

To Spend the U.S. Government Surplus or to Increase the Deficit? A Numerical Analysis of the Policy Options¹

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This paper provides a numerical analysis of the likely benefits from adopting alternative ways of reducing the projected fiscal surplus (as of the summer 2001) in the United States economy. Calibrating a small growth model, our results suggest that investing the surplus in public capital is likely to yield the greatest long-run welfare gains, although decreasing the capital income tax is only marginally inferior. Both these options dominate increasing government consumption expenditure or decreasing the tax on labor income. By shifting resources from consumption toward capital the two superior policies involve sharp intertemporal tradeoffs in welfare; significant short-run welfare losses are more than compensated by large long-run welfare gains. By contrast, the two inferior options are gradually welfare-improving through time. A crucial factor in determining the benefits of reducing the government surplus through spending is the size of the government sector relative to the social optimum. We find that the second-best optimum is to increase both forms of government expenditure to their respective social optima, while at the same time restructuring taxes by reducing the tax on capital and raising the tax on wage income to achieve the targeted reduction in the surplus. *J. Japan. Int. Econ.*, December 2002, **16**(4), pp. 405–435. Department of Economics, University of Washington, Seattle, Washington;

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1. INTRODUCTION

During the summer of 2001 the U.S. government was projecting substantial government surpluses at least for the medium-term future. On the basis of these projections the Bush administration had proposed a 1.6 trillion dollar tax cut to be phased in over 10 years, an amount that eventually was trimmed slightly to 1.5 trillion dollars. The tragic events of September 11, 2001, together with the decline in activity already in process, have cast serious doubts on the accuracy of the earlier projections with the likelihood that the debate will be revisited, this time under a less rosy scenario.² But whether one is talking about reducing (spending) a projected budget surplus or financing by deficit spending, the principle is the same. We shall therefore carry out our discussion in terms of the surplus, even though that situation is now much more in doubt.

The allocation of the projected budget surplus in the United States generated a spirited debate among policymakers and academic researchers, particularly during the spring of 2001. Basically three broad options are available: (i) to reduce the outstanding debt, (ii) to spend the surplus on new government expenditure programs, and (iii) to reduce tax rates. Options (ii) and (iii) contain several suboptions. One critical policy choice concerns the form that a proposed increase in government expenditure should take. Whether an increase in government expenditure takes the form of some publicly provided consumption good or the form of public investment that enhances the productive capacity of the economy is an important policy choice. Likewise, the nature of the tax cuts, whether they are targeted toward labor income or capital income, or are applied uniformly to both, is also a key policy decision.³

It is clear that different government policies will differ dramatically from one another in terms of the growth paths they generate, the timing of the benefits they yield, and their distributional impacts across the economy. Both forms of government expenditure crowd out private consumption, leading to short-run welfare losses. But the private consumption losses incurred in the case of government *consumption* expenditure are more than offset by the direct benefits provided by the latter, yielding overall welfare gains in the *short run*. In contrast, government

² Indeed, during the winter of 2002 the U.S. Congress was again debating an economic stimulus package in response to the prevailing economic downturn.

³ Another issue that has been discussed periodically with some vigor is the idea of replacing the income tax with a consumption tax. Since this is not part of the current discussion, we do not address it here. This policy has been analyzed by Turnovsky (2001).

investment expenditure yields no consumption benefits in the short run. Instead, these resources devoted to increasing the economy's productive capacity lead to greater consumption benefits in the *longer run*. Likewise, cutting the tax on capital income is likely to have a greater positive impact on the immediate growth performance of the economy than does a tax cut directed toward labor income.

To analyze these issues requires a carefully specified dynamic macro model. The objective of this paper, therefore, is to apply such a model to characterizing and evaluating the differential effects of such alternative policies on the transitional adjustment path of an economy faced with a large initial budget surplus. The basic model we apply has been developed by Turnovsky (2001). The key components of the model are that it is a one-sector growth model in which output depends upon the stocks of both private and public capital, as well as endogenously supplied labor. The production function is sufficiently general to allow the economy to have increasing or decreasing returns to scale in the aggregate. In addition to accumulating public capital, the government allocates resources to a utility-enhancing consumption good. These expenditures are financed by issuing bonds, distortionary taxes levied on capital income and labor income, or by imposing nondistortionary lump-sum taxation (equivalent to debt).

The model is a nonscale growth model of the type developed by Jones (1995a, 1995b) and Young (1998).⁴ These models, which can also be viewed as extensions of the standard Solow–Swan neoclassical growth model, have the characteristic that the long-run growth rate is independent of the size (scale) of the economy, thereby eliminating a counterfactual aspect of many endogenous growth models; see Backus *et al.* (1992), Easterly and Rebelo (1993), Jones (1995a, 1995b), Stokey and Rebelo (1995). One of the features of the two-capital good model, again broadly consistent with the empirical evidence, is that it is characterized by relatively slow speeds of convergence.⁵ The significance of this is that the economy spends a large proportion of its time away from steady state, thereby increasing the importance of studying the transitional path.⁶

⁴ This contrasts with the endogenous growth models, an initially regarded attractive feature of which was the key role that they assigned to fiscal policy. However, these models have shortcomings such as scale effects, knife-edge characteristics, and unsatisfactory dynamic characteristics that make them less attractive for conducting the type of numerical analysis that we are undertaking here. These issues and the relevant literature are reviewed by Turnovsky (2000, Chapters 13, 14).

⁵ Benchmark empirical estimates of the speed of convergence obtained by Barro (1991), Barro and Sala-i-Martin (1992), and Mankiw *et al.* (1992) find the speed of convergence to be around 2–3% per annum. Subsequent studies suggest that the convergence rates are more variable and more sensitive to the time periods and the characteristics of economies, and a wider range of estimates have been obtained; see Islam (1995), Evans (1996), and Temple (1998). Eicher and Turnovsky (1999) and Turnovsky (2001) obtain asymptotic speeds of convergence consistent with the 2–3% figure, although they also find that in the short run, the speed of convergence may be substantially higher.

⁶ One further attractive feature of the nonscale model is that it generates a higher order dynamic transition path than does the corresponding endogenous growth model. This has the advantage of yielding more flexible transitional adjustment paths, consistent with the empirical evidence; see Bernard and Jones (1996a, 1996b).

But the study of the transitional dynamics is not easy. Even in a small model such as this, with two types of capital, it is necessary to analyze it numerically, and in this respect the model is capable of replicating the key stylized facts of a benchmark economy, such as the United States, with relative ease. The focus of the model is on the impact of policy shocks on the transition paths and to investigate how these accumulate to yield long-run impacts on capital stocks and welfare. This type of model provides an excellent vehicle for examining the kinds of policy issues enunciated above. For this purpose, we calibrate a benchmark economy with a large initial budget surplus, such as the United States has recently enjoyed, and then assess the differential dynamic effects of various fiscal policy measures to reduce this surplus intertemporally.⁷

Using this calibrated economy, we compare the effects on the economy of adopting the following fiscal policies, each of which reduces the intertemporal budget surplus (measured in discounted present value terms) by the same specified amount:

- (i) Increasing the rate of government consumption expenditure by 5 percentage points;
- (ii) increasing the rate of government investment expenditure by 5 percentage points,
- (iii) decreasing the tax rate on capital income by 14 percentage points, and
- (iv) decreasing the tax rate on labor income by just under 8 percentage points.

Particular attention is focused on two aspects. The first is on the transitional adjustment paths of key macroeconomic variables such as private and public capital, output, and consumption, as well as the current surplus. The second is on the time path of instantaneous welfare, as well as on the overall intertemporal welfare of the representative agent in the economy. A crucial aspect of evaluating the merits of different policies aimed at reducing the fiscal surplus involves the assessment of the intertemporal tradeoffs they generate and this is a central feature of our analysis.

The general conclusion we obtain is that to the extent that the calibrated model is representative of the prevailing U.S. situation, the policy responses (i)–(iv) can be ranked as follows. Spending the surplus on government investment is best, being marginally superior to reducing the tax on capital, which in turn is substantially better than spending the surplus on government consumption or reducing the tax on labor income. Numerically, the welfare gains that range between 2.5 and 3.8% increase in terms of permanent output flows. But there are sharp intertemporal tradeoffs. The first two policies, which yield the most substantial long-run gains,

⁷ Our approach is related to the early work of Auerbach and Kotlikoff (1987) who conduct a comprehensive analysis of the dynamics of fiscal policy using simulation methods, though there are important differences. For example, whereas we use the representative agent model, they use a 55-period overlapping generations model. But the major difference is that we stress the expenditure side, contrasting the impact of government consumption with government investment expenditure under alternative tax regimes. By contrast, Auerbach and Kotlikoff focus entirely on the revenue side; government expenditure has no impact on private behavior.

also involve significant short-run losses, as they both involve diverting resources from consumption in the short run to investment having longer-run and ultimately greater payoffs. But these two policies will also lead to economies having substantially different structural characteristics. Spending the surplus on government investment will lead in the long run to an economy having a much larger ratio of public to private capital than if the surplus is allocated to reducing the cost of private investment, thereby stimulating private investment.

Alternative policy mixes are also discussed. In this respect we find that a uniform increase in the two types of government expenditure—on consumption and on investment—is marginally superior to increasing investment alone. The reason for this is because both forms of expenditure provide diminishing marginal benefits, and indeed, optimal levels of expenditure for both forms of expenditure exist. We show that welfare can be enhanced even further by setting the two types of expenditures at their respective optima, reducing the tax on capital and raising the tax on labor, consistent with reducing the intertemporal government surplus by the specified target amount.

We should emphasize that the conclusions we draw regarding the relative merits of the alternative modes of spending the surplus depend crucially upon the sizes of the parameters that reflect the benefits of the two forms of government expenditure. While we feel that these plausibly reflect the U.S. parameters, to the extent that this is not so, our conclusions would be modified. It is certainly possible for both forms of government expenditure to be dominated by tax cuts, and indeed even to be welfare deteriorating in extreme cases.

