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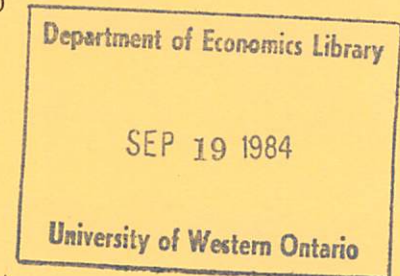
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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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MACROECONOMIC EFFECTS OF FISCAL POLICY*

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I. Introduction

Government activity in today's market economies is large by any measure. It is important for the economist, therefore, to try to understand how government policy is likely to affect economic welfare and real magnitudes such as output, consumption, investment, employment, and rates of return. This paper addresses the macroeconomic consequences of government fiscal policy. Issues concerning both government spending and taxation are examined.

The analysis is cast in terms of a very small choice-theoretic intertemporal general equilibrium model. While the model employed is simple, it still allows for government services to yield consumption benefits for individuals and production benefits for firms. Also, it permits government investment in public capital which can potentially enlarge society's future production possibilities and augment the rate of return on private investment. The examination of the macroeconomic effects of government spending contained here can be viewed as a formalization and extension of the work by Barro (1981) and Aschauer (1982). As mentioned, the impact of taxation on the macro economy is also addressed. Two types of taxation are considered, namely labour and investment income taxes. In addition to discussing the real effects of taxation policy, the issue of whether the government can and should use tax policy to stabilize the economy is examined. This latter question is addressed along the lines outlined by Kydland and Prescott (1980). Finally, open economy aspects of fiscal policy are looked at. This part of the analysis follows the recent line of theorizing in international finance by Sachs (1983), Razin and Svensson (1983), Greenwood (1983a,b), and Kimbrough (1983).

An aspect of the modeling strategy adopted here is that economic agents make their consumption, investment, labour supply, and production decisions in a rational manner based upon forward-looking behavior about both government

spending and taxation policies. A benefit of this approach is that it highlights the fact that when analyzing the impact of a shift in a fiscal variable it is important to distinguish whether the movement in it is transitory or permanent in character, and whether it reflects a current unanticipated event or a future expected one.

II. The Representative Agent's Maximization Problem

Consider the following model of a 'closed' economy. The world is inhabited by a representative agent who lives for two periods. The agent's goal in life is to maximize the value of the following lifetime utility function $\underline{U}(\cdot)$ as given by

$$\underline{U} = U(\tilde{c}_1) + V(l_1) + \beta[U(\tilde{c}_2) + V(l_2)] \quad \beta \in (0,1)$$

$$(\text{with } U' > 0, \text{ and } V', V'', U'' < 0)$$

where β is the individual's (constant) discount factor, \tilde{c}_1 and \tilde{c}_2 represent his "effective" consumption in the first and second periods, and l_1 and l_2 are his labour supply effort in these periods. Effective consumption in a period, say t , is taken to be a linear combination of private consumption expenditure, c_t , and government expenditure on consumption goods, g_t^c . Specifically, it is assumed that $\tilde{c}_t = c_t + \alpha g_t^c$ where α is constant.

As can be seen, government purchases are allowed to influence utility directly by providing a current substitute for private consumption goods with no interaction with leisure. The constant marginal rate of substitution between private and public consumption goods, α , is assumed to lie between 0 and 1 so that a unit of publically provided goods yields only a fraction of the utility to be derived from a unit of privately purchased goods. This assumption is crucial for this modelling strategy since it implies that increases in government spending will impose negative wealth effects on the representative agent. Recent

empirical work of Aschauer (1985) and Kormendi (1983) report values for α in the range of 20% to 40%, however, so that it does not appear that this assumption is overly restrictive.

The individual derives his income in each period through the owner-operation of a firm. The firm produces one good by hiring two factors of production, viz labour, l and capital, I . Also, in each period the government provides services, g^L , which aid private production in that period, and undertakes public investment, g^I , which will augment future private production. In particular, period t output, y_t , of the firm is characterized by the following production function

$$y_t = \delta_t + f(l_t, g_t^L) + h(I_t, g_t^I) + I_t + g_t^I \quad \forall t = 1, 2 \quad (2.1)$$

where δ_t represents a time-varying constant.

It is assumed that the marginal product of current public services, $f_2(\cdot)$, is less than unity. This is analogous to the negative wealth effect discussed above for the public consumption goods case although here no hard empirical evidence is available to lay a foundation for the claim of public sector "inefficiency".¹ It will also be assumed that public investment is inefficient in the sense that the marginal product of public capital, $h_2(\cdot)$, is less than that of private capital, $h_1(\cdot)$. Note that the production technology is specified such that there is no direct interplay between g^L and the marginal productivity of private capital or between g^I and the marginal product of labour. This may seem restrictive but it still allows for analysis of how changes in the level of government spending may affect the marginal product of labour, and consequently the demand for labour, and also how they might impact on the rate of return to private capital, and therefore private investment demand.

As well as earning income each period through the owner-operation of a firm, it will be assumed that the individual receives a transfer payment, τ , from the government. The agent can use the after-tax income from his firm and

this transfer payment in three ways--taxes will be discussed momentarily. These earnings can be used to finance consumption, purchase capital goods for use next period, or to buy real denominated bonds. The real denominated bonds have a return of r so that a bond purchased in the first period for one unit of consumption pays off $1+r$ units of consumption in the second period.

Recall that in each period the government engages in four types of spending. It provides consumption and production services, public investment goods, and transfer payments. Obviously, this spending activity must be financed somehow. Now assume that in period t the government levies a proportional tax in the amount λ_t on that portion of output that is attributable to labour effort. Essentially, λ_t is the labour-income tax rate in period t . Also, the value added from the firm's production derived from capital investment is taxed at the rate θ_t . One can view θ_t as being the period t corporate income tax rate.

The maximization problem facing the representative agent is shown below with the agent's choice variables being c_1 , c_2 , l_1 , l_2 and I .^{2,3}

$$W(\cdot) \equiv \text{Max}\{U(c_1 + \alpha g_1^C) + V(l_1) + \beta[U(c_2 + \alpha g_2^C) + V(l_2)]\} \quad (2.2)$$

subject to

$$c_1 + \frac{c_2}{(1+r)} = \delta_1 + (1 - \lambda_1)f(l_1, g_1^L) + \frac{(1 - \lambda_2)f(l_2, g_2^L) + (1 - \theta)h(I, g^I) - rI}{(1+r)} + \tau_1 + \frac{\tau_2}{(1+r)}$$

[Note that for simplicity it has been assumed that $\delta_2 = 0$.]

The first-order conditions associated with this maximization problem--in addition to the above budget constraint--are shown below. They are:

$$U'(c_1 + \alpha g_1^C) = \beta(1+r)U'(c_2 + \alpha g_2^C) \quad (2.3)$$

$$-V'(l_1) = (1 - \lambda_1)f_1(l_1, g_1^L)U'(c_1 + \alpha g_1^C) \quad (2.4)$$

$$-V'(l_2) = (1 - \lambda_2)f_1(l_2, g_2^L)U'(c_2 + \alpha g_2^C) \quad (2.5)$$

$$(1 - \theta)h_1(I, g^I) = r \quad (2.6)$$

III. The Model's General Equilibrium

In the model the goods market must clear each period, implying that the two market-clearing conditions shown below must hold.

$$c_1 + I + g_1^C + g_1^L + g^I = \delta_1 + f(l_1, g_1^L) \quad (3.1)$$

$$c_2 + g_2^C + g_2^L = f(l_2, g_2^L) + h(I, g^I) + I + g^I \quad (3.2)$$

By utilizing the above two conditions in conjunction with the first-order conditions (2.3) to (2.6), it can easily be seen that solutions for l_1 , l_2 , and I in the model's general equilibrium are implicitly characterized by the three equations (3.3), (3.4), and (3.5).⁴

$$-V'(l_1) = U'(\delta_1 + f(l_1, g_1^L) - I - (1-\alpha)g_1^C - g_1^L - g^I)(1-\lambda_1)f_1(l_1, g_1^L) \quad (3.3)$$

$$-V'(l_2) = U'(f(l_2, g_2^L) + h(I, g^I) + I + g^I - (1-\alpha)g_2^C - g_2^L)(1-\lambda_2)f_2(l_2, g_2^L) \quad (3.4)$$

$$\begin{aligned} U'(\delta_1 + f(l_1, g_1^L) - I - (1-\alpha)g_1^C - g_1^L - g^I) = \\ = \beta(1 + (1-\theta)h_1(I, g^I))U'(f(l_2, g_2^L) + h(I, g^I) + I + g^I - (1-\alpha)g_2^C - g_2^L) \end{aligned} \quad (3.5)$$

This system of equations can be subjected to various comparative static exercises to determine how changes in tax parameters, λ_1 , λ_2 and θ , or government spending variables, g_1^C , g_2^C , g_1^L , g_2^L and g^I , affect the economy's general equilibrium. These questions will be addressed in the next two sections of the paper.

