any impact on the technology available to the firm, or on marginal utility. Its single period budget constraint is, in per capita terms,

$$g_t + b_t \le \tau_t^r (r_t - \delta_k) v_t k_t + \tau_t^{\omega} \omega_t u_t h_t + n\frac{b_{t+1}}{R_t}, \quad t = 0, 1, 2, \dots, \tag{16}$$

where b_t denotes the per-capita stock of debt available at time t.

Given $\{g_t, \tau_t^r, \tau_t^{\omega}\}_{t=0}^{\infty}$ and k_0, h_0, b_0, a *competitive equilibrium* is a set of trajectories $\{c_t, k_{t+1}, h_{t+1}, b_{t+1}, u_t, v_t, w_t, r_t, \omega_t, R_t\}_{t=0}^{\infty}$ such that: (a) given $\{r_t, \omega_t, R_t\}_{t=0}^{\infty}$, $\{c_t, u_t, v_t, w_t, k_{t+1}, h_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ solves the dynasty optimization problem, (b) given $\{r_t, \omega_t\}_{t=0}^{\infty}$, $\{u_t h_t, k_t\}_{t=0}^{\infty}$ solves the firm's profit maximization problem, (c) (5) and (16) hold, and all markets clear, i.e.: (i) (4) holds, so that consumption plus investment is equal in each period to total production, (ii) the demand for bonds by consumers is equal to the supply of debt issued by the government, (iii) the demand for physical capital input by the firm is equal to the supply devoted to that activity by consumers, and (iv) the demand for labor input is equal to the supply of labor efficient units. In equilibrium, the marginal rate of transformation of physical capital and labor must be the same in the two sectors, the marginal product of effective labor is equal to the marginal rate of substitution between consumption and leisure, and the marginal product of physical capital is equal to the marginal rate of substitution over time, in all cases after appropriately correcting for tax effects.

A *balanced growth path* is a solution $\{c_t, k_{t+1}, h_{t+1}, b_{t+1}, u_t, v_t, w_t, r_t, \omega_t, R_t\}$ to optimization problem (6), subject to (2) and (5), for initial conditions k_0, h_0, b_0, such that $\{c_t, h_t, k_t\}$ grows at a constant rate γ^*, and $\{u_t, v_t, w_t, \omega_t, r_t\}$, as well as the capital-to-output ratio, stay constant. Values along the balanced growth path for $u^*, v^*, w^*, r^*, \omega^*, \gamma^*, (k_t/h_t)^*$, and $(c_t/h_t)^*$ can be obtained, for a given parameterization, from the utility and profit maximizing conditions (7)–(10), (14), (15), together with (2) and (4), a system of eight equations in as many variables. Then, (13) and (16) provide us with the balanced growth path values for R^* and b_t. At a difference of the other variables, the stock of debt does not remain constant along the balanced growth path, even after normalization by the stock of human capital. The value of γ^*, the growth rate of the economy along the balance growth path, depends in a complex manner on all structural parameters, as well as on tax rates.

3. Financing a reduction in tax rates

We take as benchmark a situation in which the government balances its budget each period, so that debt has never been issued, $b_t = 0\ \forall t$. We also assume that tax rates on consumption, labor and capital income have been constant at predetermined values, $\tau_t^j = \tau_0^j\ \forall t,\ j = r, \omega$.

Let us denote the initial stocks of physical and human capital as $k_{0,0}$, $h_{0,0}$, where the first subindex refers to time, while the second denotes that we are in the baseline case. We additionally suppose that these quantities are in their balanced growth proportion, $k_{0,0}/h_{0,0} = (k_{t,0}/h_{t,0})^*$. Since the government is not issuing any debt in the baseline case, we will have, at time zero, $b_{0,0} = 0$, and the government budget constraint will hold if expenditures are given by

$$g_{0,0} = \tau_0^r v_0^* k_{0,0}(r_0^* - \delta_k) + \tau_0^\omega \omega_0^* u_0^* h_{0,0} \tag{17}$$

which amounts to

$$g_{t,0} = \tau_0^r v_0^* k_{t,0}(r_0^* - \delta_k) + \tau_0^\omega \omega_0^* u_0^* h_{t,0} \quad \forall t,\ \ x_{t,0} = \gamma_0^* x_{0,0},\ \ x = g, k, h.$$

In the absence of any structural change, the economy would stay on its balanced growth path, $k_{t,0}, h_{t,0}, c_{t,0}$ growing over time at a constant rate γ_0^*, the same for all of them, while $u_{t,0}, v_{t,0}, w_{t,0}, r_{t,0}, R_{t,0}, \omega_{t,0}$ would remain constant at their steady-state values $u_0^*, v_0^*, w_0^*, r_0^*, R_0^*, \omega_0^*$, which are determined simultaneously with γ_0^*. We assume that $g_{t,0}$ also grows at a rate γ_0^* so that there will never be any need to issue debt, and a budget constraint like (17) will hold in every time period.

From this situation, let us suppose that the government considers a permanent reduction in a single tax rate, keeping the other tax rate unchanged and government transfers on their previously planned path $g_{t,0} = (\gamma_0^*)^t g_{0,0}$. Needless to say, in a non-monetary economy that will need issuing of some debt, which might hopefully be retired over time. On the other hand, a tax cut will generally produce an increase in the long-run growth rate of the economy, thereby increasing the tax base, which might lead to higher revenues at some point. We say that a reduction in a given tax rate is *feasible* if the subsequent increase in the tax base allows for the government budget constraint to hold in a present value sense. That would mean that the bigger deficit in the initial periods after the policy change can be repaid by achieving later a fiscal surplus higher in present value than that under the initial policy. That will allow for eventually retiring the initially issued debt, without having to introduce tax hikes at any point in time. This may be possible only because government expenditures continue to grow at a rate γ_0^* after the tax cut.

As an illustration, let us suppose that at a time we denote as $t=0$ for notational convenience, the government implements a reduction in labor income taxes, from τ_0^ω to τ_1^ω, $\tau_1^\omega < \tau_0^\omega$. This will have a positive effect on the long-run growth rate of the economy, as well as short-run effects on all the relevant variables, since transitional dynamics are non-trivial in this economy.