The remainder of the paper proceeds as follows. Section 2 sets out the analytical model, while Section 3 derives the equilibrium dynamics. Section 4 briefly characterizes the first-best optimum, mainly to serve as a benchmark for our choice of critical parameter values. Section 5 calibrates the model, while Section 6 discusses the dynamics of reducing the surplus. Section 7 briefly conducts some sensitivity analysis and Section 8 reviews our main conclusions.

2. THE MODEL

The economy comprises N identical individuals, with population growing exponentially at the steady rate $\dot{N} = nN$. Each representative agent has an infinite planning horizon and possesses perfect foresight. He is endowed with a unit of time that can be allocated either to leisure, l_i , or to labor, $(1 - l_i)$, and produces output, Y_i , using the Cobb–Douglas production function

$$y_i = \alpha(1 - l_i)^{1-\sigma} K_i^\sigma K_G^\eta \quad 0 < \sigma < 1, \eta > 0, \quad (1a)$$

where K_i denotes the agent's individual stock of private capital, and K_G is the stock of government capital, such as infrastructure. We assume that the services derived from the latter are not subject to congestion, so that K_G is a pure public good, generating a positive externality, parameterized by η . The producer faces

constant returns to scale in the two private factors, and increasing returns to scale, $1 + \eta$, in all three factors of production.⁸

The representative agent's welfare is specified by the intertemporal isoelastic utility function

$$\Omega \equiv \int_0^{\infty} (1/\gamma)(C_i l_i^{\theta} H^{\phi})^{\gamma} e^{-\rho t} dt; \quad (1b)$$

$$\phi > 0, \theta > 0; \quad -\infty < \gamma \leq 1; \quad 1 > \gamma(1 + \phi); \quad 1 > \gamma(1 + \theta + \phi),$$

where C denotes aggregate consumption, so that per capita consumption of the individual agent at time t is $C/N = C_i$, H denotes the consumption services of a government-provided consumption good, and the parameters θ and ϕ measure the impacts of leisure and public consumption on the agent's welfare.⁹ The remaining constraints on the coefficients appearing in (1b) are imposed in order to ensure that the utility function is concave in the quantities C_i , l_i , and H .

The agent's objective is to maximize (1b) subject to his or her accumulation equation

$$\begin{aligned} \dot{K}_i + \dot{B}_i = & [(1 - \tau_k)r - n - \delta_K]K_i + [(1 - \tau_k)s - n]B_i \\ & + (1 - \tau_w)w(1 - l_i) - C_i - T_i, \end{aligned} \quad (1c)$$

where r is gross return to capital, w is (before-tax) wage rate, s is interest rate on government bonds, the individual's holdings of which are B_i , τ_k is tax on capital (and bond) income, τ_w is tax on wage income, and $T_i = T/N$ is the agent's share of lump-sum taxes (transfers). Equation (1c) embodies the assumption that private capital depreciates at the rate δ_K , so that with the growing population the net after-tax private return to capital is $(1 - \tau_k)r - n - \delta_K$, while the net after-tax return on interest income is $(1 - \tau_k)s - n$.

Performing the optimization yields:

$$C_i^{\gamma-1} l_i^{\theta\gamma} H^{\phi\gamma} = \lambda_i(1 + \tau_c) \quad (2a)$$

$$\theta C_i^{\gamma} l_i^{\theta\gamma-1} H^{\phi\gamma} = \lambda_i w(1 - \tau_w) \quad (2b)$$

$$r(1 - \tau_k) - n - \delta_K = \rho - \frac{\dot{\lambda}_i}{\lambda_i} \quad (2c)$$

$$r(1 - \tau_k) - \delta_K = s(1 - \tau_k). \quad (2d)$$

Equation (2a) equates the marginal utility of consumption to the individual's

⁸ The assumption that the production function has constant returns to scale in the private factors of production so that public capital provides a positive externality is a natural one. An alternative assumption, followed by some authors, is that the production function has constant returns to scale in all three factors of production. One of the advantages of the nonscale model is that it can deal with either case. The only real restriction is that the externality provided by the public input cannot be too large that it violates the stability of the dynamic system (18).

⁹ The parameter γ is related to the intertemporal elasticity of substitution, e say, by $e = 1/(1 - \gamma)$.

tax-adjusted shadow value of wealth, λ_i , while (2b) equates the marginal utility of leisure to its opportunity cost, the after-tax real wage, valued at the shadow value of wealth.¹⁰ The third equation is the standard Keynes–Ramsey consumption rule, equating rate of return on consumption to the after-tax rate of return on capital, while (2d) equates the net rates of return on the two assets. Finally, in order to ensure that the agent's intertemporal budget constraint is met, the following transversality condition must be imposed:

$$\lim_{t \rightarrow \infty} \lambda_i K_i e^{-\rho t} = \lim_{t \rightarrow \infty} \lambda_i B_i e^{-\rho t} = 0. \quad (2e)$$

Aggregating over the individual production functions, (1a), aggregate output, Y , is

$$Y = NY_i = \alpha[(1-l)N]^{1-\sigma} K^\sigma K_G^\eta, \quad (3)$$

where $K = NK_i$ denotes aggregate capital. The equilibrium real return to private capital and the real wage are thus respectively:

$$r = \frac{\partial Y}{\partial K} = \frac{\sigma Y}{K} = \frac{\sigma Y_i}{K_i}; \quad w = \frac{\partial Y}{\partial [N(1-l)]} = \frac{(1-\sigma)Y}{N(1-l)} = \frac{(1-\sigma)Y_i}{(1-l)}. \quad (4)$$

Government capital accumulates in accordance with

$$\dot{K}_G = G - \delta_G K_G, \quad (5)$$

where G denotes the gross rate of government investment expenditure, and government capital depreciates at the rate δ_G . We assume that the government sets its current gross expenditures on the investment good and the consumption good as fixed fractions of output, namely

$$G = gY \quad (6a)$$

$$H = hY, \quad (6b)$$

where g , h are chosen policy parameters. A constant government expenditure policy is thus associated with a fixed claim on output, and an expenditure level that grows with current output, with an expansionary policy being expressed by an increase in the (fixed) fraction. This is an appropriate specification of policy in a growth environment. The government's fiscal decisions are made subject to its flow budget constraint

$$\dot{B} = (1 - \tau_k)sB + G + H - \tau_k r K - \tau_w w(1-l)N - T, \quad (7)$$

where $B \equiv NB_i$ denotes the aggregate stock of bonds. Using (6a) and (6b), together

¹⁰ Since all agents are identical, each devotes the same fraction of time to leisure, and henceforth we can drop the agent's subscript to l .

with the optimality conditions (4) we may express (7) as

$$\dot{B} = (1 - \tau_k)sB + [g + h - \tau_k\sigma - \tau_w(1 - \sigma)]Y - T. \quad (7')$$

Written in this way we see that $[g + h - \tau_k\sigma - \tau_w(1 - \sigma)]Y$ specifies the primary budget deficit. Thus, $T(t) = [g + h - \tau_k\sigma - \tau_w(1 - \sigma)]Y(t)$ represents the amount of lump-sum taxation (or transfers) necessary to finance the primary deficit and is therefore a measure of current fiscal imbalance; see Bruce and Turnovsky (1999). Defining

$$V \equiv \int_0^{\infty} T(t)e^{-\int_0^t s(u)(1-\tau_k)du} dt \quad (8)$$

the government's intertemporal budget constraint, obtained by solving (7') and imposing the transversality condition, can be written in the form

$$V = B_0 + \int_0^{\infty} [g + h - \tau_k\sigma - \tau_w(1 - \sigma)]Y(t)e^{-\int_0^t s(u)(1-\tau_k)du} dt. \quad (9)$$

In general we say that the government is operating an intertemporally consistent fiscal policy as long as its expenditure and tax rates are such that (9) is satisfied with $V = 0$. Thus V measures the present discounted value of the lump-sum taxes or transfers necessary to balance the budget over time and is thus a measure of the intertemporal (im)balance of the government's budget. We shall focus on the case where the government is running an intertemporal surplus and the alternative fiscal policies we shall consider are all constrained to reduce the balancing term V by the same amount.

Aggregating (1c) over the N individuals and combining with (7') leads to the aggregate resource constraint

$$\dot{K} = Y - C - G - H - \delta_K K. \quad (10)$$

Substituting (6a), (6b) into (10), we may write the growth rate of private capital as:

$$\frac{\dot{K}}{K} = \left(1 - g - h - \frac{C}{Y}\right) \frac{Y}{K} - \delta_K. \quad (11a)$$

Likewise, substituting (6a) into (5), the growth rate of public capital may be written as:

$$\frac{\dot{K}_G}{K_G} = g \frac{Y}{K_G} - \delta_G. \quad (11b)$$

3. EQUILIBRIUM DYNAMICS

Our objective is to specify the transitional dynamics of the aggregate economy about a long-run balanced growth path. In long-run equilibrium, aggregate output, private capital, and public capital are assumed to grow at the same constant rate, so that the output–capital ratio and the ratio of public capital to private capital remain constant, while the fraction of time devoted to leisure remains constant. Taking percentage changes of the aggregate production function, (3), the long-run equilibrium growth rate of output, private and public capital, ψ , is:

$$\psi = \left(\frac{1 - \sigma}{1 - \sigma - \eta} \right) n. \quad (12)$$

We shall show that one condition for the dynamics to be stable is that $\sigma + \eta < 1$, in which case the long-run equilibrium growth rate $\psi > 0$. As long as government capital is productive, (12) implies that long-run per capita growth, $\psi - n$, is positive as well.