Finally, before proceeding further it should be noted that the government, like any other actor in the economy, must satisfy a budget constraint. Its budget constraint is

$$g_1 + \tau_1 + \frac{g_2 + \tau_2}{(1+r)} = \lambda_1 f(l_1, g_1^L) + \frac{\lambda_2 f(l_2, g_2^L) + \theta h(I, g^I)}{(1+r)} \quad (3.6)$$

where $g_1 \equiv g_1^C + g_1^L + g^I$ and $g_2 \equiv g_2^C + g_2^L - g^I$ represent the government's absorption of resources in periods one and two, respectively.

IV. Changes in Income Tax Rates

Imagine that the government announces that it intends to increase the future level of income taxes, i.e., $d\lambda_1 = 0$, $d\lambda_2 > 0$. The increase in revenue arising from this anticipated tax hike will be used to finance lump-sum transfer payments to the representative agent. The period in which the agent receives the transfer payment is irrelevant as Ricardian equivalence holds in the model.⁵ Since the timing of transfer payments is inconsequential just their present-value, τ , will be focused on here, where $\tau = \tau_1 + (1/(1+r))\tau_2$. By subjecting (3.3), (3.4), and (3.5) to the required comparative statics exercise, it can be seen that (see Appendix A for details)

$$\frac{d\lambda_1}{d\lambda_2} > 0, \quad \frac{d\lambda_2}{d\lambda_2} < 0, \quad \text{and} \quad \frac{dI}{d\lambda_2} > 0 \quad (4.1)$$

With the help of the above solutions, the effect of an increase in current taxes on first-period consumption can be readily determined from (3.1). One obtains (again, see Appendix A for details)

$$\frac{dc_1}{d\lambda_2} = f_1(\lambda_1, \lambda_2^I) \frac{d\lambda_1}{d\lambda_2} - \frac{dI}{d\lambda_2} < 0. \quad (4.2)$$

The above results can easily be interpreted intuitively. First, as can be seen, an increase in future income taxation raises current work effort while reducing future labour input. This reflects an intertemporal substitution effect as agents substitute away from working in the future, where the after-tax rate of return is now smaller, toward working in the present, where the rate of return is now relatively higher. Second, note that current investment is increased as a result of the rise in future income taxes. This follows because future output can be obtained either by working in the future or through investing in capital during the current period. Agents would, in general, like

to obtain a relatively smooth profile of consumption over time, if possible. By investing more in the current period, they can partially compensate for the loss in future output due to the reduction in future labour effort. Third, as can be seen from (4.2), the increase in future taxes leads to a reduction in current consumption. This arises because the increase in first-period investment, while being partly financed by an increase in current labour supply, is also partly financed by a reduction in current consumption.

The welfare effect of a change in future labour income taxes is easy to uncover. To determine the impact of welfare of a change in the period- t labour income tax rate, differentiate both sides of equation (2.2) with respect to λ_t while applying the standard envelope theorem. One obtains

$$\begin{aligned} \frac{dW}{d\lambda_t} &= \frac{\partial W}{\partial \lambda_t} + \frac{\partial W}{\partial r} \frac{dr}{d\lambda_t} + \frac{\partial W}{\partial r} \frac{dr}{d\lambda_t} \\ &= U'(\tilde{c}_1) \left\{ -\left(\frac{1}{1+r}\right)^{t-1} f(\ell_t, g_t^L) + \frac{dr}{d\lambda_t} - \left(\frac{1}{1+r}\right)^2 [(1-\lambda_2)f(\ell_2, g_2^L) + (1-\theta)h(I, g^I)] \right. \\ &\quad \left. + I + \tau_2 - c_2 \right\} \frac{dr}{d\lambda_t} \quad \forall t=1,2. \end{aligned}$$

This expression can be simplified further by using the government's budget constraint (3.6) and the goods market-clearing condition (3.2) to find that

$$\frac{dW}{d\lambda_t} = U'(\tilde{c}_1) \left\{ \lambda_1 f_1(\ell_1, g_1^L) \frac{d\ell_1}{d\lambda_t} + \frac{\lambda_2 f_1(\ell_2, g_2^L)}{(1+r)} \frac{d\ell_2}{d\lambda_t} + \theta h_1(I, g^I) \frac{dI}{d\lambda_t} \right\} \geq 0 \quad (4.3)$$

In general, the effect on welfare of an increase in the period- t labour-income tax rate is ambiguous since the sign of (4.3) is uncertain. It is easy to see why. Take the case under consideration of an increase in the future labour-income tax rate. Now, suppose that the tax on capital's income is zero, or that $\theta = 0$, and that initially $\lambda_1 = 0$ and $\lambda_2 > 0$. Here an increase

in future income taxes unambiguously lowers economic welfare. When there are no other taxes in place, the anticipation of an increase in future income taxes reduces welfare. Now contrast this with the case where initially $\lambda_1 > 0$ and $\lambda_2 = 0$. Here an increase in future income taxes raises economic welfare. This may seem a little strange until one realizes that this is a second-best situation. Note that the effect of initially having an income tax solely in the first period is to create a distortion whereby agents tend to favour second-period labour effort vis-à-vis first-period labour effort. This distortion worsens welfare, ceteris paribus. The institution of a small income tax in the second period improves economic welfare since it works against this intertemporal substitution effect caused by the distortion. That is, it tends to increase labour effort in the first period and reduce it in the second which helps to ameliorate the situation. Finally, suppose that $\lambda_1 \approx \lambda_2 \approx \theta$. In this situation, where all the variable factors of production are taxed approximately at the same rate, it is fairly easy to show, by plugging in the analytic solutions for the derivatives shown in (4.1) into (4.3), that economic welfare falls when future income taxes are increased (again, see Appendix A).

V. Changes in the Corporate Income Tax

Suppose that the government increases the corporate income tax rate, θ .⁶ Again the system of equations (3.3), (3.4), and (3.5) describing the economy's general equilibrium should be subjected to the required comparative statics exercise. The results are

$$\frac{dl_1}{d\theta} < 0, \quad \frac{dl_2}{d\theta} > 0, \quad \frac{dI}{d\theta} < 0 \quad \text{and} \quad \frac{dc_1}{d\theta} > 0. \quad (5.1)$$

To begin with, as undoubtedly expected, current investment, I , falls as a result of the increase in the corporate income tax rate. This occurs

because the after-tax rate of return, r , on investment is now reduced. Since current investment falls, more first-period output is available for alternative uses. In particular, the agent uses these extra resources to increase his current consumption and to reduce his current labour effort, both of these decisions being partly motivated by the drop in the (after-tax) real interest rate, r . Finally, note that the future supply of labour, l_2 , increases. This is because the reduction in current investment causes future output, y_2 , and hence consumption, c_2 , to fall. This dropoff in future output due to a lower capital stock is partially offset by the agent increasing his labour supply effort in that period.

To conclude this section of the paper, Table 1 is presented which summarizes the model's main conclusions about changes in tax rates.⁷ As can be seen, when analyzing the impact of a shift in the labour-income tax rate it is important to distinguish whether the movement in it is transitory or permanent in character, and whether it reflects a current unanticipated event or an expected future one.