Let us denote by $rev_{t,1}$ the per-capita, period t, tax revenues under the reduced labor income tax τ_1^ω:

$$rev_{t,1} = \tau_0^r v_{t,1} k_{t,1}(r_{t,1} - \delta_k) + \tau_1^\omega \omega_{t,1} u_{t,1}, h_{t,1}, \quad t = 0, 1, 2, \dots , \tag{18}$$

so that from (16) the government budget constraint is

$$(rev_{t,1} - g_{t,0}) + n\frac{b_{t+1,1}}{R_{t,1}} - b_{t,1} \geq 0, \quad t = 0, 1, 2, \dots \tag{19}$$

with $b_{0,1} = 0$, where we maintain the same expenditure path as before the tax cut, $g_{t,0}$. After the policy intervention, physical and human capital, as well as consumption will start growing at a rate different from γ_0^*. Growth rates along the transition will generally differ for these three variables, although they will converge to a new, common long-run growth rate, γ_1^*.

Using the transversality condition (12), together with the initial condition $b_{0,1} = 0$, (19) can be solved further as

$$(rev_{0,1} - g_{0,0}) + \sum_{t=1}^{\infty} \left(\prod_{s=0}^{t-1} R_{s,1} \right)^{-1} n^t (rev_{t,1} - g_{t,0}) \geq 0 \tag{20}$$

or, equivalently,

$$rev_{0,1} + \sum_{t=1}^{\infty} \left(\prod_{s=0}^{t-1} R_{s,1} \right)^{-1} n^t \, rev_{t,1}$$
$$- g_{0,0} \left(1 + \sum_{t=1}^{\infty} \left(\prod_{s=0}^{t-1} R_{s,1} \right)^{-1} (n\gamma_0^*)^t \right) \geq 0, \tag{21}$$

since $g_{t,0} = (\gamma_0^*)^t g_{0,0}$. This inequality characterizes the time paths of revenues, expenditures and interest rates which are consistent with a *feasible tax reduction* (there will be a similar expression for each tax rate that can be reduced). If the strict inequality holds, the debt which is initially issued is eventually retired, and the government runs a present value surplus that could be returned as an additional transfer to consumers. In most cases, the time path for debt starts increasing very quickly after the tax cut, eventually reaching a maximum and going to zero after a finite (although possibly large) number of periods. That b_t eventually becomes negative in those cases means that with the lower tax rate, the government can actually finance a higher level of expenditures than it could with the initial, higher tax rate. When (21) holds as an equality, the implied debt path grows without bound at a rate R_1^*/n.

In all cases, the growth rate of the capital stock converges to γ_1^*, which is strictly less than R_1^*/n under the parameterizations we use. As a consequence, since $b_0 = 0$, the transversality condition holds. This is the only case in which the stock of debt does not go to zero in any finite time. If (21) does not hold, the stock of bonds explodes at a rate larger than R_1^*/n, violating the transversality condition, and the tax cut is unfeasible.

A cut in either labor or capital income tax rates affects the rate of growth of the economy, the marginal product of capital and the rate of return on bonds, so there are extensive effects on (21), and the behavior along the transition of all the variables in (21) becomes crucial to discuss feasibility. This is more general than the analysis in Ireland (1994), where an economy without transition between balanced growth paths is considered. The effects along the transition may reinforce the long-run effects, if they have the same sign, or compensate them, if they are of opposite sign. Characterizing that is an important component of our analysis.

To numerically evaluate (21), we assume that after 250 periods the economy is close enough to the new balanced growth path so that (21) can be approximated by

$$rev_{0,1} + \sum_{t=1}^{250} \frac{(n\gamma_1^*)^t}{\prod_{s=0}^{t-1} R_{s,1}} rev_{t,1} + rev_1^* R_1^* \frac{(n\gamma_1^*/R_1^*)^{251}}{1-(n\gamma_1^*/R_1^*)}$$

$$- g_{0,0}\left[1 + \sum_{t=1}^{250} \frac{(n\gamma_0^*)^t}{\prod_{s=0}^{t-1} R_{s,1}} + R_1^* \frac{(n\gamma_0^*/R_1^*)^{251}}{1-(n\gamma_0^*/R_1^*)}\right] \geq 0, \tag{22}$$

where asterisks denote values along the new balanced growth path. To obtain (22) we have used the fact that $n\gamma_1^*/R_1^*$ is less than 1, which guarantees that the transversality condition holds and that the objective function is bounded.

The competitive equilibrium of the economy solves the system of equations (2), (5), (7)–(10) and (13)–(16), 10 non-linear difference equations in $(c_t, k_{t+1}, h_{t+1}, u_t, w_t, v_t, R_t, \omega_t, r_t, b_t)$ with k_0, h_0 as initial conditions, together with transversality conditions (12), for given paths of the policy variables $\{\tau_t^\omega, \tau_t^r, g_t\}$, $t = 0, 1, 2, 3, \ldots$. To compute the numerical solution, we apply the procedure in Sims (1999) and Novales et al. (1999), based on the eigenvalue–eigenvector decomposition of the system, written in ratios and linearized around the balanced growth path to compute in this case two stability conditions. To actually produce equilibrium time series along the transition we substitute the two stability conditions for (9) and (10), the two Euler conditions relating variables in t with variables in $t+1$. This guarantees that the trajectories we obtain for the variables above will satisfy transversality conditions (12). The linear approximation is used just to compute the stability conditions, but not to generate the set of equilibrium time series, which are calculated from the original system of non-linear difference equations described above. These time paths can be obtained independent of the debt sequence, which is later obtained from (16).

4. Substituting debt for taxes: Long- and short-run effects

4.1. Taxes and long-run growth

We start by analyzing the *long-run* budget and growth effects of reducing taxes, which is needed to fully understand the consequences of changing a given tax structure over the lifetime of the representative private agent. We use as a benchmark parameterization

$$\sigma = 1.5,\ \ \rho = 0.99,\ \ A = 1.0,\ \ \alpha = 0.36,\ \ B = 0.039670,\ \ 1-\delta_k = 0.975,$$

$$1-\delta_h = 0.992,\ \ n = 1.0035,\ \ \beta = 0.15,\ \ p = 1/3,\ \ \tau^r = 0.50,\ \ \tau^\omega = 0.23$$

and we interpret the time unit as one quarter. This parameterization places the economy in the *normal case*, following the terminology in Caballé and Santos (1993). The relative risk aversion parameter is inside the wide range usually considered in the literature. The 0.36 share of physical capital in the production of the consumption good is standard, while we have chosen a lower share, of 0.15, for this input in the technology of human capital accumulation. Given the lack of empirical evidence on structural parameters in the human capital sector, it seems reasonable to assume that human capital accumulation is less intensive in physical capital than the production of the consumption commodity, and substantially more intensive in human than in physical capital. The relative weight of consumption in the utility function has been chosen so that, under the assumed tax rates, the fraction of time devoted to the production of consumption goods along the balanced growth path is around 0.20, in line with the values usually reported for the US economy (see for instance, Gomme, 1993).