To analyze the transitional dynamics of the economy about the long-run stationary growth path, we express the system in terms of the following stationary variables: (i) the fraction of time devoted to leisure, l , and (ii) the scale-adjusted per capita quantities¹¹

$$k \equiv \frac{K}{N^{((1-\sigma)/(1-\sigma-\eta))}}; \quad k_g \equiv \frac{K_G}{N^{((1-\sigma)/(1-\sigma-\eta))}}; \quad y \equiv \frac{Y}{N^{((1-\sigma)/(1-\sigma-\eta))}}. \quad (13)$$

Using this notation, the scale-adjusted output can be written as:

$$y = \alpha(1 - l)^{1-\sigma} k^\sigma k_g^\eta. \quad (14)$$

Elsewhere we have shown how the equilibrium dynamics can be expressed as the following system in the redefined stationary variables, l, k, k_g :

$$\begin{aligned} \dot{l} = F(l) \left\{ \left((1 - \tau_k)\sigma - [1 - \gamma(1 + \phi)] \left[\sigma(1 - c - g - h) + \frac{\eta g k}{k_g} \right] \right) \frac{y}{k} \right. \\ \left. - \delta_K(1 - \sigma[1 - \gamma(1 + \phi)]) + \delta_G \eta [1 - \gamma(1 + \phi)] \right. \\ \left. - ([1 - \sigma][1 - \gamma(1 + \phi)] + \gamma)n + \rho \right\} \end{aligned} \quad (15a)$$

$$\frac{\dot{k}}{k} = (1 - c - g - h) \frac{y}{k} - \delta_K - \psi \quad (15b)$$

¹¹ Under constant returns to scale, these expressions reduce to per capita quantities, as in the usual neoclassical model.

$$\frac{\dot{k}_g}{k_g} = g \frac{y}{k_g} - \delta_G - \psi \quad (15c)$$

$$c = (1 - \tau_w) \left(\frac{1 - \sigma}{\theta} \right) \left(\frac{l}{1 - l} \right), \quad (15d)$$

where¹²

$$c \equiv \frac{C}{Y}; \quad F(l) = \frac{l(1 - l)}{(1 - \gamma) - (1 - \sigma)[1 - \gamma(1 + \phi)]l - \theta\gamma(1 - l)}.$$

Equation (15d) is obtained by dividing the optimality conditions (2a) and (2b), while noting (4). It asserts that the marginal rate of substitution between consumption and leisure, which grows with per capita consumption, must equal the tax-adjusted wage rate, which grows with per capita income.¹³ With leisure being complementary to consumption in utility, the equilibrium consumption–output ratio thus increases with leisure.

The steady state to this economy, denoted by “ \sim ”, can be summarized by

$$(1 - \tilde{c} - g - h) \left(\frac{\tilde{y}}{\tilde{k}} \right) = \delta_K + \psi \quad (16a)$$

$$g \frac{\tilde{y}}{\tilde{k}_g} + \delta_G + \psi \quad (16b)$$

$$(1 - \tau_k)\sigma \left(\frac{\tilde{y}}{\tilde{k}} \right) = \delta_K + \rho + [1 - \gamma(1 + \phi)]\psi + \gamma n \quad (16c)$$

together with the production function, (14), and (15d). These equations determine the steady-state equilibrium in the following sequential manner. First, (16c) determines the output–capital ratio so that the long-run net return to private capital equals the rate of return on consumption. Having derived the output–capital ratio, (16a) yields the consumption–output ratio consistent with the growth rate of capital necessary to equip the growing labor force and replace depreciation, while (16b) determines the corresponding equilibrium ratio of public to private capital. Given \tilde{c} , (15d) implies the corresponding allocation of time, l . Having obtained y/k , k_g/k , l , the production function then determines k , with k_g then being obtained from (16b).¹⁴

¹² We shall assume that $F(l) > 0$. Sufficient conditions that ensure this is so include (i) $\gamma < 0$, and (ii) $\sigma > \phi$, both of which are plausible empirically, and imposed in our numerical simulations.

¹³ The marginal rate of substitution between consumption and leisure is $\theta C_l/l$. Equating this to the tax-adjusted real wage, given in (4), yields (15d).

¹⁴ Given the restrictions on utility and production this solution is unique and economically viable in the sense of all quantities being non-negative, and in particular the fractions $0 < \tilde{c} < 1$, $0 < \tilde{l} < 1$, if and only if $\frac{(1 - g - h)}{\sigma(1 - \tau_k)} > \frac{\delta_K + \rho}{\delta_K + \rho + [1 - \gamma(1 + \phi)]\psi + \gamma n}$. This condition holds throughout our simulations.

From the equilibrium conditions (16) we find the following. First, the two fiscal instruments that do not impinge directly on either form of capital accumulation—namely government consumption expenditure and the tax on labor income—lead to proportionate long-run changes in the two capital stocks and output:

$$\frac{d\tilde{k}/dh}{\tilde{k}} = \frac{d\tilde{k}_g/dh}{\tilde{k}_g} = \frac{d\tilde{y}/dh}{\tilde{y}} > 0 \tag{17a}$$

$$\frac{d\tilde{k}/d\tau_w}{\tilde{k}} = \frac{d\tilde{k}_g/d\tau_w}{\tilde{k}_g} = \frac{d\tilde{y}/d\tau_w}{\tilde{y}} < 0. \tag{17b}$$

Second, invoking the stability condition, $\eta < 1 - \sigma$, the fiscal instrument has a more than a proportionate effect on the long-run capital stock upon which it impinges directly, while changing output and the other capital stock proportionately

$$\frac{d\tilde{k}_g/dg}{\tilde{k}_g} > \frac{d\tilde{k}/dg}{\tilde{k}} = \frac{d\tilde{y}/dg}{\tilde{y}} > 0 \tag{17c}$$

$$\frac{d\tilde{k}/d\tau_k}{\tilde{k}} < \frac{d\tilde{k}_g/d\tau_k}{\tilde{k}_g} = \frac{d\tilde{y}/d\tau_k}{\tilde{y}} < 0. \tag{17d}$$

Linearizing around the steady state denoted by $\tilde{l}, \tilde{k}, \tilde{k}_g$, the dynamics may be approximated by

$$\begin{pmatrix} \dot{l} \\ \dot{k} \\ \dot{k}_g \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ \frac{-\tilde{y}}{1-\tilde{l}} \left[(1-\sigma)(1-c-g-h) + \frac{\tilde{c}}{\tilde{l}} \right] & -(1-\sigma)\frac{\tilde{y}}{\tilde{k}} [1-\tilde{c}-g-h] & \eta\frac{\tilde{y}}{\tilde{k}_g} [1-\tilde{c}-g-h] \\ -\frac{g(1-\sigma)\tilde{y}}{1-\tilde{l}} & \frac{g\sigma\tilde{y}}{\tilde{k}} & \frac{g(\eta-1)\tilde{y}}{\tilde{k}_g} \end{pmatrix} \begin{pmatrix} l-\tilde{l} \\ k-\tilde{k} \\ k_g-\tilde{k}_g \end{pmatrix}, \tag{18}$$

where

$$a_{11} \equiv \frac{F(\tilde{y}/\tilde{k})}{1-\tilde{l}} \left\{ -G(1-\sigma) + [1-\gamma(1+\phi)]\frac{\sigma\tilde{c}}{\tilde{l}} \right\}$$

$$a_{12} \equiv -\frac{F\tilde{y}}{\tilde{k}^2} \left\{ G(1-\sigma) + [1-\gamma(1+\phi)]\frac{\eta g\tilde{k}}{\tilde{k}_g} \right\};$$

$$a_{13} \equiv \frac{F\tilde{y}\eta}{\tilde{k}\tilde{k}_g} \left\{ G + [1-\gamma(1+\phi)]\frac{g\tilde{k}}{\tilde{k}_g} \right\}$$

$$G \equiv (1-\tau_k)\sigma - [1-\gamma(1+\phi)] \left[\sigma(1-\tilde{c}-g-h) + \frac{\eta g\tilde{k}}{\tilde{k}_g} \right].$$

We can readily establish that the determinant of the matrix is proportional to $(1 - \sigma - \eta)$, so that provided $\eta < 1 - \sigma$ the determinant is positive, which means that

there are either three positive or one positive roots. This condition imposes an upper bound on the positive externality generated by government capital. Unfortunately, due to the complexity of the system, we cannot find a simple general condition to rule out the explosive growth case of three positive roots. But one condition that does suffice to do so is if (i) $\gamma = 0$ and (ii) $\tilde{c} > (\delta_K + \psi)(1 - \sigma - \eta) + (1 - \sigma)\rho$. This latter condition holds in our simulations, and indeed, in all of the many simulations carried out over a wide range of plausible parameter sets, one positive and two negative roots were always obtained. Thus since the system features two state variables, k and k_g , and one jump variable, l , we are confident that the equilibrium is generally characterized by a unique stable saddlepath.¹⁵

3.1. Characterization of Transitional Dynamics

Henceforth we assume that the stability properties are ensured so that we can denote the two stable roots by μ_1, μ_2 , with $\mu_2 < \mu_1 < 0$. The two state variables are scale-adjusted public and private capital. The generic form of the stable solution for these variables is given by

$$k(t) - \tilde{k} = B_1 e^{\mu_1 t} + B_2 e^{\mu_2 t} \quad (19a)$$

$$k_g(t) - \tilde{k}_g = B_1 v_{21} e^{\mu_1 t} + B_2 v_{22} e^{\mu_2 t}, \quad (19b)$$

where B_1, B_2 are constants and the vector $(1 \ v_{2i} \ v_{3i}) \ i = 1, 2$ (where the prime denotes vector transpose) is the normalized eigenvector associated with the stable eigenvalue, μ_i . The constants, B_1, B_2 , appearing in the solution (19) are determined by initial conditions and depend upon the specific shocks. Thus suppose that the economy starts out with given initial stocks of private and public capital, k_0, k_{g0} , and through some policy shock converges to \tilde{k}, \tilde{k}_g . Setting $t = 0$ in (19a), (19b) and letting $d\tilde{k} \equiv \tilde{k} - k_0, d\tilde{k}_g \equiv \tilde{k}_g - k_{g0}$, B_1, B_2 are given by:

$$B_1 = \frac{d\tilde{k}_g - v_{22} d\tilde{k}}{v_{22} - v_{21}}; \quad B_2 = \frac{v_{21} d\tilde{k} - d\tilde{k}_g}{v_{22} - v_{21}}. \quad (20)$$

Having thus derived B_1, B_2 , the implied time path for leisure is determined by

$$l(t) - \tilde{l} = B_1 v_{31} e^{\mu_1 t} + B_2 v_{32} e^{\mu_2 t} \quad (19c)$$

so that $l(0) = \tilde{l} + B_1 v_{31} + B_2 v_{32}$ is now determined in response to the shock.