VI. Tax Policy and Business Cycle Stabilization

It has often been suggested that tax instruments should be used to dampen business cycle fluctuations. In this section of the paper, through the use of a simple example the "feasibility and desirability" of such policies are addressed. To begin with, to abstract from the revenue raising motives for taxation assume that there is no government spending on goods in this economy so that $g_1^C = g_1^L = g_2^C = g_2^L = g^I = 0$. (Consequently, in this section the government spending terms in the functions $U(\cdot)$, $f(\cdot)$ and $h(\cdot)$ will be ignored.) Also, assume that all taxes and lump-sum transfer payments are initially set at zero implying that $\lambda_1 = \lambda_2 = \theta = \tau_1 = \tau_2 = 0$. Now, let the first-period production function be subjected to a downward technological shift in the proportional amount $(1-\gamma)$, say, due to bad weather. That is, the first-period production function should

Table 1

Tax Change	l_1 (and y_1)	l_2	I	c_1
(i) Anticipated increase in future income tax rate, i.e., $\Delta\lambda_1 = 0$, $\Delta\lambda_2 > 0$.	(+)	(-)	(+)	(-)
(ii) Unanticipated temporary increase in current income tax rate, i.e., $\Delta\lambda_1 > 0$, $\Delta\lambda_2 = 0$.	(-)	(+)	(-)	(-)
(iii) Unanticipated permanent increase in the current income tax rate, i.e., $\Delta\lambda_1 = \Delta\lambda_2 > 0$.	(-)	(-)	(0) ¹	(-)
(iv) An increase in the corporate income tax rate, θ .	(-)	(+)	(-)	(+)

¹Some initial conditions have been assumed in deriving this result. First, it has been assumed that $g_1^C = g_2^C$, $g_1^L = g_2^L$, and $\theta = 0$. Second, note from (2.6) that investment, I, can be written as a function of the real interest rate, r, and government spending on public investment, g^I , so that $I = I(r, g^I)$. Now also assume that $\delta_1 = h(I(\frac{1-\beta}{\beta}, g^I), g^I) + 2I(\frac{1-\beta}{\beta}, g^I) + 2g^I$. These initial conditions make the first and second periods identical from the agent's perspective and start the model off from a steady-state situation.

now be written as $y_1 = \delta_1 + (1-\gamma)f(l_1)$. Furthermore, suppose the government desires to keep domestic first- and second-period output at the constant levels y^* and y^{**} , respectively, using labour-income taxes as its policy instrument. In other words, assume that it wants to select values for λ_1 and λ_2 so as to attain $y_1 = y^*$ and $y_2 = y^{**}$. One could imagine that these target levels of output are those output levels that would exist in the economy in the absence of the first-period technology shock.

From (2.1) the following two conditions would then hold:

$$y^* = \delta_1 + (1-\gamma)f(l_1) \quad [\text{so that } l_1 = f^{-1}\left(\frac{y^* - \delta_1}{1-\gamma}\right)] \quad (6.1)$$

and

$$y^{**} = f(l_2) + I + h(I) \quad [\text{so that } l_2 = f^{-1}(y^{**} - I - h(I))] \quad (6.2)$$

Using these two restrictions in conjunction with the first-order conditions (2.3), (2.4), (2.5), and (2.6) and the market-clearing conditions (3.1) and (3.2) it can be seen that solutions for λ_1 , λ_2 , and I in the economy's general equilibrium are implicitly given by the three equations shown below. (Since government expenditure on goods is always fixed at zero, the revenue raised through any income taxation scheme must be rebated back to individuals through lump-sum transfer payments. Again, the timing of these lump-sum transfer payments is irrelevant due to the Ricardian equivalence theorem.)

$$-V'(f^{-1}\left(\frac{y^* - \delta_1}{1-\gamma}\right)) = U'(y^* - I)(1-\lambda_1)(1-\gamma)f_1(f^{-1}\left(\frac{y^* - \delta_1}{1-\gamma}\right)) \quad (6.3)$$

$$-V'(f^{-1}(y^{**} - I - h(I))) = U'(y^{**})(1-\lambda_2)f_1(f^{-1}(y^{**} - I - h(I))) \quad (6.4)$$

$$U'(y^* - I) = \beta(1+h_1(I))U'(y^{**}) \quad (6.5)$$

The responsiveness of the income tax rates λ_1 and λ_2 (and investment) to a shift in the technology factor γ can easily be discerned from the above equation system to be⁸

$$\frac{d\lambda_1}{d\gamma} < -\frac{(1-\lambda_1)}{(1-\gamma)}, \quad \frac{d\lambda_2}{d\gamma} = 0, \quad \frac{dI}{d\gamma} = 0 \quad (6.6)$$

Thus, in response to a downward proportional shift in the first-period production function the government should subsidize the earnings from first-period labour effort. This will encourage extra production of first-period output and allow it to be maintained at the target level y^* . Also, note the amplified response in $(1-\lambda_1)$ to a change in $(1-\gamma)$, i.e., the absolute value of the proportionate change in $(1-\lambda_1)$ is greater than that in $(1-\gamma)$.

Finally, the welfare effect of this tax policy is easy to discount by utilizing the line of argument adopted in Section IV. Specifically, the total effect on welfare due to both the technological shock and the first-period income tax change is

$$\frac{dW(\cdot)}{d\gamma} = \frac{\partial W}{\partial \gamma} + \left[\frac{\partial W}{\partial \lambda_1} \frac{\partial \lambda_1}{\partial \gamma} + \frac{\partial W}{\partial \tau} \frac{\partial \tau}{\partial \gamma} \right]$$

[Note that the interest rate, r , remains unchanged since I is maintained at its original value, cf. (6.6).]

$$\begin{aligned} &= -U'(c_1) \left[f(\ell_1) - \lambda_1 f_1(\ell_1) \frac{d\ell_1}{d\lambda_1} \frac{d\lambda_1}{d\gamma} \right] \\ &< 0 \\ & \left[\text{since } -\lambda_1 f_1(\ell_1) \frac{d\ell_1}{d\lambda_1} \frac{d\lambda_1}{d\gamma} > 0 \right]. \end{aligned} \quad (6.7)$$

As was probably expected, welfare drops in response to the negative technological innovation. But note that this drop in welfare is greater than that which would have occurred in the absence of the government's stabilization scheme. This follows since (6.7) implies that

$$\left| \frac{dW}{dy} \right| > U'(c_1) f_1(l_1) = \left| \frac{\partial W}{\partial y} \right|$$

Thus, in this example while it is feasible for the government to stabilize economic fluctuations it is not desirable, a point which has been made before by Kydland and Prescott (1980). In general, stabilizing some arbitrary statistic such as real income, employment, interest rates, or even the price level, will not correspond with maximizing economic welfare.

VII. Optimal Labour-Income Taxes

As has been shown, the imposition of labour-income taxes--unlike lump-sum taxes--affects private sector decision-making. It was argued that labour-income taxes should not be used to stabilize business fluctuations. It might be the case, however, that the government needs to levy labour-income taxes so as to raise enough revenue to cover the expenses incurred from its various programs since lump-sum taxes may be infeasible. The government should raise this revenue in a manner which will minimize the deadweight burden associated with income taxation. The question of how the government should pick the time profile of labour-income tax rates $\{\lambda_i\}_{i=1}^2$ so as to do this will now be addressed. (So as to focus on labour-income taxation, per se, the assumption that the corporate income-tax rate, θ , is equal to zero will be retained.)

The determination of the government's optimum labour-income tax policy is just a variation on the Ramsey tax problem. The government should pick the labour-income tax rates so as to maximize agents' welfare, as given

by the outcome of the optimization problem posed in (2.2), subject to its revenue requirements as shown by (3.6). Formally, the government's problem is

$$\text{Max}_{\lambda_1, \lambda_2} W(\cdot) + \phi [\lambda_1 f(\ell_1, g_1^L) + \frac{\lambda_2 f(\ell_2, g_2^L)}{(1+r)} - g_1 - \frac{g_2}{(1+r)}] \quad (7.1)$$

where ϕ is defined to be the Lagrange multiplier associated with the government's budget constraint.^{9,10} The first-order conditions--in addition to the budget constraint (3.6)--associated with this maximization problem are

$$\frac{\partial W}{\partial \lambda_1} + \frac{\partial W}{\partial \tau} \frac{\partial \tau}{\partial \lambda_1} + \frac{\partial W}{\partial r} \frac{\partial r}{\partial \lambda_1} = -\phi [f(1) + \lambda_1 f_1(1) \frac{d\ell_1}{d\lambda_1} + \frac{\lambda_2 f_1(2) d\ell_2}{(1+r)} \frac{d\ell_2}{d\lambda_1} - \frac{[\lambda_2 f(2) - g_2]}{(1+r)^2} \frac{dr}{d\lambda_1}] \quad (7.2)$$

$$-U'(1) [\lambda_1 f_1(1) \frac{d\ell_1}{d\lambda_1} + \frac{\lambda_2 f_1(2) d\ell_2}{(1+r)} \frac{d\ell_2}{d\lambda_1}] = -\phi [f(1) + \lambda_1 f_1(1) \frac{d\ell_1}{d\lambda_1} + \frac{\lambda_2 f_1(2) d\ell_2}{(1+r)} \frac{d\ell_2}{d\lambda_1} - \frac{[\lambda_2 f(2) - g_2]}{(1+r)^2} \frac{dr}{d\lambda_1}]$$

and (using (4.3))

$$\frac{\partial W}{\partial \lambda_2} + \frac{\partial W}{\partial \tau} \frac{\partial \tau}{\partial \lambda_2} + \frac{\partial W}{\partial r} \frac{\partial r}{\partial \lambda_2} = -\phi [\frac{f(2)}{(1+r)} + \lambda_1 f_1(1) \frac{d\ell_1}{d\lambda_2} + \frac{\lambda_2 f_1(2) d\ell_2}{(1+r)} \frac{d\ell_2}{d\lambda_2} - \frac{[\lambda_2 f(2) - g_2]}{(1+r)^2} \frac{dr}{d\lambda_2}] \quad (7.3)$$

$$-U'(1) [\lambda_1 f_1(1) \frac{d\ell_1}{d\lambda_2} + \lambda_2 f_1(2) \frac{d\ell_2}{d\lambda_2}] = -\phi [\frac{f(2)}{(1+r)} + \lambda_1 f_1(1) \frac{d\ell_1}{d\lambda_2} + \frac{\lambda_2 f_1(2) - g_2}{(1+r)^2} \frac{dr}{d\lambda_2}]$$

(again using (4.3)).