Tax rates on labor and capital income are as in Cooley and Hansen (1992). The implied annual real rate of return on physical capital is 5.5%, and the economy grows along its balanced growth path at a quarterly gross rate of $\gamma_0 = 1.00365$, as in Gomme (1993), i.e., annual growth under this benchmark policy is 1.47%.

As shown in Table 1, along the balanced growth path corresponding to this parameterization, consumers devote 58% of their time to leisure, 20% to producing the consumption good and 22% to human capital accumulation. This sector also absorbs 26.7% of the stock of physical capital, while the remaining 73.3% is devoted to producing the consumption good. Investment in physical capital represents 29.4% of the output, while consumption amounts to the remaining 70.6%. The government is raising 24.4% of the

Table 1
Steady-state values of relevant variables for different tax structures

	$\tau^r = 0.50$, $\tau^\omega = 0.23$	$\tau^r = 0.50$, $\tau^\omega = 0.20$	$\tau^r = 0.43$, $\tau^\omega = 0.23$	$\tau^r = 0.50$, $\tau^\omega = 0.30$	$\tau^r = 0.50$, $\tau^\omega = 0.27$	$\tau^r = 0.43$, $\tau^\omega = 0.30$
Leisure: w_t	0.5766	0.5624	0.5690	0.6021	0.5869	0.5946
Working time: u_t	0.2011	0.2049	0.2030	0.1890	0.1931	0.1909
Human capital accumulation time: $1 - u_t - w_t$	0.2222	0.2326	0.2280	0.2089	0.2200	0.2145
Proportion of physical capital in the commodity sector: v_t	0.7328	0.7184	0.7421	0.7511	0.7357	0.7598
Physical capital devoted to human capital accumulation: $1 - v_t$	0.2672	0.2816	0.2579	0.2489	0.2643	0.2402
Consumption/output: c_t/y_t	0.7064	0.7025	0.6907	0.7135	0.7098	0.6979
Investment in physical capital/output: i_t/y_t	0.2936	0.2975	0.3093	0.2865	0.2902	0.3021
Consumption/augmented output	0.4305	0.4173	0.4182	0.4509	0.4365	0.4383
Investment in physical capital/augmented output	0.1790	0.1767	0.1873	0.1810	0.1785	0.1897
Investment in human capital/augmented output	0.3905	0.4061	0.3944	0.3681	0.3850	0.3720
Public revenues/output	0.2436	0.2264	0.2261	0.2884	0.2714	0.2709
Quarterly growth	1.00365	1.00421	1.00400	1.00366	1.00429	1.00401

output as revenues. *Augmented* output is obtained adding to produced output the cross-product of human capital investment and the relative shadow price of both types of capital. The second and third columns in Table 1 consider alternative tax cuts in labor and capital income, respectively, which will be analyzed in the next sections. Under our benchmark parameterization, these cuts produce a similar fall in revenues, as a percentage of the output. The remaining three columns allow for analyzing the effects of similar tax cuts, starting from a higher labor income tax rate.

A labor tax induces a shift from working time to leisure and leads to substituting physical capital for labor in the production of the consumption good. It also discourages human capital accumulation, since it is being taxed as an input in the production sector. Less hours are devoted to learning, and a lower proportion of physical capital is used to accumulate human capital. A capital income tax induces a shift from physical to human capital in the production of the consumption commodity. A higher proportion of physical capital is devoted to human capital accumulation, leading to the desired substitution between inputs in production. Transferring resources between sectors as a response to a capital income tax allows for a smaller distortion than under a labor income tax of the same size. Besides, the distortions produced by a labor income tax on the allocation of time among its different uses, as well as on the split of physical capital between the two sectors, are bigger than those of a capital income tax of the same size, which is a second reason explaining the fact that the effect on growth of a labor income tax is more important.

Effects of opposite sign arise under tax cuts. For our parameterization, it is the amount of time devoted to human capital accumulation which is strongly stimulated by a cut in labor income taxes, while the effect on hours devoted to producing the consumption commodity is relatively minor. Besides, the percentage of physical capital allocated to the educational sector also increases, so that there are two reasons why human capital accumulation accelerates, and it is through this double effect that the rate of growth of the economy increases. Long-run effects on the steady-state allocation of time following a reduction in capital income tax rates go in the same direction as those arising after a comparable labor income tax cut, but they are much smaller. Contrary to the result under a payroll tax cut, the proportion of physical capital devoted to human capital accumulation now decreases. In the face of a capital income tax cut, it is this shift of resources out of human capital accumulation and into the production of the consumption good, that creates a smaller stimulus on growth than a similar cut on labor income taxes.

Fig. 1a shows, for our parameterization, that annual growth in our model economy uniformly increases from its benchmark value of 1.47% when taxes on labor income or capital income decrease. Tax cuts in the graph are bounded by the initial levels of the tax rates. Payroll taxes have a much bigger per