¹⁵ The fact that our simulations are associated with unique stable saddlepaths does not rule out the possibility of more complex dynamic behavior for other less plausible parameter values. In cases where $\gamma > 0$ (intertemporal elasticity of substitution greater than unity) and for large shares of government expenditure (in excess of 40%) it is possible to obtain complex roots, giving rise to cyclical behavior.

4. SOCIALLY OPTIMAL GOVERNMENT EXPENDITURE

One characteristic of our numerical results is that the benefits to increasing government expenditure are limited. This is because there are socially optimal levels of both types of expenditure. To see this it is useful to set out the steady-state equilibrium for the centrally planned economy in which the planner controls resources directly. The optimality conditions for such an economy consist of Eqs. (14), (16a), (16b), together with

$$c \equiv \frac{C}{Y} = \left(\frac{1-\sigma}{\theta} \right) \left(\frac{l}{1-l} \right) v \quad (15d')$$

$$v\sigma \left(\frac{\tilde{y}}{k} \right) = \delta_K + \rho + [1 - \gamma(1 + \phi)]\psi + \gamma n \quad (16c')$$

$$v = 1 + (q - 1)g + (\phi c - h) \quad (21a)$$

$$v\sigma \frac{\tilde{y}}{k} - \delta_K = v \frac{\eta}{q} \frac{\tilde{y}}{k_g} - \delta_G, \quad (21b)$$

where v denotes the shadow price of a marginal unit of output in terms of capital and q denotes the shadow price of public capital in terms of private capital. These equations determine the steady-state solutions for c , y , l , k , k_g , v , q in terms of the arbitrarily set expenditure parameters g and h .

In contrast to the decentralized economy the after-tax prices relevant for the marginal rate of substitution condition in (15d') and for the return to capital in (16c') are replaced by the relative price of output in terms of consumption (capital). Equation (21a) determines the relative price of output to capital. In the absence of government expenditure, $v = 1$. Otherwise, the social value of a unit of output deviates from the social value of capital due to the claims of government on output and the value this has for the consumer. Specifically, with the size of government expenditure being tied to aggregate output, an increase in output will divert resources away from private consumption, leaving $1 - g - h$ available to the agent. But offsetting this, public investment augments the stock of public capital, valued at qg , and public consumption provides utility benefits equal to ϕc , making the overall value of output to capital as described in (21a). The final equation equates the long-run net social returns to investments in the two types of capital.

Choosing the expenditure shares g and h optimally implies the socially optimal fractions of output devoted to government consumption and investment are

$$\hat{h} = \phi c; \quad \hat{q} = 1, \quad \text{and hence } v = 1.$$

The marginal benefit of government consumption expenditure should equal its resource cost, while the shadow values of the two types of capital should be equated. Substituting these conditions into (16b), (16c'), and (21b), the optimal

share of output devoted to government production expenditure is

$$\hat{g} = \frac{\eta[\delta_G + \psi]}{\delta_G + \rho + \left[\frac{[1 - \gamma(1 + \phi)](1 - \sigma)}{1 - \sigma - \eta} + \gamma \right] n} \quad (22)$$

which provided $\gamma < 0$ implies $\hat{g} < \eta$.¹⁶

5. CALIBRATING THE ECONOMY

We begin our numerical analysis of the alternative fiscal policies by calibrating a benchmark economy, using the following parameters representative of the US economy:

<i>Production parameters</i>	$\alpha = 1, \quad \sigma = 0.35, \quad \eta = 0.20, \quad n = 0.015, \quad \delta_K = 0.05,$ $\delta_G = 0.05$
<i>Preference parameters</i>	$e = 1/(1 - \gamma) = 0.4, \quad \text{i.e., } \gamma = -1.5, \quad \rho = 0.04,$ $\theta = 1.75, \quad \phi = 0.3$
<i>Fiscal parameters</i>	$g = 0.08, \quad h = 0.14, \quad \tau_w = 0.28, \quad \tau_k = 0.28$

The elasticity on capital implies that approximately 35% of output accrues to private capital and the rest to labor, which grows at the annual rate of 1.5%. The elasticity $\eta = 0.20$ on public capital implies that public capital generates a significant externality in production. The chosen value is substantially smaller than the extreme value (0.39) suggested by Aschauer (1989) and lies within the range of the consensus estimates; see Gramlich (1994).

The preference parameters imply an intertemporal elasticity of substitution in consumption of 0.4, consistent with empirical evidence; see, e.g., Ogaki and Reinhart (1998).¹⁷ The elasticity of leisure $\theta = 1.75$ accords with the value generally chosen by real business cycle theorists and yields an equilibrium fraction of time devoted to leisure of about 0.7, consistent with the empirical evidence). The elasticity of 0.3 on government consumption implies that the optimal ratio of government consumption to private consumption is 0.3.

Our benchmark tax on wage income, $\tau_w = 0.28$, reflects the average marginal personal income tax rate in the United States. Given the complex nature of capital income taxes, part of which may be taxed at a lower rate than wages, and part

¹⁶ This result contrasts with the optimal government expenditure in the Barro (1990) model, where, when government production expenditure impacts output as a flow, $\hat{g} = \eta$. It is consistent with endogenous growth models, in which government production appears as a stock; see Futagami *et al.* (1993) and Turnovsky (1997). The replication of this by the decentralized economy requires that $\tau_k = \tau_w = 0$ so that public expenditures are financed by appropriately set lump-sum taxes. However, this replication is in general impossible here, given the other policy objective (government surplus reduction) being simultaneously imposed.

¹⁷ The empirical evidence on the intertemporal elasticity of substitution is quite varied, ranging between 0.1 (Hall, 1988) and 1 (Beaudry and van Wincoop, 1995).

at a higher rate, we have chosen the common rate $\tau_k = 0.28$ as the benchmark. Government expenditure parameters have been chosen so that the total fraction of net national production devoted to government expenditure on goods and services equals 0.22, the historical average in the United States. The breakdown between $h = 0.14$ and $g = 0.08$ is arbitrary, but plausible. Government investment expenditure is less than 0.08 and our choice of $g = 0.08$ is motivated by the fact that a substantial fraction of government consumption expenditure, such as public health services, impacts as much on productivity as they do on utility. The annual (equal) depreciation rates $\delta_K = \delta_G = 0.05$ serve as a plausible benchmark case.

These parameters lead to the following plausible benchmark equilibrium, reported in Row 1 of Table I: fraction of time allocated to leisure, $l = 0.71$; consumption–output ratio is 0.64; the ratio of public to private capital is 0.58.¹⁸ The equilibrium levels of scale-adjusted private capital, public capital, and output are 0.57, 0.33, and 0.52, respectively. Since these units are arbitrary (depending on α) they have all been normalized to unity. The corresponding quantities in the rows below are all measured relative to the respective benchmark values of unity.¹⁹ In addition the steady-state growth rate, which by the nonscale nature of the economy is independent of policy, equals 2.17%.

The stable adjustment path for the benchmark economy is characterized by the two stable eigenvalues (not reported), which are approximately -0.034 and -0.104 . These imply that per capita output and capital converge at the asymptotic rate of approximately 2.7%, consistent with the accepted empirical evidence.²⁰ An interesting feature of the model is that both stable roots are remarkably stable over the fiscal exercises conducted.²¹

One of our primary concerns is the impact of the alternative policies on economic welfare. This is measured by the optimized utility of the representative agent:

$$W \equiv \int_0^{\infty} Z(t) dt = \int_0^{\infty} \frac{1}{\gamma} ((C/N)l^\theta H^\phi)^\gamma e^{-\rho t} dt \quad (23)$$

where $Z(t)$ denotes instantaneous utility and C/N , l , H are evaluated along the

¹⁸ Estimates of time allocation studies suggest that households allocate somewhat less than one-third of their discretionary time to market activities (labor) and our equilibrium value $l = 0.71$ is generally consistent with that. Direct evidence on the ratio of public to private capital is sparse. Using the following relationships: (i) $\dot{K} = I - \delta_K K$, $\dot{K}_G = G - \delta_G K_G$. Assuming that on the balanced growth path that $\dot{K}/K = \dot{K}_G/K_G$ and $\delta_K = \delta_G$ implies the long-run relationship $K_G/K = k_g/k = G/I$. Taking $G = 0.08$, $I = 0.14$ yields the long-run ratio of public to private capital of around 0.57.

¹⁹ Thus, for example, in Row 2 the new steady-state stocks of private and public capital when h is increased by 0.05 are 0.621.

²⁰ These statements are based on the measure of the speed of convergence proposed by Eicher and Turnovsky (1999).

²¹ The unstable root is larger and more variable across policies. This implies that the speeds of adjustments are fairly uniform across permanent fiscal changes, though they may vary across temporary policy changes; see Turnovsky (2001). The speed of convergence is also more sensitive to structural changes, such as changes in the productive elasticities.