The above first-order conditions are readily interpretable. To see their implications intuitively, divide both sides of (7.2) by minus the term in brackets on the right-hand side of this equation. The term on the left-hand side of the resulting equation illustrates the marginal welfare loss per extra dollar raised via an increase in the first-period tax rate, λ_1 . The right-hand side of this new equation, or ϕ , represents the marginal cost of an extra dollar raised in revenue. Note that one could also perform an analogous operation on both sides of equation (7.3). It is easy to see that the right-hand sides of these new versions of (7.2) and (7.3) are identical,

both being equal to ϕ . Consequently, an optimal labour-income tax policy necessitates that the marginal welfare loss per extra (present-value) dollar raised through either first or second period labour-income taxation be equivalent.

A complete characterization of the government's optimal labour-income tax program is implicitly given by equations (7.2) and (7.3) which are the efficiency conditions governing the tax policy, (3.6) representing the government's budget constraint, and (3.3), (3.4), and (3.5) describing the economy's general equilibrium. This is a system of six equations in six unknowns, viz. λ_1 , λ_2 , ϕ , l_1 , l_2 , and I . As can be seen, even a basic understanding of the optimal tax policy in this simple model requires a detailed knowledge of the interaction between tastes and technology.¹¹ An elementary question one could ask is whether or not labour-income tax rates are likely to be constant through time. That is, will there be uniform labour-income taxation across time here? A glance at the system of equations (3.3), (3.4), (3.5), (3.6), (7.2), and (7.3) would seem to indicate that in general the answer is no. Hopefully, the following two examples will shed some light on this issue.

Example 1

It is easy to construct a case where the labour-income tax rates are equal in the two periods. To begin with, assume that $g_1^C = g_2^C$ and that $g_1^L = g_2^L$. Next, note that from the first-order condition (2.6), private investment, I , can be written as a function of the real interest rate, r , and government investment in public goods, g^I . Thus, one could write $I = I(r, g^I)$. Evaluate this function at $r = (1-\beta)/\beta$ and set $\delta_1 = h(I(\frac{1-\beta}{\beta}, g^I), g^I) + 2I(\frac{1-\beta}{\beta}, g^I) + 2g^I$. Now suppose that income tax rates were the same across

time and test whether this provides a solution to the model. If $\lambda_1 = \lambda_2$, it can easily be seen that equations (3.3), (3.4), and (3.5) describing the model's general equilibrium would imply that $l_1 = l_2$ and $I = I(\frac{1-\beta}{\beta}, g^I)$. Consequently, it follows that $c_1 = c_2$. Also, note that (3.6) implies that the government must have a balanced budget in each period here, so that $g_1 = \lambda_1 f(l_1, g_1^L)$ and $g_2 = \lambda_2 f(l_2, g_2^L)$. Finally, this solution also satisfies equations (7.2) and (7.3). This follows because in this circumstance

$$\frac{dl_1}{d\lambda_1} + \left(\frac{1}{1+r}\right) \frac{dl_2}{d\lambda_1} = \frac{dl_2}{d\lambda_2} + (1+r) \frac{dl_1}{d\lambda_2}, \text{ while the budget deficit terms vanish.}$$

Thus, a sufficient condition to have uniform labour-income taxation across time in the model is that the real equilibriums in the first and second periods are identical. How departures from this benchmark case will influence the time profile of labour-income taxes is unclear. This is the subject of the next example.

Example 2

In this example a situation where the labour-income tax rates are different in the two periods is constructed. This is done by numerically simulating the above optimal tax problem. The constants, β and δ_1 , and the functions, $U(\cdot)$, $V(\cdot)$, $f(\cdot)$, and $h(\cdot)$ are parameterized as follows: $\beta = .95$, $\delta_1 \approx 20.13$, $U \approx -40.2e^{-.025c}$, $V = -e^l$, $f \approx 20.09l$, and $h = .5 \ln I$.

The solution to the optimal tax problem for various values of first- and second-period government spending is reported in Table 2. As can be seen, in general, the labour-income tax rates are not absolutely constant through time.¹² There is a remarkable tendency to smooth tax rates over time, though. For instance, temporary current government spending is partly financed by current taxation with the remainder being financed by future

TABLE 2

Case	ϵ_1	ϵ_2	λ_1	λ_2	Deficit $\epsilon_1 - \lambda_1 f(1)$	k_1	k_2	I	c_1	c_2	r
I. No Government Spending	0	0	0	0	0	1.8238	1.8238	9.50	47.3	47.3	.053
II. Temporary Government Spending	5	0	.0709	.0704	2.40	1.8239	1.8109	7.46	44.3	44.8	.067
	10	0	.1448	.1425	4.7	1.8211	1.7900	5.63	41.1	42.4	.089
	15	0	.2239	.2178	6.85	1.8137	1.7571	4.08	37.5	40.0	.123
III. Anticipated Government Spending	0	5	.0669	.0672	-2.44	1.8137	1.8227	11.67	44.9	44.5	.043
	0	10	.1348	.1358	-4.87	1.8008	1.8157	13.93	42.4	41.7	.036
	0	15	.2043	.2060	-7.32	1.7835	1.8023	16.26	39.7	38.9	.031
IV. Permanent Government Spending	5	5	.1377	.1377	0.0	1.8080	1.8080	9.5	41.9	41.9	.053
	10	10	.2814	.2814	0.0	1.7964	1.7964	9.5	36.2	36.2	.053
	15	15	.4443	.4443	0.0	1.6810	1.6810	9.5	29.3	29.3	.053

taxation. Since both the labour-income tax rate and labour effort are greater in the first than in the second period, the bulk of this government expenditure is financed in the first period. Note that this temporary current government expenditure is associated both with high real interest rates and government budget deficits.¹³ Last, in congruence with the above example, it can be seen that when all government spending is permanent its burden is evenly spread across the two periods.¹⁴

Finally, the issue of business cycle stabilization will be returned to briefly. In line with the previous section of the paper, suppose that the government decides to achieve a target level for first-period output denoted by y^* . The government's objective is now to pick the time profile of labour-income taxes $\{\lambda_i\}_{i=1}^2$ so as to maximize societal welfare, while both raising enough revenue to cover the expenses of its various programs and achieving its first-period output goal. Clearly, the government's maximization problem in this circumstance is given by augmenting the optimal tax problem (7.1) to incorporate the new constraint $y^* = \delta_1 + f(l_1, g_1^I)$. Equally as clearly, the economy is at least as well off without the first-period output goal as with it. This is obvious since now the government is being forced to maximize societal welfare subject to an opportunity set which is being artificially restricted by the presence of the output target. Thus, in general, disembarking from the optimum tax program so as to stabilize certain business cycle statistics, such as output, only serves to worsen welfare.

VIII. Changes in Government Spending on Services

Attention will now be directed to the macroeconomic effects of government purchases. So as to isolate the impact of government purchases, per se, it will be assumed that all revenue is raised through lump-sum taxation (i.e., let $\lambda_1 = \lambda_2 = \theta = 0$).¹⁵ As has been mentioned, due to the Richardian equivalence theorem the timing of lump-sum taxation is irrelevant. To begin with, consider an unanticipated temporary increase in government spending on services. So as to operationalize this experiment, define g_1^S as first-period total government spending on services so that $g_1^S = g_1^C + g_1^L$. Now let ρ be the fraction of total government expenditure on services devoted to the provision of government consumption services so that $(1-\rho)$ represents the fraction assigned to the provision of production services. Consequently, it follows that a temporary increase in government expenditure on services implies that $dg_1^C = \rho dg_1^S$, $dg_1^L = (1-\rho) dg_1^S$, and $dg_2^C = dg_2^L = 0$.