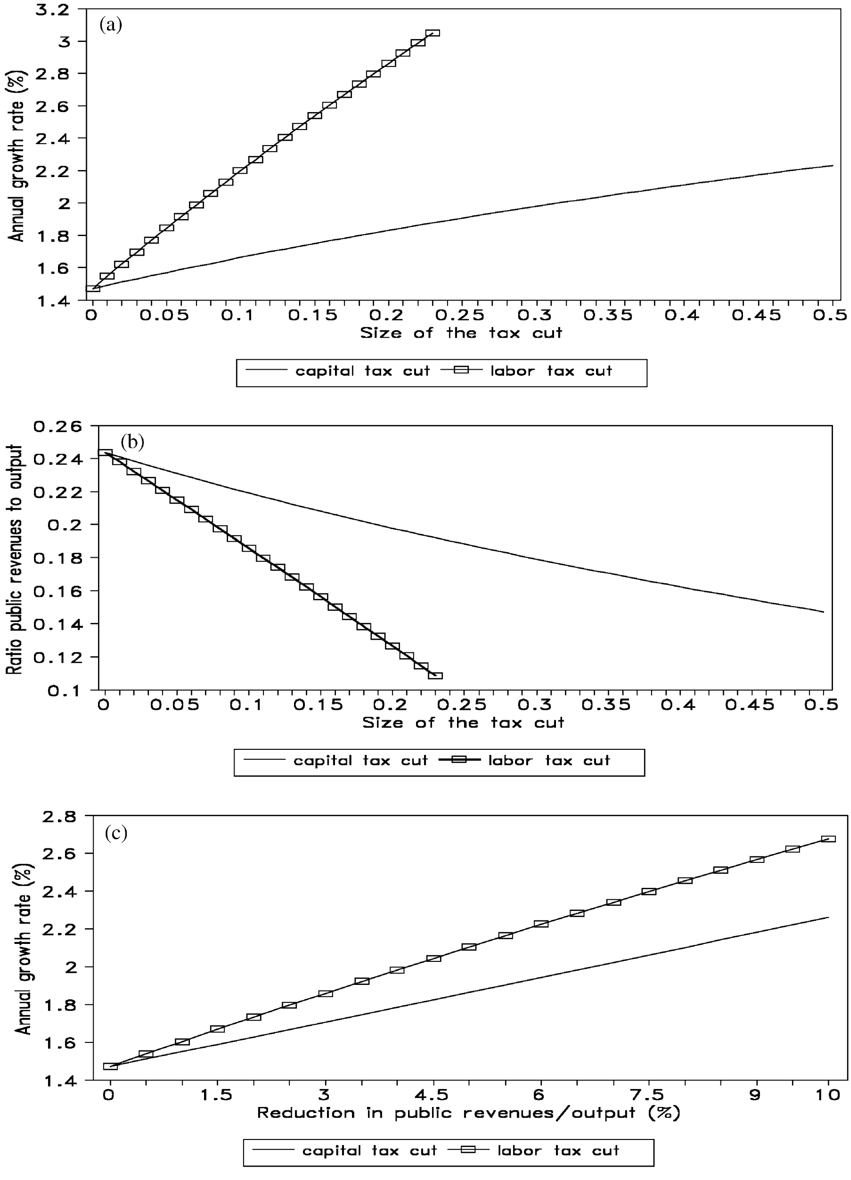


Fig. 1. (a) and (b) show annual growth and the ratio of public revenues to output, respectively, as a function of each possible tax cut. (c) shows annual growth as a function of the implied public revenues/output ratio. Starting tax rates: $\tau^{\omega} = 0.23$, $\tau^{r} = 0.50$.

unit impact on long-term growth, so a much larger tax cut on capital income than on labor income can be implemented before a given loss of revenue, as a percentage of output, arises (Fig. 1b). This is due to the fact that capital income is a smaller base than labor income. In spite of that, since the per unit distortion of capital income taxes on growth is small, a cut in payroll taxes turns out also to be a much better stimulus for growth than the cut in capital income taxes that would produce the same fall in the revenue/output ratio (Fig. 1c).

Starting from $\tau_0^r = 0.50$, $\tau_0^\omega = 0.23$, a 0.10 cut in labor income tax rates, to $\tau_1^\omega = 0.13$, while maintaining capital income tax rates unchanged, would bring the revenue/output ratio down to 0.186, from its starting value of 0.244. A similar fall in the public revenues to output ratio would be produced by a cut of 0.26 in the tax rate on capital income, to $\tau_1^r = 0.24$. They would lead to an increase in the long-run annual growth rates from 1.47% for the initial tax rates, to 2.20% and 1.93%, respectively, so the differences can be substantial.

Long-run effects of a feasible tax cut on consumers' utility are parallel to those on growth, increasing with the size of the reduction in the tax rate. The reason is that the higher growth implied by lower taxes will allow for the consumption and the single period utility level to also grow in the long run faster than before the tax cut. Effects on the initial periods, i.e., the *transitional dynamics*, are less obvious: on the one hand, lower taxes will leave more resources available for consumption; on the other hand, consumers will have to acquire the debt which is issued at the time of the tax cut, reducing available resources. The set of equilibrium conditions already shows that all variables will be affected by a tax cut in a non-trivial manner, making it impossible to analytically characterize the sign of the short-run utility effects. A numerical discussion of their importance is the purpose of the next section.

4.2. Feasible tax cuts

While the responses of the main variables to a reduction in labor income taxes is roughly constant over time, important differences can be seen between short- and long-run effects following a tax cut on the cumulative factor, physical capital. After a reduction from $\tau_0^r = 0.50$ to $\tau_1^r = 0.43$ when $\tau^\omega = 0.23$, the fraction of time devoted to production immediately jumps by 6% (not shown in the paper), then decreasing to stabilize around a gain of just 0.9%, as reflected in Table 1. Leisure immediately decreases by 0.4%, falling over time for a steady-state reduction of 1.3%. The time devoted to accumulate human capital immediately falls by 4.3%, recovering to stabilize at 2.7% *above* its initial level. Ignoring these transitional dynamics would affect the quantitative results significantly, potentially biasing the results of our policy analysis.

In what follows, the parameter values are as in Section 4.1, except for $B = 0.042818$ when $\tau_0^r = 0.50$, $\tau_0^\omega = 0.30$ which is the alternative tax vector we will consider in our policy analysis. This change in B guarantees that the annual growth remains at 1.47%, as in Gomme (1993). Fig. 2 presents the effects on the budget of a permanent reduction on either labor (upper panel) or capital income tax rates (lower panel), starting from $\tau_0^r = 0.50$ and either $\tau_0^\omega = 0.23$ (left side) or $\tau_0^\omega = 0.30$ (right side). The horizontal axis shows the size of the tax cut. The value of the left-hand side in (22) under a reduction in one of the tax rates is shown on the left vertical axis, under the *Budget effect* label. Positive values associated to small tax cuts mean that a small reduction in the tax rate stimulates growth sufficiently such that a future higher tax base compensates for the permanent reduction in the tax rate. Negative values farther away from the origin mean that the initial deficit produced by bigger tax cuts cannot possibly be compensated in the present value government budget constraint with future tax revenues without any further fiscal adjustment. The right axis shows the long-run effects on quarterly growth, measured by the absolute difference between the growth rates before and after the tax cut.

The upper panel shows that the tax rate on labor income can be reduced by up to 0.05 from its benchmark level of $\tau_0^\omega = 0.23$, down to $\tau_1^\omega = 0.18$. The implied increase on the quarterly growth rate, shown on the right axis, is up to 0.092 under the maximum feasible cut, the annual growth increasing from 1.47% to 1.84%. A bigger tax cut would violate the present value government budget constraint, while a lower tax cut would produce a time-aggregate, present value government surplus.

The higher the initial tax rate, the bigger the margin for feasible reductions. When $\tau_0^\omega = 0.30$, the feasible range for labor income tax rates is $(0.15, 0.30)$ versus the (0.18,0.23) feasible range when $\tau_0^\omega = 0.23$. Cutting the tax rate down to $\tau_1^\omega = 0.15$ would produce an increase in the quarterly growth rate of 0.28, so that annual growth would rise from 1.47% to 2.61%.