TABLE I

	τ_k	τ_w	g	h	l	c	k_g/k	Private capital (relative to base)	Public capital (relative to base)	Output (relative to base)	Long-run government balance	Short-run welfare gains	Long-run welfare gains
A. Long-Run Effects of Fiscal Policy Shocks													
Base economy	0.28	0.28	0.08	0.14	0.706	0.643	0.582	0.570 (=1)	0.332 (=1)	0.522 (=1)	-0.298	—	—
Increase in h	0.28	0.28	0.08	0.190	0.689	0.593	0.582	1.09	1.09	1.09	-0.050	+1.11%	+2.86%
Increase in g	0.28	0.28	0.130	0.14	0.689	0.593	0.943	1.34	2.18	1.34	-0.050	-4.13%	+3.77%
Decrease in τ_k	0.140	0.28	0.08	0.14	0.697	0.616	0.487	1.43	1.20	1.20	-0.050	-4.31%	+3.49%
Decrease in τ_w	0.28	0.203	0.08	0.14	0.685	0.643	0.582	1.11	1.11	1.00	-0.050	+0.32%	+2.51%
B. Some Alternative Policy Mixes and Long-Run Equilibrium													
Base economy	0.28	0.28	0.08	0.14	0.706	0.643	0.582	0.570 (=1)	0.332 (=1)	0.522 (=1)	-0.298	—	—
Uniform increase in government expenditures	0.28	0.28	0.105	0.105	0.689	0.593	0.763	1.22	1.60	1.22	-0.050	-0.97%	+3.81%
Uniform cut in taxes	0.230	0.230	0.08	0.14	0.689	0.633	0.543	1.22	1.14	1.14	-0.050	-1.34%	+3.00%
Optimal government expenditures	0.284	0.28	0.109	0.162	0.689	0.592	0.798	1.23	1.69	1.24	-0.050	-1.28%	+3.84%
τ_k adjusts	0.28	0.282	0.109	0.162	0.689	0.592	0.798	1.24	1.69	1.24	-0.050	-1.42%	+3.88%
Optimal government expenditures τ_w adjusts	0.160	0.348	0.109	0.162	0.701	0.569	0.680	1.55	1.80	1.33	-0.050	-5.52%	+4.38%
Second-best optimal government expenditures	0.160	0.348	0.109	0.162	0.701	0.569	0.680	1.55	1.80	1.33	-0.050	-5.52%	+4.38%

equilibrium path. The welfare gains reported are calculated as the percentage change in the flow of base income necessary to maintain the level of welfare unchanged in response to the policy shock. The short-run impact is measured by the changes in $Z(t)$, while the long-run impact is summarized by the change in the overall intertemporal index W .

The other key measure of economic performance, the measure of the intertemporal fiscal balance has been defined previously in equation (8). For the chosen parameters tax revenues exceed government expenditures on goods and services by around 6% of current income.²² Evaluating (9) along the balanced growth path and assuming without loss of generality that $B_0 = 0$, we find that in the benchmark case, $V = -0.298$, a surplus nearly 30% measured in terms of current income. In all cases, the fiscal policies we consider involve reducing the surplus from its initial value of $V = -0.298$ to $V = -0.05$. However, the results are insensitive to the arbitrarily chosen level of B_0 and thus V ; what is relevant is the *reduction* in V .²³

6. REDUCING THE SURPLUS (INCREASING THE DEFICIT)

Rows 2–5 in Table I-A describe the four basic policy changes from the benchmark economy, with the corresponding dynamic transition paths being illustrated in Figs. 1–4. One striking pattern throughout all simulations is that the labor supply responds almost completely upon impact to an unanticipated permanent shock. After the initial jump, the transitional path for labor supply is virtually flat. The reason for this is that for plausible parameter values the elements a_{12} , a_{13} in the transitional matrix in (18) are both small relative to $a_{11} > 0$; there is little feedback from the changing stocks of capital to labor supply. In other words, the dynamics of labor can be approximated by the *unstable* first order system

$$dl(t)/dt = a_{11}(l(t) - \tilde{l})$$

which for bounded behavior essentially requires that l jump to steady state.

6.1. Increase in Government Consumption Expenditure

One way of reducing the surplus from -0.298 to -0.05 is to increase government consumption expenditure h by 0.05 percentage points from 0.14 to 0.19. This increases long-run private capital, public capital, and output proportionately by 9%, while crowding out the long-run private consumption–output ratio by 0.05 percentage points, with a corresponding reduction in leisure by 0.02. The lower private consumption and higher labor supply reduce welfare, while the higher

²² This accords approximately with recent data on the surplus of government account on goods and services.

²³ The reduction in V we consider is equivalent to 25% of current income, an amount something in excess of 2 trillion dollars.

government consumption is welfare increasing. On balance, the latter effect dominates and short-run welfare increases by a little over 1%. The higher employment increases the productivity of capital, stimulating its accumulation and the growth of output over time. Thus, despite the reduction in the long-run consumption–output ratio the accumulation of capital and growth of output over time implies that the fall in absolute consumption is small so that overall welfare rises by 2.86% relative to the benchmark.

The dynamics of this shock are illustrated in the four panels of Fig. 1. The immediate effect of the lump-sum tax-financed increase in expenditure is to reduce the private agent's wealth, inducing him or her to supply more labor, thereby raising the marginal productivity of both types of capital and raising output.

The phase diagram Fig. 1a indicates that the two capital stocks accumulate approximately proportionately. This is also reflected in their growth rates (Fig. 1b), which both jump initially to around 2.5% and track one another closely as they both gradually decline to their steady-state rates of around 2.2%, as both types of capital accumulate and their respective rates of return decline. With the labor supply remaining virtually fixed after the initial jump, the growth rate of output is below that of either form of capital during the transition. In Fig. 1c the implied adjustment paths of output, consumption, and employment are illustrated relative to their respective benchmark economies. As noted, upon impact, the initial expenditure increase raises instantaneous welfare by over 1% and this grows uniformly with the growth in the capital stocks and output to an asymptotic improvement relative to the benchmark, of over 5%, the present value of which is 2.86%. Finally, the expenditure increase drastically reduces the current government deficit relative to the benchmark economy, which then rises modestly throughout the transition, reflecting the corresponding rise in the growth of output.²⁴

6.2. Increase in Government Investment Expenditure

Increasing the rate of government expenditure g by 0.05 from 0.08 to 0.13 also will reduce the surplus from -0.298 to -0.05 .²⁵ But it is associated with markedly different equilibrium responses and therefore long-run capital structure. Long-run private capital and output both increase by 34%, and public capital increases by 118%, raising the ratio of public to private capital from 0.58 to 0.94. The effects on employment and the consumption–output ratio are precisely as for h , as noted in Table I. The reduction in initial consumption and leisure, illustrated in Fig. 2c, with no immediate public expenditure benefits, leads to an initial reduction in welfare of 4.13% (Fig. 2d), although the long-run increase in productive capacity raises overall welfare.

²⁴ These paths are almost all identical for the different modes of reducing the surplus and are not illustrated.

²⁵ Actually, the amounts of the government expenditures consistent with the same reduction in the intertemporal surplus differ slightly in the two cases. Because of the larger increases in $Y(t)$ over time, the increase in g is only 0.0496, rather than 0.05. We have computed the policies and the implied transitional dynamics using the more accurate numbers.

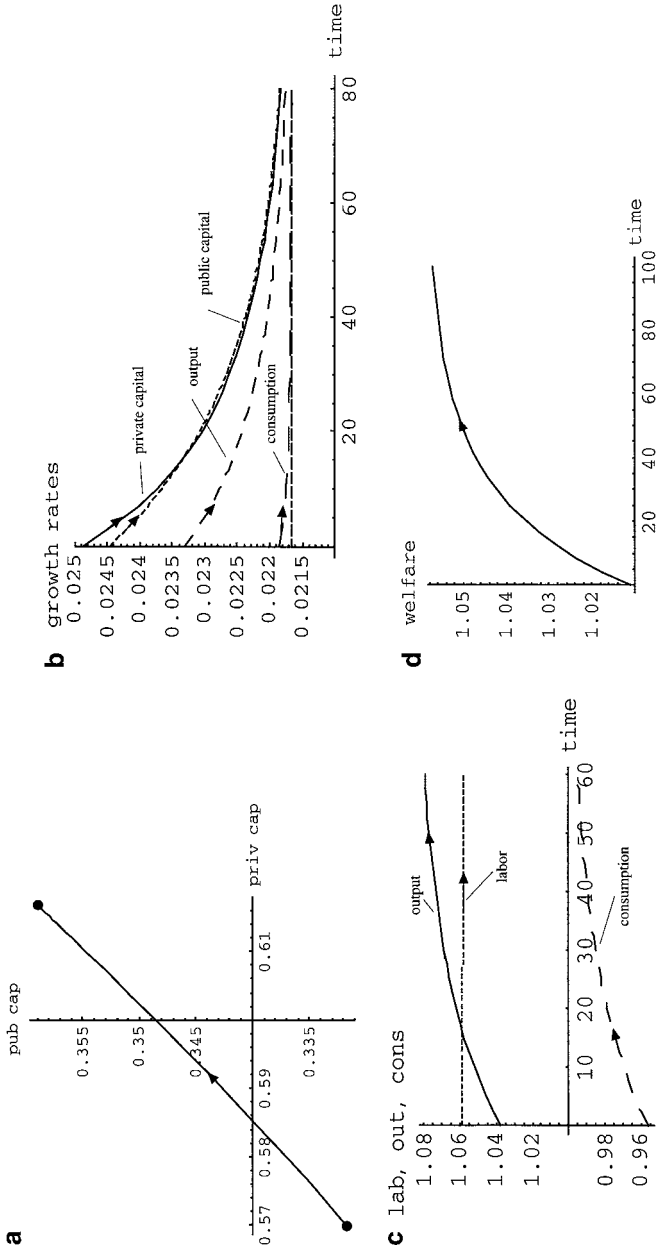


FIG. 1. Transitional dynamics: Increase in government consumption. (a) Phase diagram—Scale adjusted private and public capital. (b) Time paths for growth rates. (c) Transition paths for labor, output, consumption relative to benchmark economy. (d) Time path for instantaneous welfare gains.

