International effects of government expenditure in interdependent economies

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Abstract. A dynamic analysis of the international transmission of government expenditure shocks under alternative methods of finance is presented. The benchmark case of lump-sum tax financing yields an expansion in both the short-run and the long-run levels of domestic activity, while crowding out domestic consumption. Activity abroad declines in the short run, and while it is stimulated during the transition, long-run activity abroad also declines. With capital income tax financing, the accompanying distortion outweighs the direct expenditure effects, so that all these responses are reversed. Financing with a tax on labour produces ambiguous responses. The welfare implications of these policies are also examined.

Effets internationaux de la dépense gouvernementale dans des économies interdépendantes. Les auteurs présentent une analyse dynamique de la transmission internationale de chocs dans la dépense gouvernementale selon la méthode de financement utilisée. Le cas qui sert de point de référence est le financement via un impôt forfaitaire qui entraîne une expansion dans le niveau d'activité économique au niveau domestique tant à long terme qu'à court terme, tout en ayant un effet d'éviction sur le niveau de consommation domestique. Le niveau d'activité économique outre-frontières chute à court terme et même si le niveau d'activité à long terme chute aussi, il y a stimulation de l'activité économique dans la période de transition. Quand le financement est fait par le truchement d'un impôt sur le revenu du capital l'effet de distorsion domine les effets de dépenses directes, ce qui fait que ces réactions sont renversées. Les effets d'un financement par le truchement d'un impôt sur le revenu du travail sont ambigus. Les auteurs examinent aussi les effets sur le niveau de bien-être de ces diverses politiques.

I. INTRODUCTION

The international transmission of fiscal disturbances has long been a central issue in international macroeconomics. Early analyses examined this issue using variants

An earlier draft of this paper benefited from comments at the International Economics Lunch Group of the NBER, as well as from participants at the Summer 1994 Research Workshop at the University of Warwick. We appreciate the constructive comments of two anonymous referees.

Canadian Journal of Economics Revue canadienne d'Economique, XXX, No. 1
February février 1997. Printed in Canada Imprimé au Canada

0008-4085 / 97 / 57–84 $1.50

of the static Mundell-Fleming model and static real trade models; see, for example, Mussa (1979), Branson and Rotemberg (1980), Schmid (1982), and Corden and Turnovsky (1983). One of the issues emphasized in this early discussion pertained to the potential for the *negative* transmission of fiscal shocks, the possibility that an expansion in one country may lead to a contraction in another. This is in contrast to the so-called 'locomotive theory' advanced by the OECD, suggesting that major world economies should 'pull up' the others through demand expansion.

With the emergence of large fiscal and current account deficits in the United States and other major western economies during the 1980s, the analysis of fiscal policies has continued to receive the attention of economists. In contrast to the earlier work, the recent literature typically adopts some variant of the utility maximizing representative agent framework, where the current account is viewed as the outcome of planned savings and investment behaviour. Two types of issues have received attention: the effects of changes in government expenditure policy on the one hand, and issues pertaining to debt and tax-financing policies on the other. Of necessity, formal analyses of this type are restrictive, being required to invoke abstractions that enable them to focus on the specific issues at hand in the most lucid way. But in many cases the role of capital accumulation, a central component of the adjustment process, is not taken into account.

Among the contributions to this literature, Frenkel and Razin (1987) is particularly significant. This book, which incorporates a series of the authors' previous papers, provides a comprehensive treatment of the impact of deficits in a two-country world economy. In large part their analysis abstracted from investment and output effects, and when these effects are included, they are restricted to a two-period analysis. Buiter (1987) introduces capital accumulation into a true intertemporal framework, although like Frenkel and Razin he assumes that employment remains fixed. The main question he addresses concerns the choice between borrowing and the tax-financing of a given level of government expenditure. In order to obtain a non-trivial analysis of this issue, Ricardian equivalence must be broken, and this is achieved by adopting the finite-life consumer model of Blanchard (1985).

Several other earlier papers have examined related issues, including Lipton and Sachs (1983), who adopt a large infinite horizon two-country simulation model to study short-run and long-run effects of alternative forms of disturbances, and Frenkel and Razin (1985), who adopt simple two-country exogenous growth models to study the effects of government expenditure disturbances. The latter emphasize how the international transmission of an expansion in government expenditure depends upon whether the country is a net saver or a net dissaver in the world economy. More recently, Razin (1990) examined fiscal policy effects in a two-period two-country world under alternative-asset market structures and uncertainty.[1]

1 Other recent contributions include Canova and Dellas (1993), who study theoretical and empirical aspects of trade interdependence. In the real business cycle vein, Kollmann (1993) and Backus, Kehoe, and Kydland (1994) have applied two-country versions of the infinite-horizon representative-agent model to study the links between fiscal policy and trade deficits.