There are two lines in the lower panel graphs showing the *Budget effect*, since not including the transition between balanced growth paths in the analysis of capital income tax cuts makes a difference. Taking into account the transition, and starting from a tax rate of $\tau_0^\omega = 0.23$ on labor income, the tax rate on capital income can be reduced by up to 0.12 from its benchmark level of $\tau_0^r = 0.50$, down to $\tau_1^r = 0.38$. For this minimum feasible value, the quarterly growth rate would increase by 0.056, the annual growth moving from 1.47% to 1.70%. When the tax rate on labor income is $\tau_0^\omega = 0.30$, the tax on capital income can be reduced by up to 0.43, to a minimum feasible value of $\tau_1^r = 0.07$. The maximum increase in the quarterly growth rate would be 0.17, which would bring the annual growth from its initial value of 1.47% to 2.16%.

Ignoring the transition would have led us to believe that, for $\tau_0^\omega = 0.30$, the maximum feasible cut in the capital income is from $\tau_0^r = 0.50$ to $\tau_1^r = 0.16$ with an increase in the annual growth from 1.47% to 2.05%, versus the

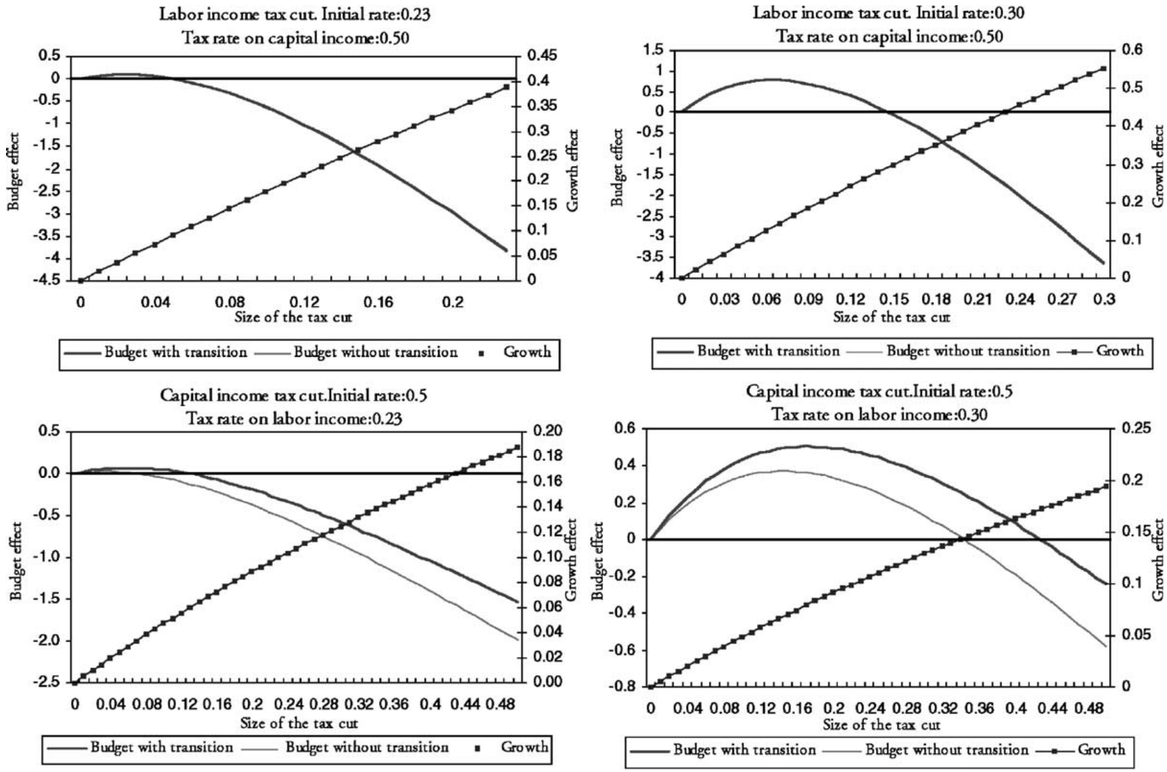
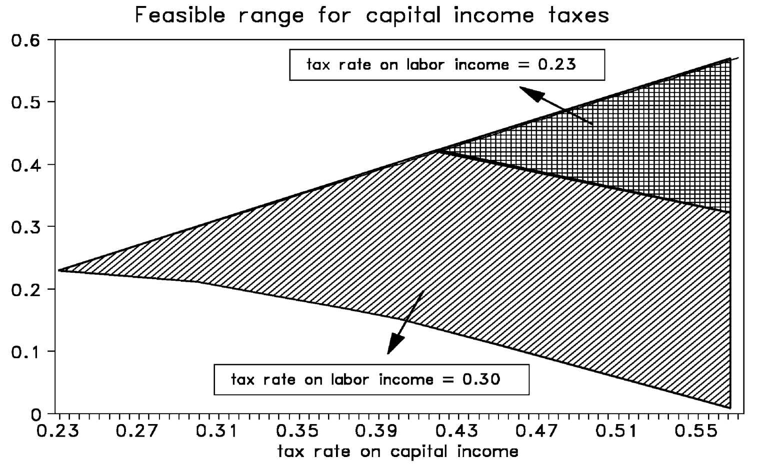


Fig. 2. Growth and budget effects of a tax cut. Each graph presents the effects of a tax cut on the present value government budget and on long-run quarterly growth. The budget effect, not including the transition, is also shown, for comparison. Upper panel: labor income tax cut. Lower panel: capital income tax cut.



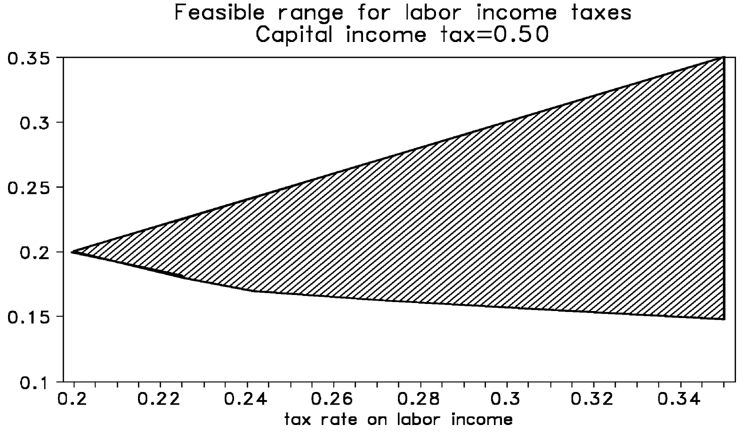


Fig. 3. The upper graph shows the range of feasible tax rates on capital income as a function of their initial level, for tax rates on labor income of either $\tau^{\omega} = 0.23$ or 0.30. The lower graph shows the range of feasible tax rates on labor income for a starting tax rate on capital income: $\tau^{r} = 0.50$.

actual possibility of bringing down capital income taxes to $\tau_1^r = 0.07$, with an annual growth of 2.16%. For other parameterizations, ignoring the transition would have led us to believe that the largest feasible capital income tax cut is bigger than it actually is. In any event, the quantitative results of a pure long-run analysis of the effects of changes in tax rates as well as the numerical characterization of their feasible range could be rather misleading.