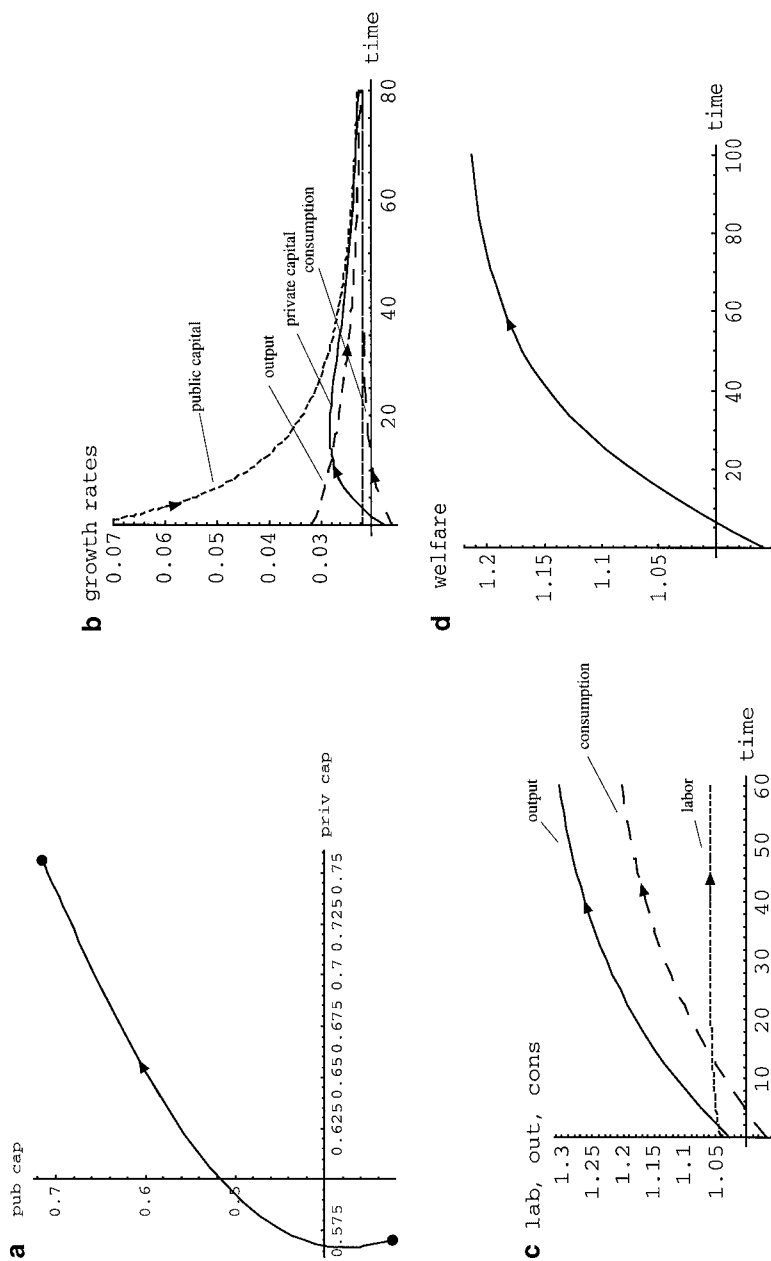


FIG. 2. Transitional dynamics: Increase in government investment. (a) Phase diagram—scale adjusted private and public capital. (b) Time paths for growth rates. (c) Transition paths for labor, output, consumption relative to benchmark economy. (d) Time path for instantaneous welfare gains.

The dynamic adjustments paths followed by the two capital stocks are in sharp contrast both to one another and to the adjustment that occurs in response to an equivalent increase in government consumption. The initial claim on capital by the government crowds out private investment, so that the growth rate of private capital is reduced below the growth rate of population; the scale-adjusted stock of private capital therefore initially declines. By contrast, the direct investment raises the initial growth rate of public capital to over 6% (see Fig. 2b), although this then declines steadily over time as the increase in its stock reduces the return to further public investment. As the new public capital is put in place, its productivity raises the return to private capital, thereby stimulating its rate of accumulation and its growth rate. Over time, as the more public capital is in place and its growth rate declines, this effect is mitigated and the growth rate of private capital, after initially rising, begins to fall to its constant steady-state rate. Thus, whereas the growth rates of the two forms of capital track one another closely in response to an increase in h , they diverge markedly during the transition in the present case.

As capital is accumulated and output and consumption grow, so does welfare, and asymptotically the instantaneous welfare rises 25% above the base level. The present value of this increase, after allowing for the initial loss, is around 4.13%.

6.3. *Decrease in Tax on Capital*

A third way to reduce the surplus to -0.05 is to lower the tax on capital income from 0.28 to 0.140. This also has a dramatic long-run effect, increasing private capital by about 43% and public capital and output by around 20%. The dynamics are illustrated in Fig. 3. The reduced tax on capital increases the return to labor leading to an initial substitution toward more labor and less consumption. Initially welfare falls by 4.31% (Fig. 3d). Upon impact, the lower tax raises the growth rate on private capital to around 5%, so that the scale-adjusted per capita stock, k , begins to increase rapidly. The increase in labor and the increase in private capital increases the growth rate of output, and the growth rate of public capital begins to rise as well, so that k and k_g follow the increasing paths in Fig. 3a. With the incentive applying directly to private capital, k increases relative to k_g during the initial stages. But as private capital increases in relative abundance its productivity declines, inducing less investment in private capital and thereby retarding its growth rate. This in turn reduces the productivity of public capital, the increasing growth rate of which is reversed after 15 periods. The steady increase in relative consumption over time implies that after the initial decrease, instantaneous welfare increases steadily relative to the benchmark, increasing asymptotically by about 12.5%. The present value of this increase is equivalent to a 3.49% increase in income. Thus we see that reducing the surplus by reducing the tax on capital income is significantly superior to spending the surplus on a government consumption good and is nearly as good as spending the surplus on a government investment good. And like the latter it involves a sharp intertemporal tradeoff in benefits. In both cases significant short-run welfare losses must be incurred in order to obtain large long-run welfare gains resulting from the stimulus to investment in both cases.

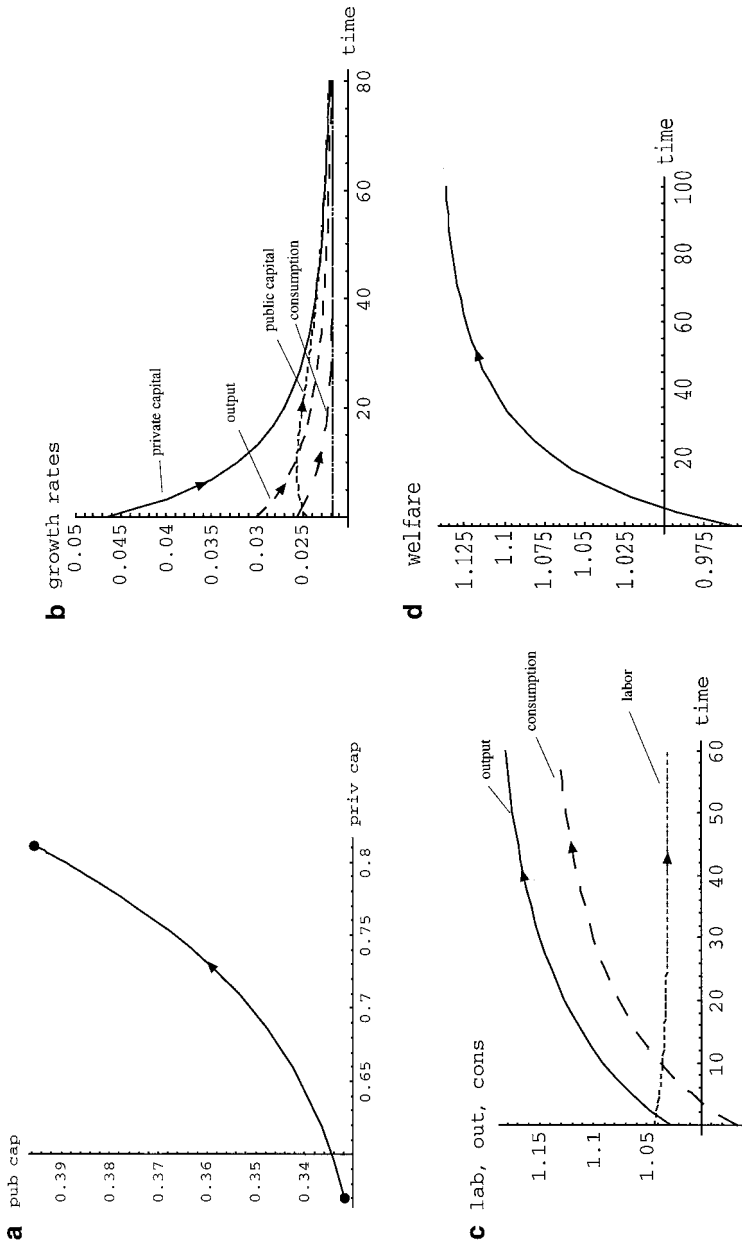


FIG. 3. Transitional dynamics: Decrease in tax on capital income. (a) Phase diagram—scale adjusted private and public capital. (b) Time paths for growth rates. (c) Transition paths for labor, output, consumption relative to benchmark economy. (d) Time path for instantaneous welfare gains.