In this paper we examine the international transmission of government expenditure shocks in an integrated infinite-horizon intertemporal optimizing model of a two-country world economy. The model employs the two-country framework developed by Turnovsky and Bianconi (1992). That paper was concerned specifically with the analysis of the transmission of changes in tax rates under alternative capital income tax regimes. In the present paper we focus on the transmission of government expenditure shocks, examining in particular the importance of the method of government finance in the transmission process, both in the domestic economy and abroad. In this respect, we analyse in a two-country world economy the issue addressed by Cooley and Hansen (1992) and Turnovsky (1992), who study the welfare implications of alternative modes of government expenditure financing in a purely closed economy framework.[2]

More specifically, we analyse the dynamic transmission characteristics of an increase in government expenditure under three forms of tax financing: (i) lump-sum taxes, (ii) tax on capital income, and (iii) tax on labour income. The contrast between these forms of financing turns out to be striking. Taking the lump-sum tax as a benchmark, we show how in this intertemporal setting an increase in domestic government expenditure will lead to a negative transmission of activity abroad both in the short run and over time.[3] A decline in activity abroad, however, does not necessarily mean a decline in foreign welfare. On the contrary, we show how consumption, leisure, and ultimately welfare may actually be enhanced in the foreign economy.

An appealing aspect of our analysis is the ability to parameterize the various forms of financing that enable us to provide a very simple comparison of their effects. Thus, in constrast to lump-sum tax financing, distortionary-tax financing has offsetting effects, which in the case of a capital tax will almost certainly outweigh the direct expenditure effects on activity, while in the case of a labour tax are less clear cut. Thus, while an increase in government expenditure under lump-sum tax financing will stimulate domestic activity and reduce it abroad, under plausible conditions this is reversed if at the margin the additional expenditure is financed by a tax on capital. Accordingly, our analysis demonstrates, in an international context, the possibility of negative government expenditure multipliers, reflecting the existence of a 'supply-side multiplier'; see Baxter and King (1993).

2 See also the recent paper by Baxter and King (1993). The approach adopted in this paper is along the general lines of papers by Cantor and Mark (1987, 1988) among others, mainly with respect to the focus on capital flows. Gerlach (1988) is an early attempt to show that there do indeed exist international co-movements of some key variables.

3 While in general Frenkel and Razin show that the international transmission of expenditure shocks depends upon the net saving position of the economy, they also show that if (i) the world is stationary, (ii) discount rates are equal across countries, and (iii) labour supply is fixed, a permanent increase in government expenditure leads to full domestic crowding out, with no effects abroad. Lipton and Sachs (1983) similarly obtain full crowding out and no transmission in the case where labour supply is fixed; see also Devereux and Shi (1991) for further discussion. In the variable labour supply case, Lipton and Sachs (1983) obtain transmission effects by considering a tax decrease coupled with an endogenous adjustment in government expenditures to balance the budget.

II. TWO-COUNTRY MACROECONOMIC STRUCTURE

Consider a two-country one-good model of a decentralized world economy inhabited by households, firms, and their respective governments. Both countries accumulate capital gradually over time, with the world market for capital being perfectly integrated. Labour supply is endogenously determined and assumed to be perfectly immobile across international borders. The analysis employs the basic infinite-horizon, representative-agent framework, extended to a two-country setting, and in this respect it is related to the recent contributions by Devereux and Shi (1991), Turnovsky and Bianconi (1992), and Bianconi (1995), among others. In expositing the model, we shall focus primarily on the domestic economy. Variables pertaining to the domestic economy are unstarred, while the corresponding foreign economy variables are starred. The superscript d refers to the holdings of domestic residents, while f describes the holdings of foreign agents.

For simplicity, the economy is a real one, abstracting from money and other nominal assets. The representative household in the domestic economy chooses its consumption level c, its labour supply l, its holdings of domestic capital k^d, and foreign capital k^{*d}, so as to[4]

$$\text{Max} \int_o^\infty U(c, l, g)e^{-\beta t}dt, \tag{1a}$$

subject to the budget constraint

$$c + \dot{k}^d + \dot{k}^{*d} = wl(1 - \tau_w) + rk^d(1 - \tau_c) + r^*k^{*d}(1 - \tau_c^*) - T \tag{1b}$$

and given initial holdings of capital, $k_o > 0$, $k_o^{*d} > 0$, where $\beta > 0$ denotes the domestic rate of time preference, taken to be constant, w is the domestic (real) wage rate, r is the rental rate earned on domestic capital, r^* is the rental rate earned on foreign capital, and capital stocks are assumed not to depreciate.