Fig. 3 shows the *feasible* range of capital and labor income tax rates. The upper graph shows the feasible range for capital income taxes, as a function of their starting level both, when the labor income tax rate is $\tau_0^{\omega} = 0.23$, and when it is $\tau_0^{\omega} = 0.30$. Any capital income tax rate which is *feasible* for $\tau_0^{\omega} = 0.23$, is also *feasible* for $\tau_0^{\omega} = 0.30$. For $\tau_0^{\omega} = 0.23$, capital income taxes cannot be reduced at all if $\tau_0^r < 0.42$. When $\tau_0^{\omega} = 0.30$, no capital income tax cuts are feasible unless τ_0^r is above 0.23. The lower graph shows the feasible range for labor income tax rates when $\tau_0^r = 0.50$, which is consistent with the maximum feasible reductions discussed above for $\tau_0^{\omega} = 0.30$ and 0.23. There are no feasible reductions in labor income taxes if $\tau_0^{\omega} < 0.20$.

4.3. Welfare effects

Consumption decreases following a cut in either labor or capital income tax rates. The fall in consumption is particularly significant after a capital income tax cut, since there is then an important stimulus to build-up physical capital. We have already discussed that leisure also decreases after either tax cut, so it is clear that utility falls immediately after a tax cut of either kind. Under a labor income tax cut, the lower utility is mainly due to the fall in leisure, while under a capital income tax cut, both the inputs contribute to the loss of utility. However, the negative effect of the tax cut on single period utility gets smaller, eventually becoming positive in such a way that the long-run effect dominates and the time aggregate welfare is always higher after a tax cut. Besides, the welfare gain increases with the size of the tax cut.

With $\tau_0^{\omega} = 0.23$, the largest feasible reduction in labor income taxes to $\tau_1^{\omega} = 0.18$ leads to an increase in welfare equal to that produced by a permanent increase in consumption of 5.1%, while the largest feasible cut in capital income taxes from $\tau_1^{\omega} = 0.50$ to 0.38 amounts to a permanent increase in consumption of 4.7%. Welfare gains increase when the benchmark tax rate on labor income is $\tau_0^{\omega} = 0.30$. A cut to the lowest feasible level of the labor income tax rate, of $\tau_1^{\omega} = 0.15$, would produce a welfare gain equivalent to a permanent increase in consumption of 14.9% every quarter. On the other hand, a cut to the lowest feasible level of the capital income tax rate, $\tau_1^r = 0.07$, while maintaining the labor income tax at $\tau_0^{\omega} = 0.30$ would be welfare-equivalent to an increase of 12.6% in consumption every period.

Our results do not have much bearing on the optimal fiscal policy, but they are very relevant to characterize welfare-improving interventions on fiscal structures similar to those observed in actual economies. We have shown that from a somewhat standard fiscal stance, the welfare gain produced by lowering taxes on labor income is bigger than that produced by a similar cut in capital income taxes. Furthermore, under our parameterization, reducing the labor income tax rate to its lowest feasible level while leaving taxes on capital income unchanged leads to a bigger welfare gain than reducing the capital income tax rate to its lowest feasible level.

Qualitative results concerning the range of feasible tax rates do not change for different values of most structural parameters, like depreciation rates of physical and human capital or population growth. However, other parameters are crucial for these results, as we will see next.

5. Sensitivity analysis

To discuss the relevance of the main structural parameters on our previous results, Fig. 4 shows the budget and growth effects of a reduction in the tax rate on labor income from $\tau_0^{\omega} = 0.23$ to $\tau_1^{\omega} = 0.20$ or, alternatively, a tax cut on capital income from $\tau_0^r = 0.50$ to $\tau_1^r = 0.43$. As already mentioned, these cuts produce a similar fall in long-run government revenues, as a proportion of output, and any other pair of comparable cuts should be expected to produce similar qualitative results. Each graph changes the value of one structural parameter, to characterize the range of values for which feasible tax cuts exist. Since we maintain the other parameters at their benchmark values, long-run growth prior to any tax cut changes with the structural parameter under consideration and the right axes shows absolute differences in quarterly growth before and after the tax cuts.

For small values of A, tax cuts will have a minor impact on growth, and the tax base will barely increase over time, without any possibility of ever compensating the deficit initially produced by the tax cut (upper left graph). For A below 0.54, the proposed tax cuts are not feasible. For A between 0.54 and 0.64, it is possible to finance the labor income tax cut, but not the proposed capital income tax cut, while for A greater than 0.64, both tax cuts can be financed. In this analysis, the value of B is maintained constant, so that long-run growth prior to any tax cut increases with A. For $A = 1$, we have the effect on growth under our benchmark parameterization: annual growth would increase from 1.47% to 1.70% under the proposed labor income tax cut, and to 1.61% under the proposed capital income tax cut. The capital income tax cut would increase growth from 0.87% to 0.99% when $A = 0.7$, or from 3.14% to 3.32% when $A = 2.4$. The proposed labor income tax cut would increase growth from 0.87% to 1.08% when $A = 0.7$, or from 3.14% to 3.41% when $A = 2.4$.

Either tax cut would have an important impact on growth if the elasticity of physical capital in the commodity sector, α, was close to 0.50 or higher, so substituting debt for taxes in that economy would be very advantageous (graph not shown). For the proposed tax cuts to be feasible, this elasticity must be above $\alpha = 0.31$. Substitution of debt for taxes is also feasible in an economy in which the human capital accumulation technology is somewhat intensive in physical capital. The proposed tax cut on labor income is feasible for $\beta > 0.11$, while the proposed cut on capital income taxes is feasible for $\beta > 0.12$ (upper right graph).