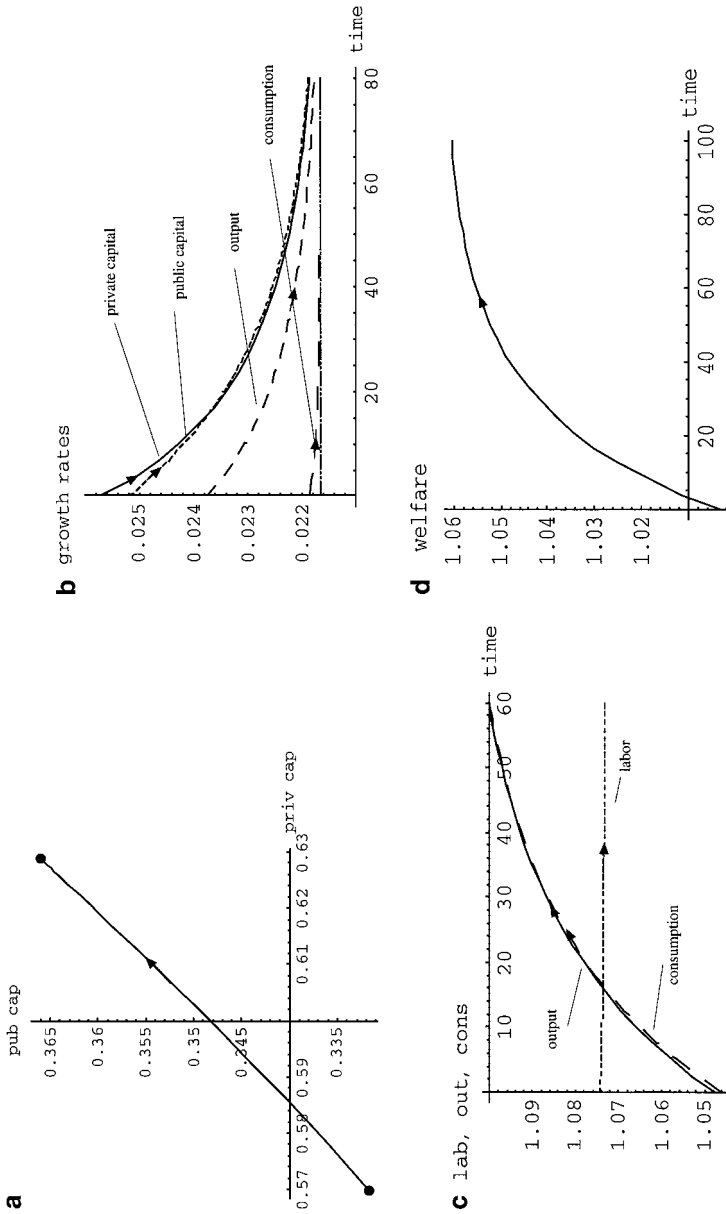


FIG. 4. Transitional dynamics: Decrease in tax on labor income. (a) Phase diagram—scale adjusted private and public capital. (b) Time paths for growth rates. (c) Transition paths for labor, output, consumption relative to benchmark economy. (d) Time path for instantaneous welfare gains.

6.4. *Decrease in Tax on Wage Income*

Finally, the government may reduce the surplus by reducing the tax on labor income to 0.203. The effects of this are much closer to those of an increase in government expenditure on consumption. Private capital, public capital, and output all increase proportionately by around 11% and labor supply is reduced by 0.02. As in the other shocks, the increase in employment occurs virtually instantaneously, reducing short-run welfare. On the other hand, the reduction in the tax on labor income stimulates initial consumption by around 5% and this is welfare improving. Overall, the latter effect dominates and welfare improves slightly in the short run by around 0.32%. The increase in employment enhances the productivity of both private and public capital which are accumulated over time. As in the case of an increase in government consumption expenditure, which does not impact on either form of capital directly, the lower tax on labor income stimulates the accumulation of both types of capital approximately equally, so that their respective growth rates track one another closely. The accumulation of capital and the output over time raises consumption and intertemporal welfare increases by around 2.5%. Thus, at least for the model as parameterized, reducing the tax on labor income is dominated by the other policies we have considered.

6.5. *Other Policy Mixes*

The four policies considered in Table I-A describe the basic options and we now address some alternatives summarized in Table I-B. First, we see that increasing government expenditure uniformly on the two types of good by 0.025 each is marginally superior to increasing expenditure on the productive input alone. This is because there are in fact optimal degrees of expenditure on both types of government goods $\hat{g} = 0.109$, $\hat{h} = 0.162$, respectively. Increasing g from its initial value of 0.08 to 0.13 takes it too far beyond the optimum. The uniform increase takes g to 0.105 and h to 0.165, both close to their respective optima. By contrast, a uniform cut in the tax rate to 0.23 is significantly inferior to targeting the capital income tax alone.

The final three policy shocks involve setting the two forms of government expenditure at their respective optimal values. This involves increasing total government expenditure by 0.051, requiring a slight adjustment in the tax rates in order to maintain the long-run surplus at its target level of -0.05 . In the first case this can be accomplished by raising the tax on capital income from 0.28 to 0.284; in the second case it is done by raising the tax on labor income slightly from 0.28 to 0.282. Of these two options, the latter is marginally superior.

However, greater gains can be obtained by increasing the tax on labor and reducing it correspondingly on capital. Indeed the optimal fiscal mix consistent with maintaining the surplus at its target level of -0.05 is to set expenditures at their respective optimal values $\hat{g} = 0.109$, $\hat{h} = 0.162$, reduce the tax on capital to 0.160, and raise the tax on labor income to 0.348. While this will lead to substantial short-run welfare losses while consumption is foregone and capital is accumulated,

this will be more than offset by long-run welfare gains, the present value of which is around 4.4%. These results suggest that further welfare gains can be attained by combining the reduction of the surplus with some revision of the tax structure.

7. SOME SENSITIVITY ANALYSIS

The sensitivity of utility to government consumption, ϕ , and the productivity of public capital, η , are two key parameters. While the values we have chosen are plausible for the United States, the empirical evidence on them is sparse and in some cases far-ranging. Table II therefore summarizes the welfare effects obtained for the combination of cases over the ranges $\phi = 0.15, 0.30, 0.45$ and $\eta = 0.10, 0.20, 0.30$. These we identify with low, medium, and high direct impacts of government expenditure, respectively. Varying the parameters in this way also aids in our appreciation of the importance of the levels of government expenditure relative to their respective optima.

In studying Table II we should point out that changes in the structural parameters ϕ and η will generate differences in the initial government surplus V . To preserve comparability we shall normalize everything so that all changes begin from the same initial government surplus $V = -0.298$. This is done by simply introducing a transfer term v which has no effect on any other aspect of the equilibrium. Thus in all cases, our experiments begin with the same initial tax and expenditure structure, $g = 0.08, h = 0.13, \tau_k = \tau_w = 0.28$, with the corresponding surplus $V = -0.298$ and reducing V to -0.050 , as in Table I. The cell in bold letters corresponds to the base parameter set assumed in Table I. The quantities $h = 0.19$ etc. in the box describes the increase in h consistent with reducing the surplus to -0.05 , and $\hat{h} = 0.162$ describes the optimum. All other boxes are similar, but the main point to observe is that the magnitude of the elasticity parameters ϕ and η has an important bearing on the magnitudes of the tax and expenditure changes that are consistent with reducing the surplus by the (common) required amount.

From Table II we can detect the following patterns:

1. Decreasing the tax rate on labor income always yields long-run (intertemporal) benefits which, not surprisingly, increase with the importance of government consumption in utility, ϕ . Less obviously, they also increase with the productivity of public capital, η , and indeed are more sensitive to increases in the latter. This is because the decrease in τ_w stimulates employment, which interacts with both types of capital in production. The more productive public capital, the more output increases, ultimately generating greater consumption benefits.

2. The short-run welfare effects of decreasing the tax rate on labor income depend upon ϕ and will be mildly adverse if ϕ is small (0.15). This is because the positive short-run consumption benefits stemming from the lower tax rate are now dominated by the adverse employment effects.

3. Decreasing the tax rate on capital income always has adverse short-run effects on welfare but positive long-run benefits. This is because by directing

TABLE II
Sensitivity of Welfare Gains to Variations in ϕ and η (Measured in Percentages)

	$\phi = 0.15$				$\phi = 0.30$				$\phi = 0.45$			
	Increase in h	Increase in g	Decrease in τ_k	Decrease in τ_w	Increase in h	Increase in g	Decrease in τ_k	Decrease in τ_w	Increase in h	Increase in g	Decrease in τ_k	Decrease in τ_w
$\eta = 0.10$	$\nu = 0.024$ $h = 0.170$ $g = 0.110$ $\tau_k = 0.196$ $\tau_w = 0.234$ $h = 0.173$ $g = 0.113$ $\tau_k = 0.186$ $\tau_w = 0.229$ $h = 0.177$ $g = 0.117$ $\tau_k = 0.177$ $\tau_w = 0.224$ $\hat{h} = 0.096$, $\hat{g} = 0.058$ $\hat{h} = 0.172$, $\hat{g} = 0.057$ $\hat{h} = 0.234$, $\hat{g} = 0.055$											
Short-run welf. gain	-1.87	-3.49	-3.62	-0.26	+0.93	-3.15	-3.11	+0.15	+3.68	-2.84	-2.68	+0.55
Long-run welf. gain	-0.90	-0.86	+1.42	+1.00	+1.96	-0.35	+2.02	+1.45	+4.75	+0.11	+2.57	+1.89
$\eta = 0.20$	$\nu = 0.007$ $h = 0.184$ $g = 0.124$ $\tau_k = 0.155$ $\tau_w = 0.211$ $h = 0.190$ $g = 0.130$ $\tau_k = 0.140$ $\tau_w = 0.203$ $h = 0.196$ $g = 0.136$ $\tau_k = 0.123$ $\tau_w = 0.194$ $\hat{h} = 0.090$, $\hat{g} = 0.113$ $\hat{h} = 0.162$, $\hat{g} = 0.109$ $\hat{h} = 0.221$, $\hat{g} = 0.105$											
Short-run welf. gain	-2.85	-4.48	-4.98	-0.27	+1.11	-4.13	-4.31	+0.32	+5.09	-3.85	-3.77	+0.90
Long-run welf. gain	-1.22	+2.90	+2.62	+1.82	+2.86	+3.77	+3.49	+2.51	+6.99	+4.57	+4.31	+3.18
$\eta = 0.30$	$\nu = -0.046$ $h = 0.229$ $g = 0.169$ $\tau_k = 0.032$ $\tau_w = 0.144$ $h = 0.242$ $g = 0.184$ $\tau_k = -0.006$ $\tau_w = 0.123$ $h = 0.257$ $g = 0.199$ $\tau_k = -0.047$ $\tau_w = 0.100$ $\hat{h} = 0.084$, $\hat{g} = 0.163$ $\hat{h} = 0.153$, $\hat{g} = 0.156$ $\hat{h} = 0.210$, $\hat{g} = 0.150$											
Short-run welf. gain	-6.65	-10.4	-8.69	-0.55	+0.00	-10.2	-7.71	+0.50	+6.97	-9.99	-6.84	+1.56
Long-run welf. gain	-2.99	+15.3	+6.10	+4.02	+4.17	+17.9	+7.86	+5.36	+11.7	+20.6	+9.53	+6.71