The impact on the agent's welfare resulting from the temporary increase in government services can easily be seen by differentiating (2.2) to be¹⁶

$$\begin{aligned} \frac{dW}{dg_1^S} &= \rho \frac{\partial W}{\partial g_1^C} + (1-\rho) \frac{\partial W}{\partial g_1^L} + \frac{\partial W}{\partial \tau} + \frac{\partial W}{\partial r} \frac{dr}{dg_1^S} \\ &\quad \text{(where again, } \tau \equiv \tau_1 + (1/(1+\tau))\tau_2) \\ &= -U'(\tilde{c}_1) \{1 - \rho\alpha - (1-\rho)f_2(l_1, g_1^S)\} < 0 \end{aligned}$$

[Using the standard envelope theorem result, and (3.2) and (3.6)].

As can be seen, when government expenditure is increased temporarily, the agent suffers a welfare loss since by assumption both α and $f_2(\cdot)$ lie between zero and one.

The effect of a temporary change in g_1^S on l_1 , l_2 , and I can easily be deduced from the system of equations (3.3), (3.4), and (3.5). Under the assumption that the private production process is separable in labour and

government services (to be relaxed momentarily), the following results obtain:¹⁶

$$\frac{dl_1}{dg_1} > 0, \quad \frac{dl_2}{dg_1} > 0, \quad \frac{dI}{dg_1} < 0.$$

Consequently, the effect on output in the first and second periods, respectively, is given by

$$\frac{dy_1}{dg_1} = f_1(1) \frac{dl_1}{dg_1} + (1-\rho)f_2(1) > 0$$

(+)

and

$$\frac{dy_2}{dg_1} = f_1(2) \frac{dl_2}{dg_1} + (1+r) \frac{dI}{dg_1} < 0$$

(+) (-)

Note that the negative wealth effect associated with the temporary rise in government purchases induces the agent to decrease consumption and increase labour supply in both periods. Further, the temporal incidence of the rise in government purchases lies in the current period. That is, the impact effect of fiscal shock is to reduce the amount of first-period resources available for private consumption in that period. In an attempt to smooth effective consumption and leisure over time, therefore, the agent decreases capital accumulation which, in turn, raises the real rate of return and promotes an intertemporal substitution of work effort to the present and of consumption to the future. On net, output rises in the current period and falls in the future. In the latter case, the increased output due to increased labour effort is dominated by the fall in output due to decreased capital accumulation. This insures that consumption in both periods is reduced in the final equilibrium.

The direct impact which higher government spending may have on the marginal product of labour is now considered. If government services are technical complements with labour, then the positive effect on current work effort is reinforced as labour is substituted across periods in response to the rise in the relative wage $(1+r)f_1(1)/f_1(2)$. Ambiguities arise given a sufficiently large value of the complementarity term $f_{12}(1)$ since it becomes possible for the rise in the relative wage to induce a reduction in second-period work effort and an increase in capital accumulation. Ambiguities also become evident in the opposite case of technical substitutability since the decrease in the relative wage in the first period tends to reduce current work effort, acting against the rise in labour prompted by the negative wealth effect of higher government expenditure. Note that if $\rho\alpha + (1-\rho)f_2(1)$ equals unity--so that there would be no wealth effect associated with a marginal increase in government spending--this channel would still allow for real effects of government purchases. For the case of technical complementarity and zero wealth effects it is possible to state unambiguously that current work effort would increase at the expense of future work effort and capital accumulation would rise to carry forward part of the production of the relatively favourable first period.

Next consider a rise in government expenditure in the second period which is foreseen by the agent. Again assuming separability in production between labour and government services, one finds

$$\frac{dl_1}{dg_2} > 0, \quad \frac{dl_2}{dg_2} > 0, \quad \frac{dI}{dg_2} > 0.$$

Further, the effect on output is (clearly) positive in both periods. The

anticipated government expenditure imposes a negative wealth effect, as before, and the agent responds by reducing consumption and increasing work effort in both periods. In his attempt to prepare for the extraordinary call for resources in the second period, the agent increases investment which, in turn, lowers the rate of return and causes a secondary shift in work effort from the present to the future.

Notice that the main qualitative difference in the effects of unanticipated versus anticipated changes in government expenditure lies in the behavior of private investment and the capital stock. In a more general model with multiple periods, anticipated increases in government spending would tend to lead to increased capital accumulation prior to the fiscal policy action, an effect which would be absent from the case where the fiscal policy change is unexpected. That is, the ability to accumulate (or decumulate) capital allows the agent partially to buffer fiscal shocks. Consequently, it would appear that the effect on work effort at the time of the fiscal change would be smaller in the anticipated case since the agent has had time to prepare for the expected excess demand for resources at that time.

Finally, a permanent increase in government spending of an equal amount in both periods will be considered (i.e., $dg_1^S = dg_2^S = dg^{-S}$). Assuming, once again, separability in production one gets in the lump-sum tax environment

$$\frac{dl_1}{dg^{-S}} > 0, \quad \frac{dl_2}{dg^{-S}} > 0, \quad \frac{dI}{dg^{-S}} \stackrel{?}{\geq} 0.$$

Furthermore, output rises and consumption falls in both periods.

As before, the rise in government spending is a drain on wealth and labour effort and consumption react accordingly, the first rising and the latter falling in both periods. Note the ambiguity in the response of investment to the permanent shock in government spending.

In the benchmark case where the real rate of return and time preference are equal--the steady-state result of optimizing models along the lines of Sidrauski (1967)--the effect on capital accumulation is nil. In this situation the agent desires to distribute the burden of the government spending shock equally across both periods. Concrete predictions outside of the benchmark case seem hard to obtain.¹⁷ To the extent that the borderline condition holds, there arises an important empirical distinction between (unanticipated) temporary and permanent changes in government expenditures, with investment falling in the former case and remaining unchanged in the latter case.

IX. Public Investment

As a final exercise, consider a rise in the level of public investment, $dg^I > 0$. Recall that it is assumed that the public capital is less productive at the margin than private capital (i.e., $h_2(I, g^I) < h_1(I, g^I)$). By following the line of argument employed in the previous section, it can easily be deduced that the welfare loss associated with an increase in public investment is given by

$$\frac{dW}{dg^I} = -U'(\tilde{c}_1) [r - h_2(I, g^I)] / (1+\tau) < 0.$$

The net effect on work effort in both periods and private capital accumulation under the assumption that there is no complementarity between the two types

of capital [or $h_{12}(I, g^I) = 0$] are

$$\frac{d\ell_1}{dg} > 0, \quad \frac{d\ell_2}{dg} \stackrel{?}{\approx} 0, \quad -1 < \frac{dI}{dg} < 0.$$

There are two effects operational in explaining these results. First, as usual, the negative wealth effect arising as a result of excessive public capital accumulation tends to raise work effort and lower consumption in each period. Second, the impact effect of the increased public investment is to reduce the amount of first-period resources available for consumption and increase their second-period availability. The agent in his desire to smooth his time profiles for consumption and leisure partially offsets this by a less than one-to-one reduction in private investment. In other words, the individual borrows from the future to ease the burden of the shock in the current period. Note that total investment still has increased, as is evidenced by the fact that current labour supply has risen while current consumption has dropped. The fall in private investment, however, is associated with an increase in the private rate of return which promotes a reduction in second-period work effort relative to the first period, and thus an ambiguity in the response of second-period labour supply arises. Note that if public and private capital were equally as efficient at the margin (i.e., $h_1 = h_2$), so that there was no wealth effect associated with the increase in public investment, then second-period labour effort would unambiguously decline.

It is also useful to investigate the effects of a rise in public investment which is complementary with private investment, e.g., infrastructure investment. The impact effect of such an increase in public investment would

be to raise the marginal product of private capital and hence its real return since $\partial r / \partial g^I = h_{12}(I, g^I) > 0$. This would tend to promote an intertemporal reallocation of labour to the current period and an increase in private investment to take advantage of private capital's higher marginal productivity.

To conclude this section, the effects of various changes in government spending are provided in Table 3. As before, it is particularly important to distinguish between changes which are regarded as temporary versus those which are permanent and also between those which are anticipated versus unanticipated. Further, the composition of the change in government spending is crucial to the various results.

X. Open Economy Extensions

The above model can be modified easily to analyze the effects of taxation in a "small" open economy. In a "small" open economy version of the model domestic residents would be free to borrow and lend on international capital markets. Suppose that the world real interest rate is r^* and assume that the government taxes (subsidizes) the interest rate on foreign lending (borrowing) at the rate θ . The domestic after-tax real interest rate, r , would thus be given by $r = (1-\theta)r^*$. The agent's maximization problem would again be described by (2.2).