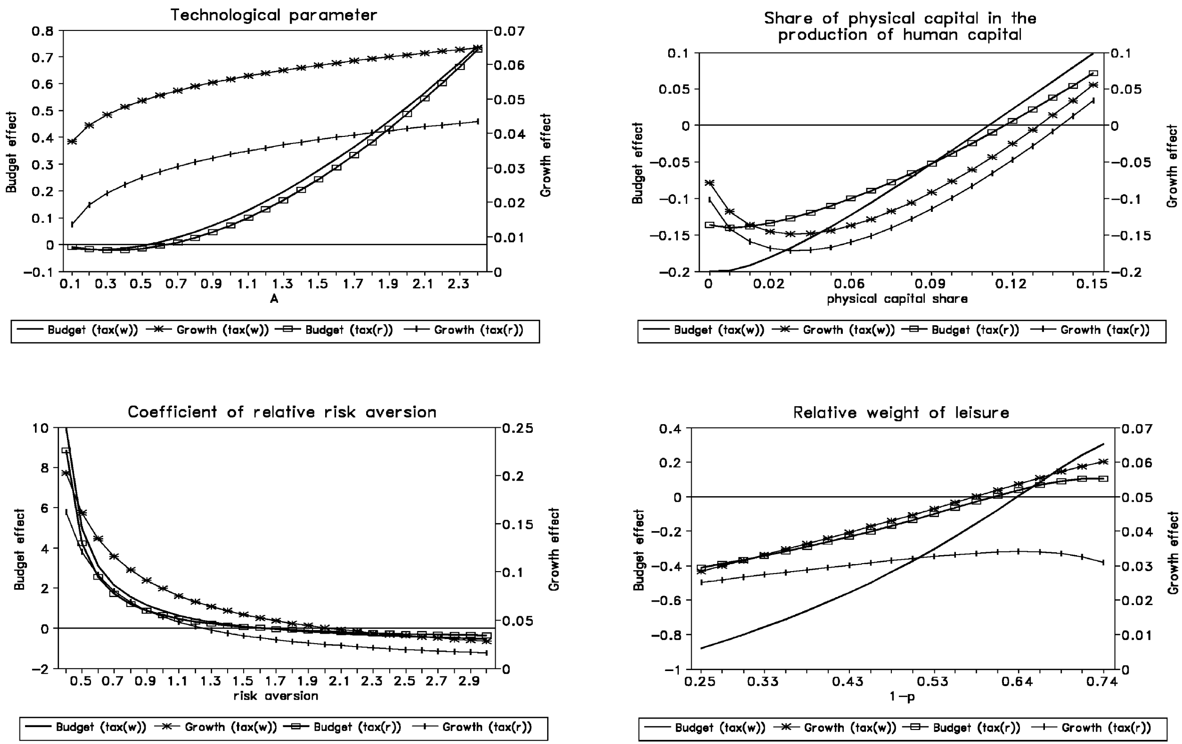


Fig. 4. Budget and growth effects of alternative tax cuts on capital and labor income. Initial tax rates: $\tau_0^r = 0.50$, $\tau_0^\omega = 0.23$. Alternative final tax rates: $\tau_1^r = 0.43$, $\tau_1^\omega = 0.23$ and $\tau_1^r = 0.50$, $\tau_1^\omega = 0.20$. These tax cuts generate the same long-run fall in public revenues as a percentage of output. *Budget*(*tax*(w)), *Budget*(*tax*(r)) show the budget effects following the proposed cuts in labor and capital income, respectively. *Growth*(*tax*(w)) and *Growth*(*tax*(r)) show the absolute long-run effects on quarterly growth.

A given tax cut is easier to finance for low degrees of relative risk aversion, i.e., for high values of the intertemporal elasticity of substitution of consumption of the composite good (lower left graph). With a high elasticity of substitution, i.e., a close to linear utility function, consumers are glad to substitute future for current consumption, to take advantage of a permanently higher long-run growth. In spite of the negative initial effect on utility, these consumers keep accumulating physical and human capital, implying robust long-run growth. Therefore, these consumers will tend to be more in favor of a given tax cut, since they are relatively indifferent with respect to the timing of consumption.

On the contrary, consumers with a low elasticity of substitution, i.e., with a high relative risk aversion, will desire to smooth their consumption/leisure path, devoting relatively more resources to current consumption and leisure in detriment of physical and human capital accumulation, with a negative impact on future growth. As a consequence, the positive long-run effect on growth of any tax cut will be smaller, and it will be harder to finance. For our benchmark parameterization, the proposed tax cuts are not feasible for σ above 1.6, i.e., for an elasticity of intertemporal substitution below 0.63, which includes values which are sometimes considered in theoretical and empirical studies. However, some tax cuts, smaller than those considered in Fig. 4, would still be feasible for $\sigma > 1.6$. On the other hand, the tax cuts in Fig. 4 would be feasible for some values of σ above 1.6, provided we started from sufficiently higher initial tax rates. Finally, maintaining the benchmark values of all parameters except σ, there would not be any feasible tax for $\sigma > 1.8$.

The proposed tax cut on capital income is easier to implement in economies where leisure is more important, relative to consumption, in the preferences of the representative agent (lower right graph). For low values of p, consumption is relatively less important, and it can decrease further, to provide for physical capital accumulation. That would lead to higher growth, although there is a compensating effect from the strong initial fall in the hours devoted to learning. The graph shows that growth is only slightly increasing in $1-p$, and even decreasing for high values of $1-p$. A similar comment applies to a labor income tax cut, except that then there is no reduction in the hours of learning. The growth and budget effects are increasing in $1-p$ on a plausible range of values, making it easier to eventually finance any tax cut. For values of $1-p$ above 0.64, both the proposed tax cuts are feasible. For $1-p$ between 0.62 and 0.64, the proposed capital income tax cut can be financed, but not the labor income tax cut. None of the proposed tax cuts can be financed for $1-p$ below 0.62.

As the time discount factor increases consumers become more patient, being more willing to substitute future for current consumption, and devoting more resources to accumulate physical and human capital after a tax cut. That

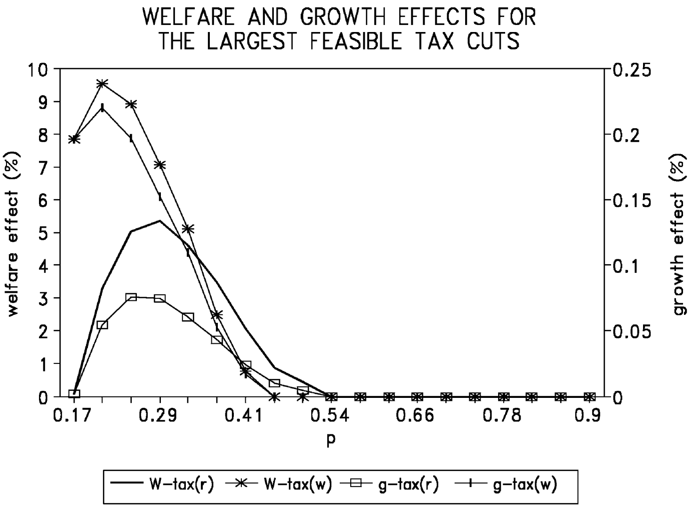


Fig. 5. W-$tax(r)$ and W-$tax(\omega)$ denote the welfare effects of the maximum feasible tax cuts, as a function of p. g-$tax(r)$ and g-$tax(\omega)$ denote their effects on quarterly growth.

produces a bigger impact on long-run growth, making it easier to finance the initial fall in revenues. For ρ above 0.989, the proposed tax cuts are feasible.