resources toward private investment, consumption and leisure are both reduced in the short run. Over time, the increased capital stock leads to more output, more consumption, and positive welfare effects. The intertemporal tradeoff in benefits increase sharply with the productivity of public capital. A larger η increases the returns to sacrificing consumption in the short run for greater future consumption benefits.

4. An increase in government consumption expenditure will produce positive short-run and long-run benefits provided ϕ is sufficiently large. However, if ϕ is small increasing h is welfare-deteriorating. This is because the initial benchmark value of $h = 0.14$, from which the increase is occurring, is greater than the socially optimal level, \hat{h} . The increase in utility obtained from more government consumption is dominated by the losses incurred from the crowding out of private consumption and decline in leisure. Both the short-run and long-run benefits from government consumption increase with ϕ . In contrast, the short-run and long-run benefits from government consumption increase with the productivity of public capital η as long as the utility of government consumption is sufficiently large. However, if the latter are small, an increase in the productivity of government production simply exacerbates the losses stemming from increased government consumption.

5. An increase in government investment expenditure is always associated with short-run welfare losses, as resources are diverted away from consumption. In general, the increase in government capital will generate positive long-run welfare gains, unless the direct impacts of public capital and public consumption are both small. Thus, for example, if $\phi = 0.15$, $\eta = 0.10$, the initial rates of government expenditure ($g = 0.08$, $h = 0.14$) exceed their respective social optima ($\hat{g} = 0.058$, $\hat{h} = 0.096$) so that any further government investment is undesirable. Both the short-run welfare losses and the long-run gains resulting from an increase in government investment increase with its productivity η . That is, the more productive government sharpens the intertemporal tradeoff in benefits from further investment.

The relative desirability of the four alternative modes of spending the surplus is sensitive to the direct impacts of the two forms of government spending. In this respect the following rankings can be observed.

1. For the calibrated U.S. economy increasing government investment is best, followed by reducing the tax on capital, increasing government consumption expenditure, and reducing the tax on labor income.

2. Decreasing the tax on capital is always superior to decreasing the tax on labor income.

3. If the benefits of both forms of government expenditure are low ($\phi = 0.15$, $\eta = 0.10$) reducing the tax rate on capital is best, while increasing government consumption expenditure is worst. If the benefits of government consumption are high and government investment remain low ($\phi = 0.45$, $\eta = 0.10$) increasing

government consumption becomes the best policy and government investment the worst. If the benefits of government investment are high and government consumption remain low ($\phi = 0.15$, $\eta = 0.30$) these rankings are reversed. If the benefits of both forms of government expenditure are high ($\phi = 0.45$, $\eta = 0.30$) both forms of government expenditure dominate both forms of tax cuts, with investment being the preferred policy.

8. CONCLUSIONS AND CAVEATS

How to spend the projected budget surplus has generated a lively policy debate. This paper has provided a numerical analysis of the likely benefits from adopting different policy options in a model calibrated to approximate the U.S. economy. Our results suggest that insofar as the U.S. economy is concerned, to invest the government surplus productively will yield the greatest long-run welfare gains of around 3.8%. Decreasing the tax on capital income is only marginally inferior, yielding welfare gains of around 3.5%. Both of these options clearly dominate increasing government consumption expenditure (welfare gains 2.9%) or decreasing the tax on labor income (welfare gains 2.5%).

The two superior policy options—increasing the rate of government investment or reducing the tax on capital income—have the characteristic that they impinge directly on the rates of accumulation of one of the types of capital. By shifting resources directly toward the accumulation of capital and away from consumption they induce significant short-run welfare losses that are more than compensated by large long-run welfare gains. They are therefore both characterized by sharp intertemporal tradeoffs in welfare. But at the same time they will ultimately lead to very different economic structures, at least insofar as the mix between public and private capital is concerned. By contrast, the two inferior options impinge only indirectly on capital accumulation. Accordingly they are associated with mildly uniform increases in welfare through time. In addition, they have no long-run impact on the long-run mix between public and private capital.

Either form of government spending is associated with a socially optimal expenditure level. Thus a crucial determinant of the benefits of reducing the government surplus through spending is the size of government spending relative to the social optimum. For the calibrated economy devoting the entire surplus to one form of expenditure is not optimal, as it increases that form of expenditure beyond its social optimum. Indeed, we find that the second-best optimum is to increase both forms of government expenditure to their respective social optima, while at the same time restructuring taxes by reducing the tax on capital and raising the tax on wage income, subject to the targeted reduction in the budget surplus. In other circumstances, increasing either form of government expenditure may be welfare-deteriorating.

While we find our numerical results to be plausible, we should not lose sight of the fact that they are derived from a stylized economic model that abstracts from

many important theoretical and practical aspects. The policy implications therefore need be interpreted with some caution, and considered within the broader economic and political framework within which the government operates. It is therefore useful to acknowledge some of the limitations of our analysis.

First, the investment option available to the government has been restricted to public (physical) capital. It is the interaction of public capital with private capital that is the key source of economic growth, and the more productive is government capital, the higher the long-run growth rate will be. In addition, public capital has been assumed to be a pure public good, free of congestion. This assumption is clearly a polar one, since almost all public services are subject to some degree of congestion. Eicher and Turnovsky (2000) develop a simple nonscale growth model in which productive public expenditure, introduced as flow (as in Barro 1990), is subject to two types of congestion. They discuss the effects of both types of congestion on the long-run growth rate, the speed of convergence, and the equilibrium capital stock. Although they do not address the issue, their model also implies that congestion reduces the productivity of the public input. The reduction in the productivity parameter, η , briefly considered in Section 7, can be viewed as a partial attempt to take account of congestion in this model. But clearly, this is an important issue and is a dimension in which the present model of public capital could be fruitfully extended.

Second, the model excludes human capital and knowledge-based capital, a key source of growth in the class of endogenous growth models pioneered by Lucas (1988). Indeed, the choice between investing in human capital and physical capital is an important policy decision and needs to be addressed in an integrated model that includes both types of capital. It seems plausible to conjecture that taxes on labor income will have a greater impact on transitional growth rates and economic performance in an economy in which agents are choosing between accumulating human as well as and physical capital. But in order to be more precise as to the extent that this might be so, one needs to distinguish between the decision to supply raw labor and the decision to acquire skills through the accumulation of human capital.

Third, there are several other sources of growth that are excluded from this model. These include the accumulation of knowledge, the development of new technology, reduced regulation, the reform of financial systems, and so on. There are also the political aspects, and these too need to be taken into account. In part as a political compromise most of the tax cuts proposed by the Bush administration are being phased in over a number of years. A consideration of the timing aspects of these policies therefore merits further investigation.

More important, political decisions are driven by short-run considerations. Thus for example, whereas increasing government investment may yield the largest long-run benefits, the fact that it is also associated with large short-run losses may inhibit politicians from adopting the preferred long-run policy. Indeed, being a long-run equilibrium model that abstracts from short-run rigidities it does not focus on the types of short-run issues, such as job creation, that tend to attract the attention of politicians.

One final matter concerns distributional aspects, an issue having several dimensions. Since the basic framework we have employed is a Ramsey-type model with an infinitely lived agent, it is characterized by Ricardian equivalence. The initial stock of government debt, B_0 , does not matter per se. The real effects we have been discussing arise from the impact of the real fiscal changes introduced—the expenditure and tax rates—and precisely the same results would obtain if budget-balance through issuing additional debt was maintained at all times. Thus the Ramsey model has no implications for intergenerational distribution issues. Yet these issues are an important part of the debate, but to study them one would need to adopt an alternative framework such as a finite-lived overlapping generations model.

The relationship between income distribution (inequality) and growth is becoming topical, with no definitive conclusions at this time concerning the causality or relationship between them. Here one can distinguish between functional income distribution (the distribution between factors) and personal income distribution. The present framework cannot address either aspect satisfactorily. Being based on a Cobb–Douglas production function, (pre-tax) income shares, one measure of functional income distribution, are constant through time, being determined by their respective exponents in the production function. A more general production function is therefore required in order to analyze this aspect in a more profound way. To analyze personal income distribution, one needs to extend the model to include heterogeneous agents, indexed say by their initial endowments of private or human capital. Both of these extensions are feasible and are directions in which the present model should be developed in order to gain a complete understanding of the consequences of alternative fiscal policies.

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