Now define b_1 to be the first-period trade balance. Thus

$$b_1 \equiv f(l_1, g_1^L) - c_1 - I - g_1$$

Note that b_1 represents the amount of net foreign lending that the domestic economy does in the first period. By substituting an open economy version of the government's budget constraint (3.6), which incorporates a modification to reflect the fact that the government now taxes the earnings on foreign

TABLE 3

Spending Change	l_1	l_2	I	c_1
(i) Anticipated increase in future spending, i.e., $dg_2^s > 0, dg_1^s = 0$. ²	(+)	(+)	(+)	(-)
(ii) Unanticipated temporary increase in current spending, i.e., $dg_1^s > 0, dg_2^s = 0$. ²	(+)	(+)	(-)	(-)
(iii) Unanticipated permanent change in spending, i.e., $dg_1^s = dg_2^s = dg^s$.	(+)	(+)	(0) ³	(-)
(iv) Increase in public investment. ⁴	(+)	(?), (-) ⁵	(-)	(-)

¹The results obtained in this table are premised on the assumptions that $0 < \alpha$, $f_2(\cdot) < 1$, and $h_2(\cdot) < h_1(\cdot)$.

²Assuming that $f_{12}(\cdot) = 0$.

³The initial conditions mentioned in Table 1, footnote 1 have been assumed in deriving this result.

⁴Assuming that $h_{12}(\cdot) = 0$.

⁵This result obtains if $h_2(\cdot) \approx h_1(\cdot)$.

lending, into the representative agent's one, shown in (2.2), a relationship stating that trade must balance intertemporally is obtained.

$$c_1 + g_1 + I + \left(\frac{1}{1+r^*}\right) [c_2 + g_2] = \delta_1 + f(l_1, g_1^L) + \left(\frac{1}{1+r^*}\right) [f(l_2, g_2^L) + h(I, g^I) + I] \quad (10.1)$$

The small open economy's general equilibrium can be implicitly described by the first-order conditions (2.3) to (2.6) in addition to the economy's intertemporal budget constraint (10.1). Specifically, these conditions yield the following three equations which implicitly define solutions for l_1 , l_2 , and b_1 :

$$-V'(l_1) = U'(f(l_1, g_1^L) + \alpha g_1^C - \bar{I} - b_1 - g_1)(1 - \lambda_1) f_1(l_1, g_1^L) \quad (10.2)$$

$$-V'(l_2) = U'(f(l_2, g_2^L) + \alpha g_2^C + h(\bar{I}, g^I) + I + (1+r^*)b_1 - g_2) f_1(l_2, g_2^L) \quad (10.3)$$

$$U'(f(l_1, g_1^L) + \alpha g_1^C - \bar{I} - b_1 - g_1) = (1 + (1-\theta)r^*)\beta U'(f(l_2, g_2^L) + \alpha g_2^C + h(\bar{I}, g^I) + \bar{I} + (1+r^*)b_1 - g_2) \quad (10.4)$$

$$[\text{with } \bar{I} \equiv \bar{I}(r^*, g^I), \text{ cf. (2.6)}]$$

Note that equation (2.6) implies that private investment, I , is solely a function of the world real interest rate, r^* , and the size of the public capital stock, g^I . Thus, one could write $\bar{I} = \bar{I}(r^*, g^I)$, where \bar{I} is the level of private investment which is undertaken in the open economy.

It is easy to see that the "small" open economy version of the model closely parallels the closed economy one. Basically, net foreign lending, b_1 , in the open economy reacts the same way in response to many shocks as investment, I , does in the closed economy.

To see this, consider the effect of a temporary increase in current labour-income taxes on labour effort in each period and on net external savings. By performing the required comparative statics exercise on (10.2), (10.3), and (10.4) it is easy to show that current labour effort, l_1 , falls, future labour effort, l_2 , rises, and net foreign lending, b_1 , decreases. The intuition is obvious. Since a temporary increase in current labour-income taxes creates a disincentive to work today, people will substitute intertemporally toward working more tomorrow where the after-tax marginal product of labour is now relatively higher. The reduction in current work effort will cause a loss in current income. Current consumption will not drop off by the loss in current income. Agents will smooth out the effects from this loss in income over both periods. Consequently, individuals will reduce consumption in the first-period by less than the reduction in current income. This can be achieved by lending less (or borrowing more) on international capital markets. Thus, b_1 will fall. Due to the reduction in net foreign lending that part of second-period income derived from first-period net foreign savings will be smaller. This short fall in income from net foreign savings will be met by a reduction in second-period consumption as well as by an increase in second-period labour effort.

The important point to note here is that a temporary increase in the current labour-income tax rate causes first-period savings to decrease in both the closed and open economy versions of the model. In the closed economy this causes the interest rate to rise, and investment to fall, while in the open economy the trade balance tends to swing into a deficit. It

happens that in many situations the trade balance deficit of a small open economy responds in the same fashion to shocks as the real interest rate does in a closed economy. Since the trade balance is more readily observable than the real interest rate, it may be more useful to test the open economy version rather than the closed economy version of the above model.

There is one important difference, however, between the closed and open economy versions of the model. In the closed economy domestic fiscal shocks cause movements in the after-tax real interest rate which in turn generate intertemporal substitution effects which affect agents' consumption-leisure decision-making. In the small open economy this channel of effect is no longer operational since the domestic after-tax real interest rate is now exogenous, given by $r = (1-\theta)r^*$. Fiscal policy shocks impact on agents' consumption-leisure decision-making only to the extent that they are either associated with wealth effects or with changes in incentives to work or to invest induced by changes in proportional taxation.¹⁸

To see this more clearly, consider the case where the government increases public investment and assume that there is no complementarity between private and public capital. As analyzed previously, such a change in fiscal policy exerts two effects on the closed economy's general equilibrium. First, to the extent that public capital is less efficient than private capital, a negative wealth effect is created. This tends to stimulate labour effort and reduce consumption in both periods. Second, this increased public investment tends to reduce the economy's resources available for first-period vis-à-vis second-period consumption and leisure. This tends to drive up the real interest rate which works to reduce current consumption,

investment, and future labour supply effort and stimulate current labour supply effort and future consumption. In the small open economy this second channel of impact is not operational. Consequently, consumption falls and labour supply effort rises in both periods with no effect on private investment. Note that the economy finances this increased current public investment by reducing current consumption, increasing current labour supply effort, and by borrowing from abroad against its increased future output--derived from both a higher level of labour supply effort in the future and an increased public capital stock. Finally, to the extent that public and private capital are complements in production, a greater level of public investment will induce an upward movement in private investment which is required in order to equilibrate the return on private investment with the world interest rate. The agent will finance this new higher level of private investment by borrowing on world markets and this will tend to further exacerbate the deterioration in the trade balance.

To conclude this section, the effects in the small open economy of various shocks in fiscal policy are presented in Table 4.

XI. Conclusions

A small neoclassical general equilibrium is constructed in this paper to investigate the macroeconomic effects of fiscal policy. The two-period model presented probably represents about the simplest choice-theoretic paradigm that can be utilized to address fiscal policy adequately. Despite its simplicity, the framework employed allowed economic actors to make a consumption and labour supply choice in each period and decisions about how

TABLE 4

Tax Change	l_1 (and y_1)	l_2	I	c_1	b_1
(i) Anticipated increase in future income tax rate, i.e., $\Delta\lambda_1 = 0$, $\Delta\lambda_2 > 0$.	(+)	(-)	(0)	(-)	(+)
(ii) Unanticipated temporary increase in current income tax rate, i.e., $\Delta\lambda_1 > 0$, $\Delta\lambda_2 = 0$.	(-)	(+)	(0)	(-)	(-)
(iii) Unanticipated permanent increase in the current income tax rate, i.e., $\Delta\lambda_1 = \Delta\lambda_2 > 0$.	(-)	(-)	(0)	(-)	(0) ¹
(iv) An increase in the tax rate on investment income, θ .	(-)	(+)	(0)	(+)	(-)

Spending Change ²	l_1 (and y_1)	l_2	I	c_1	b_1
(i) Anticipated increase in future spending, i.e., $\Delta g_2^s > 0$, $\Delta g_1^s = 0$. ³	(+)	(+)	(0)	(-)	(+)
(ii) Unanticipated temporary increase in current spending, i.e., $\Delta g_1^s > 0$, $\Delta g_2^s = 0$. ³	(+)	(+)	(0)	(-)	(-)
(iii) Unanticipated permanent change in spending, i.e., $\Delta g_1^s = \Delta g_2^s = \Delta g^s$.	(+)	(+)	(0)	(-)	(0) ⁴
(iv) Increase in public investment. ⁵	(+)	(+)	(0), (+) ⁶	(-)	(-)

¹Some initial conditions have been assumed in deriving this result. They are:
 $g_1^L = g_2^L$, $\lambda_1 = \lambda_2$, $\theta = 0$, and $1/\beta = (1+r^*)$.

²It has been assumed that: $0 < \alpha$, $f_2(\cdot) < 1$, and $h_2(\cdot) < h_1(\cdot)$.