A high depreciation in either physical or human capital renders the corresponding factor obsolete very quickly, demanding a large amount of resources to sustain long-run growth, which makes it harder to finance a given tax cut. The proposed tax cut on capital income becomes feasible for a depreciation rate on *physical capital* less than 4.2% (annual depreciation below 15.8%: $1-(1-\delta)^4=0.842$) while the cut on labor income taxes is feasible for a depreciation rate below 3.8% (annual depreciation below 14.3%). The capital income tax cut is feasible for a depreciation rate on *human capital* below 1.4% (annual depreciation below 5.5%), while the labor income tax cut becomes feasible for a depreciation rate less than 2.5% (annual depreciation rate below 9.6%).

All the results in this section have been obtained for a zero consumption tax. Any positive tax rate on consumption will make it easier to finance any given tax cut, so the described feasible range for each structural parameter will become wider.

In Section 4 we have shown that, for our benchmark parameterization, the largest feasible labor income tax cut is more effective in terms of the long-run growth and welfare than the largest feasible capital income tax cut. This preference for labor income tax cuts does not change under changes in any structural parameter other than p, the relative weight of consumption in the utility function. Fig. 5 shows the welfare and growth effects of the largest feasible tax cuts, as a function of p. For p above 0.39 the capital income tax cut produces a larger stimulus on growth than the labor income tax cut, while for p above 0.35 the largest feasible tax cut on capital income produces a larger welfare gain than the largest feasible tax cut on labor income.

6. Conclusions

We have discussed the possibility of introducing welfare improving changes on fiscal policies being implemented in actual economies. In a model economy with the accumulation of physical and human capital and constant returns to scale technologies in the production of both, the consumption good and human capital, we have started by analyzing the extent to which debt can substitute for taxes on labor and capital income in deficit management. Together with a constant relative risk aversion utility function on consumption and leisure for the representative agent, this model produces endogenous growth.

As a consequence, tax cuts on labor and capital income have a positive effect on the rate of growth of the economy, thereby progressively increasing the tax base over time. Given a time path for government expenditures, a cut in a tax rate while keeping other taxes unchanged will have to come together with issuing some debt. However, the positive effects on the tax base of a tax cut may allow for eventually repaying the debt which was initially issued, in which case we say that the tax cut is *feasible. Feasible* tax cuts satisfy the present value government budget constraint.

We generalize Ireland (1994) by (a) considering different taxes, whose relative effects on welfare we can compare, (b) using a human capital accumulation economy which experiences a non-trivial transition between balanced growth paths following a government intervention. This allows us to distinguish between short- and long-run effects on growth, welfare, and any variable of interest. Another related work is Pecorino (1995), who characterizes the position of the peak in Laffer's curve. Alternatively, as in Ireland (1994), we focus on a different point in the curve, that corresponding to the minimum tax rate which is able to support the exogenous stream of Government expenditures. Since welfare is increasing in the size of a tax cut, moving to that minimum tax rate will also lead to the largest welfare increase. At a difference of these two authors, we have taken into account the transition between balanced growth paths. The relevance of the transition arises from the fact that impulse response functions following a policy intervention often change their sign over time; time aggregate budget and welfare effects can be substantially different from the long-run effects.

Starting from tax rates on capital and labor income $\tau_0^r = 0.50$, $\tau_0^\omega = 0.23$, similar to those used in previous work to represent US fiscal policy (as in

Cooley and Hansen, 1992), or from $\tau_0^r = 0.50$, $\tau_0^\omega = 0.30$ as an alternative, we have shown that there is a non-trivial range of feasible reductions in either tax rate. Feasible cuts can be quite substantial, and we have shown that the effects on long-run growth and welfare are increasing in the size of the tax cut. The exception is consumption tax cuts, which imply small long-run growth effects, making it impossible to finance any reduction in tax rates. With our parameterization, there are no dynamic Laffer effects for consumption taxes.

A reduction in labor income tax rates from our benchmark value produces a more important stimulus on *long-run growth* than a similar nominal reduction in capital income tax rates. Even though either tax cut produces an initial fall in utility, the positive longer-term impact dominates, and the welfare effect of any feasible tax cut is always positive. Furthermore, we have shown that, from a somewhat standard fiscal stance, it can well be the case that the welfare gain from the *largest feasible cut* in labor income taxes exceeds that from the *largest feasible cut* in capital income taxes.

Some qualifications need to be made on the previous results: (a) under our parameterization, tailored to the US economy, feasible tax cuts exist only for values of the intertemporal elasticity of substitution above 0.56, i.e., for constant relative risk aversion parameter values below 1.8, a range that excludes values which are sometimes considered in theoretical and empirical work, (b) cuts in capital income taxes become preferable to reductions in labor income taxes when consumption is highly preferred, relative to leisure, by the representative agent in the economy, and (c) in an economy in which the initial labor income tax is much smaller than that on capital income, the largest feasible tax cut in the former, if any, might have a minimum impact on growth and welfare, being less preferred than the largest feasible cut in capital income tax rates.

Pecorino (1995) and Milesi-Ferretti and Roubini (1998) have shown that considering a market for human capital enhances the negative effects of factor income taxes on growth. Besides, these authors show that the growth implications of factor income taxes depend on the tax treatment of the human capital sector. As a consequence, the relative preference for feasible cuts on labor or income taxes may depend on considering human capital accumulation as a market activity. Presumably, considering the substitution of debt for taxes in such a model would be a non-trivial and interesting complement to this paper.

Finally, it might well be the case that simultaneous, smaller cuts in both factor taxes could be preferred in terms of welfare to the largest feasible tax cut on a single factor. However, analyzing that issue requires characterizing the feasible range of tax rates on a given factor for each level of the tax rate on the other factor, which is computationally rather demanding and we have left for future research.

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