³Assuming that $f_{12}(\cdot) = 0$.

⁴In deriving this result it has been assumed that $g_1^L = g_2^L$, and $1/\beta = (1+r^*)$.

⁵Assuming that $h_{12}(\cdot) = 0$.

⁶This holds when $h_{12}(\cdot) > 0$.

much real and financial capital to carry over between the two periods. It can also be used to address issues on both the expenditure and taxation sides of fiscal policy. On the expenditure side of fiscal policy, government services were modeled as yielding consumption and production benefits for the private sector while government investment in public capital augmented society's future production possibilities. On the taxation side, government revenue could be raised through either labour-income taxation, corporate income taxation, or bond financing. A salient feature of the analysis is that when investigating the impact of fiscal policy changes, it is important to distinguish whether they are transitory or permanent in character, and whether they reflect current but unanticipated events or expected future ones. The framework was also flexible enough to model both the closed and "small" open economies.

While the simplistic framework used can generate a qualitative picture about fiscal policy issues, it provides no insight about the likely quantitative impact of various fiscal programs. Obtaining quantitative estimates on the effect of alternative fiscal policies is likely to be an avenue for future research. One way to proceed toward this end would be to construct a numerical dynamic general equilibrium and then simulate the impact of alternative fiscal programs. By judiciously picking functional forms and parameter values in the model, a quantitative estimate of the welfare gains and losses associated with various government policies could perhaps be obtained. Such a modelling strategy would seem to be in the spirit of Kydland and Prescott's (1980, 1982) work. The model presented in this paper, hopefully, is a stepping-stone toward this goal.

APPENDIX A

This appendix is presented to provide the interested reader with a taste of some of the technical aspects of the comparative statics results discussed in the text. The results of those comparative static exercises not discussed here can be easily deduced by mimicking the line of argument utilized below. To begin with, the impact of a change in λ_2 on l_1 , l_2 and I can be discussed by taking the total differential of equations (3.3), (3.4), and (3.5). The resulting system of three equations is:

$$\begin{bmatrix}
 -(v''(1) + u''(1) \epsilon_{II}(1) \tilde{\lambda}_1 + u'(1) \tilde{\lambda}_1 \epsilon_{II}(1)) & u''(1) \epsilon_I(1) \tilde{\lambda}_1 & 0 \\
 0 & -u''(2) (1 + n_1) \tilde{\lambda}_2 \epsilon_I(2) & -(v''(2) + u''(2) \tilde{\lambda}_2 \epsilon_{II}(2)) \\
 u''(1) \epsilon_I(1) & -[u''(1) + \beta \tilde{\theta}_1 u'(2) + \beta (1 + \tilde{\theta}_1) (1 + n_1) u''(2)] & -\beta (1 + \tilde{\theta}_1) u''(2) \epsilon_I(2)
 \end{bmatrix}
 \begin{bmatrix}
 d\lambda_1 \\
 dI \\
 d\lambda_2
 \end{bmatrix}$$

$$= \begin{bmatrix}
 0 \\
 -u'(2) \epsilon_I(2) \\
 0
 \end{bmatrix} d\lambda_2 \quad (A.1)$$

where $\tilde{\lambda}_1 \equiv (1 - \lambda_1)$, $\tilde{\lambda}_2 \equiv (1 - \lambda_2)$, $\tilde{\theta} \equiv (1 - \theta)$ and the notation $x(t)$ means that the arguments in the function $x(\cdot)$ are being evaluated at their date t values. Define $-\Omega$ as the determinant of the 3x3 matrix on the left-hand side of the above equation system. The expression for Ω is

$$\begin{aligned} \Omega = & -[V''(1) + U''(1)\tilde{\lambda}_1 f_1(1)^2 + U'(1)\tilde{\lambda}_1 f_{11}(1)] \{ \beta \tilde{\theta} h_{11} U'(2) [V''(2) + U''(2)\tilde{\lambda}_2 f_1(2)^2 + U'(2)\tilde{\lambda}_2 f_{11}(2)] \\ & + \beta(1 + \tilde{\theta} h_1)(1 + h_1)U''(2) [V''(2) + U''(2)\tilde{\lambda}_2 f_1(2)] \} \\ & + U''(1) [V''(1) + U'(1)\tilde{\lambda}_1 f_1(1)] [V''(2) + U''(2)\tilde{\lambda}_2 f_1(2)^2 + U'(2)\tilde{\lambda}_2 f_{11}(2)] \\ & > 0. \end{aligned}$$

Solving the system of equations (A.1) yields

$$\frac{d\lambda_1}{d\lambda_2} = U'(2) f_1(2) U''(1) f_1(1) \tilde{\lambda}_1 \beta (1 + \tilde{\theta} h_1) U''(2) f_1(2) / \Omega > 0 \quad (\text{A.2})$$

$$\frac{dI}{d\lambda_2} = U'(2) f_1(2) [V''(1) + U''(1) f_1(1)^2 \tilde{\lambda}_1 + U'(1) f_{11}(1) \tilde{\lambda}_1] \beta (1 + \tilde{\theta} h_1) U''(2) f_1(2) / \Omega > 0 \quad (\text{A.3})$$

$$\begin{aligned} \frac{d\lambda_2}{d\lambda_2} = & -U'(2) f_1(2) \{ [V''(1) + U''(1) f_1(1)^2 \tilde{\lambda}_1 + U'(1) f_{11}(1) \tilde{\lambda}_1] [\beta \tilde{\theta} h_{11} U'(2) + \beta(1 + \tilde{\theta} h_1)(1 + h_1)U''(2)] \\ & + [V''(1) + U''(1)\tilde{\lambda}_1 f_1(1)] U''(1) \} / \Omega < 0 \end{aligned} \quad (\text{A.4})$$

Consequently, it follows from (A.2), (A.3), and (A.4) that the derivatives presented in the text in (4.1) have the signs shown.

Also, through the use of (A.2) and (A.3) it can be seen that

$$\frac{dI}{d\lambda_2} = f_1(1) \frac{d\lambda_1}{d\lambda_2} + \{U'(2)f_1(2)[V''(1) + U'(1)\tilde{\lambda}_1 f_{11}(1)]\beta(1+\tilde{\theta}h_{11})U''(2)f_1(2)\}/\Omega \quad (A.5)$$

where the last term in this expression is unambiguously positive. Using (A.5) together with (4.2) in text it immediately follows that $dc_1/d\lambda_2 < 0$, as was stated. Finally, when $\tilde{\lambda}_1 \approx \tilde{\lambda}_2 \approx \tilde{\theta}$, it can be seen by plugging (A.2), (A.3) and (A.4) into (4.3) that welfare unambiguously falls when future income taxes rise.

By undertaking a similar comparative static exercise on the system of equations (6.3), (6.4), and (6.5) it follows that

$$\frac{d\lambda_1}{d\gamma} = -\frac{\tilde{\lambda}_1}{\tilde{\gamma}_1} + \frac{V''(1)(y^* - \delta_1)}{f_1(1)\tilde{\gamma}^3 U'(1)} + \frac{\tilde{\lambda}_1 f_{11}(1)(y^* - \delta_1)}{f_1(1)\tilde{\gamma}^2} < 0 \quad (A.6)$$

$$\frac{d\lambda_2}{d\gamma} = 0$$

and

$$\frac{dI}{d\gamma} = 0$$

where $\tilde{\gamma} \equiv (1-\gamma)$. Note that (A.6) implies that $|\frac{d\lambda_1}{d\gamma}| > \frac{\tilde{\lambda}_1}{\tilde{\gamma}_1}$.

Finally by taking the total differential of equations (3.3), (3.4), and (3.5) the impact that a temporary increase in government spending on services has on λ_1 , λ_2 and I can easily be uncovered. It is easy to see that when doing this exercise the 3×3 matrix on the left-hand side of (A.1) remains the same and all that changes is the 3×1 displacement vector on the right-hand side of this equation. The results obtained are:

$$\begin{aligned} \frac{d\lambda_1}{dg_1} = & - [1 - \alpha\phi - (1-\rho)f_2(2)]U''(1)\{f_1(1)\beta h_{11}U'(2)[V''(2)+U''(2)f_1(2)^2 + U'(2)f_{11}(2)] \\ & + f_1(1)\beta(1+h_1)^2U''(2)[V''(2) + U'(2)f_{11}(2)]\}/\Omega > 0, \end{aligned} \quad (A.7)$$

$$\frac{d\ell_2}{dg_1} = -[1 - \alpha\rho - (1-\rho)f_2(2)]U''(1)\{[V''(1)+U'(1)f_{11}(1)][V''(2)+U''(2)f_1(2)^2 + U'(2)f_{11}(2)]\}/\Omega < 0 \quad (\text{A.8})$$

and

$$\frac{dI}{dg_1} = [1 - \alpha\rho - (1-\rho)f_2(2)]U''(1)\{[V''(1)+U'(1)f_{11}(1)][V''(2)+U''(2)f_1(2)^2 + U'(2)f_{11}(2)]\}/\Omega < 0. \quad (\text{A.9})$$

FOOTNOTES

¹Clearly, it is possible to have $f_2(\cdot) < 1$ and "efficient" public expenditure. A proper devotion of resources to pollution control comes to mind. This model is not suited to dealing with externalities and so forth, and therefore these types of considerations are abstracted from in this paper.

²Note that it is being assumed that the world "starts up" at the beginning of period one. Consequently, in the first period the agent does not have either any physical capital or bonds which he has brought over from the past. Since there is only physical capital in the second period there is no need to index I (or g^I) with a subscript. Also, it trivially follows that first-period private investment equals the second-period capital stock. Alternatively if one liked, δ_1 could be viewed as capturing the effects of capital investment undertaken prior to period one. For instance, if I_0 and g_0^I were the amounts of (reversible) private and public capital investment undertaken in period zero then $\delta_1 = h(I_0, g_0^I) + I_0 + g_0^I$ -- for simplicity it would be assumed that the value-added from this period-zero capital investment is not taxed.

³The arguments inside the function $W(\cdot)$ are: $\lambda_1, \lambda_2, \theta, \tau_1, \tau_2, r, g_1^C, g_2^C, g_1^L, g_2^L, g^I$, and r .

⁴An alternative, and perhaps more intuitive, representation of the model's general equilibrium describing the system of demand and supply functions implicit in (3.1) to (3.5) is given by the following four equations

$$\begin{aligned} \ell_t^d(w_t, g_t^L) &= \ell_t^S(\tilde{w}_1, D\tilde{w}_2, D, \underline{U}) \quad (\text{with } \tilde{w}_t \equiv (1-\lambda_t)w_t \text{ and } D \equiv 1/(1+r)), \forall t=1,2 \\ c_1^d(\tilde{w}_1, D\tilde{w}_2, D, g_1^C, g_2^C, \underline{U}) + I^d(D, \theta, g^I) + g_1 &= \delta_1 + f(\ell_1^d(\cdot), g_1^L) \\ &(\text{with } g_t \equiv g_t^C + g_t^L + g_t^I - g_{t-1}^I) \end{aligned}$$

and

$$E(\tilde{w}_1, D\tilde{w}_2, D, g_1^C, g_2^C, \underline{U}) + I^d(\cdot) + g_1 + Dg_2 = \delta_1 + f(l_1^d(\cdot), g_1^L) + \\ D[f(l_2^d(\cdot), g_2^L) + h(I^d(\cdot), g^I) + I^d + g^I] - \tilde{w}_1 l_1^S(\cdot) - D\tilde{w}_2 l_2^S(\cdot)$$

where w_t and \tilde{w}_t are the before- and after-tax period-trend wages, D is the after-tax market discount factor, and $E(\cdot)$ is the expenditure function associated with the problem $\min\{c^1 + Dc^2 - \tilde{w}^1 l^1 - D\tilde{w}^2 l^2 \mid g_1^C, g_2^C, \underline{U}\}$. [Note that the endogenous variables here are w_1 , w_2 , D and \underline{U} .] Greenwood and Kimbrough (1984) use a framework similar to this to analyze the international transmission of fiscal policy shocks in a two-country world--with and without capital controls.

⁵This can easily be seen by noting that the system of equations (3.3), (3.5) and (3.6) describing the model's general equilibrium does not involve any transfer payment terms. For a full discussion of the theorem see Barro (1974) and Chan (1983).

⁶One could also view θ as a tax on private savings. To see this, suppose that the government taxes both the real return on bonds, r , and the value-added from capital $h(I, g^I)$ at the rate θ . Now denote \tilde{r} as the after-tax real rate of return on bonds so that $\tilde{r} = (1-\theta)r$. Solving the agent's optimization problem in this circumstance leads to almost the identical set of first-order conditions as those shown above; equations (2.4) and (2.5) remain the same, whereas now \tilde{r} replaces r in (2.3), (2.6), and the agent's budget constraint. Note that the representative agent's choices are implicitly described by his first-order conditions (2.3), (2.4), (2.5), and his budget constraint, with (2.6) being eliminated by substituting it into both (2.3) and the budget constraint. However, this system of equations is identical in both circumstances.

⁷All the results reported in Table 1 can be readily obtained by following the standard comparative static procedure outlined in Appendix A.

⁸See Appendix A for further details.

⁹A similar maximization problem is posed by Persson and Svensson () in their analysis of the time inconsistent optimal taxation policy.

¹⁰Note from Section III describing the economy's general equilibrium that λ_1 and λ_2 in (7.1) are implicit functions of $\lambda_1, \lambda_2, g_1^C, g_2^C, g_1^L, g_2^L$ and g^I , i.e., $\lambda_t = \lambda_t(\lambda_1, \lambda_2, g_1^C, g_2^C, g_1^L, g_2^L, g^I) \forall t=1,2$. Also to aid in understanding this maximization problem it might help to artificially break it down into two parts. In the first part think of the government financing all of its expenditure via lump sum taxation. In the second, imagine the lump sum taxes being rebated back by lump transfer payments which are financed by labour-income taxation implying that $\lambda_1 f(1) + \lambda_2 f(2)/(1+r) = \tau = g_1 + g_2/(1+r)$.

¹¹Note that the derivatives contained in (7.2) and (7.3) are themselves dependent upon taste and technology, as can be verified by glancing at the solutions for (4.1) contained in Appendix A.

¹²Certain restrictions can be placed on the forms of preferences and the production technology which will guarantee uniform labour income through time. For an example, see Razin and Svensson (1983).

¹³A simulation was also run which allowed investment income to be taxed. Again while there was a tendency to smooth labour-income tax rates across time they were not constant. Also temporary current government spending was associated with high real interest rates and government budget deficits.

¹⁴The maximum level of permanent government expenditure that the model economy could sustain was 18.8. That there is such a maximum follows from the Laffer curve effect. Note that as the level of permanent government expenditure

is increased so does the labour income tax rate, and this induces a drop in labour supply effort. At high enough tax rates the gain in revenue resulting from higher tax rates is outweighed by the fall in revenue caused by the cut in labour supply effort. (Initially a value of 20 was tried for permanent government spending. One of the authors--the dumber one--couldn't understand why the computer algorithm being utilized was failing to converge properly.)

¹⁵As has already been demonstrated, the timing of distortionary taxes has important implications for the macro economy. To combine the effects of a government spending scheme with a distortionary tax financing policy would be to run the risk of confounding the effects of government spending with income taxation. Also, there would be many distortionary tax schemes capable of financing a given change in the present-value of government spending and it would be hard to know how to choose among them.

¹⁶Note that the definition for a temporary change in government spending employed here is different from that of Barro (1981). Barro's definition holds, at the original interest rate, constant the present-value of government spending. That is, in the two period setting adopted here he would fix the value of $g_1^S + (1/(1+r))g_2^S$. This would imply, at the initial interest rate, that an increase in current government spending, g_1^S , must be offset by a reduction in future government spending, g_2^S . The analogous exercise in the current model would be to reduce second-period government expenditure, g_2^S , by an amount which would keep the representative agent's level of utility, \underline{U} , constant. Barro deletes the wealth effects from a temporary increase in current government spending so as to emphasize the scarcity of private disposable resources in the current period vis à vis the future that results. This tends to drive up the real interest rate and consequently increase current labour supply and output. The definition employed here incorporates the negative effect that a temporary increase

in government spending will have on agents' wealth. Presumably, temporary government spending, such as for wars, could have significant adverse effects on agents' wealth positions. This negative wealth effect would tend to increase labour supply effort and output in the first and second periods.

¹⁷It may seem reasonable to conjecture that the effect on capital accumulation will depend upon whether the time profiles of consumption and leisure are positively or negatively inclined through time. For instance, one may speculate that if $(1+r) > \beta$ so that the time profiles of consumption and leisure are upward sloping ceteris paribus, then the bulk of the burden of the shock will be absorbed in the future. The original conjecture, however, turns out to be false. It seems that how the burden of the shock is distributed through depends upon the time profiles of the marginal propensities to consume goods and leisure (see Greenwood and Kimbrough (1984)). These marginal propensities to consume in general may be either increasing or decreasing functions of the real interest rate.

¹⁸Fiscal shocks emanating from within a large open economy can obviously affect the world real interest rate. For an analysis of the international transmission of fiscal policy in a two-country world, where such an effect is operational, see Greenwood and Kimbrough (1984).

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