In addition, the agent derives utility from government expenditure g, and is subject to the following forms of taxation: τ_w is the tax paid on domestic labour income; τ_c is the tax paid on domestic capital income; τ_c^* is the tax paid on foreign capital income; and T is a lump-sum tax. Since we do not wish to address issues pertaining to the viability of alternative tax regimes, we shall assume that capital income taxes are *source based*, so that τ_c is levied by the domestic government and τ_c^* is levied by the foreign government.[5]

The instantaneous utility function $U(c,l,g)$ is concave in its three arguments. While private and public consumption provide positive utility, work yields disutility; that is, $U_c > 0$, $U_g > 0$, $U_l < 0$. The signs of the cross-partial derivatives

4 We adopt the following notation. Time derivatives are denoted by dots. Where the meaning is clear, partial derivatives are denoted by lower-case letters.

5 The issue of residence-based versus source-based taxation of capital is discussed at length by many authors; see, for example, Slemrod (1988) and Frenkel, Razin, and Sadka (1991).

depend upon many parameters, including the elasticity of intertemporal substitution, the substitutability or complementarity of government expenditure with private consumption, and so on. In order to simplify the analysis, we shall assume that the utility function is additively separable in its three arguments, c, l, g; that is, $U_{cl} = U_{cg} = U_{lg} = 0$.[6]

The problem specified in (1) is standard. The domestic household budget constraint is expressed in real flow terms and consists of after-tax labour and capital income on holdings of both domestic and foreign capital, less lump-sum taxes, to be spent on consumption, or accumulated as additional holdings of domestic and/or foreign capital. Tax rates are assumed to be linear.

The first-order optimality conditions to this problem are

$$U_c(c) = \alpha \tag{2a}$$

$$U_l(l) = -\alpha w(1 - \tau_w) \tag{2b}$$

$$(1 - \tau_c)r = \theta \tag{2c}$$

$$(1 - \tau_c^*)r^* = \theta \tag{2d}$$

$$\theta = \beta - \dot{\alpha}/\alpha \tag{2e}$$

together with the transversality conditions

$$\lim_{t \to \infty} \alpha k^d e^{-\beta t} = 0; \qquad \lim_{t \to \infty} \alpha k^{*d} e^{-\beta t} = 0, \tag{2f}$$

where α is the Lagrange multiplier associated with the accumulation equation (1b) and is the marginal utility of wealth of the domestic resident. The optimality conditions, (2a) and (2b), describe the usual marginal rate of substitution condition between consumption and labour supply, where in writing these equations the assumed separability of the utility function is taken into account. Equations (2c) and (2d) are arbitrage conditions equating the after-tax rates of return on domestic and foreign capital to the rate of return on consumption, defined in (2e).

The problem facing the foreign household is symmetric. We shall assume that the rate of time discount of the foreign resident equals that of the domestic agent. As is well known, under the assumption of perfect foresight and perfect capital markets, this assumption is necessary in order for a well-defined steady state to exist.

The domestic representative firm employs labour and capital to produce output using a neoclassical production function having the usual neoclassical properties of positive, but diminishing, marginal physical products and constant returns to scale; that is, $f_k > 0, f_l > 0, f_{kk} < 0, f_{ll} < 0, f_{kk}f_{ll} - f_{kl}^2 = 0$. In the absence of adjustment

6 This assumption is made primarily to provide analytical tractability; it is straightforward to generalize.

costs and corporate taxes, the optimality conditions for the domestic firm are the usual marginal productivity conditions:

$$f_k(k, l) = r \tag{3a}$$

$$f_l(k, l) = w. \tag{3b}$$

The foreign firm is symmetric. We should observe that k and k^* refer to the capital stock domiciled in the domestic and foreign economies, respectively. The fact that these capital stocks are owned by either domestic residents or foreigners implies the relationships:

$$k^d + k^f = k; \qquad k^{*d} + k^{*f} = k^*. \tag{4a, 4b}$$

We abstract from government bonds so that each government maintains a continuously balanced budget in accordance with

$$g = wl\tau_w + rk\tau_c + T; \qquad g^* = w^*l^*\tau_w^* + r^*k^*\tau_c^* + T^*. \tag{5a, 5b}$$

The focus of subsequent analysis is to compare the effects of an increase in government expenditure under the following three alternative tax regimes:

i. The increase in government expenditure is financed entirely by a *lump-sum tax.*[7]
ii. The increase in government expenditure is financed in steady state entirely by an increase in the *tax on capital.*
iii. The increase in government expenditure is financed in steady state entirely by an increase in the *tax on labour.*

As noted below, the two tax regimes (ii) and (iii) involve residual lump-sum tax financing along the transitional path in order to ensure that the government budget remains balanced at all times. See Cooley and Hansen (1992), who consider this form of financing in a closed economy context.[8]

In a one-commodity world, goods market equilibrium is described by

$$f(k, l) + f^*(k^*, l^*) = c + c^* + \dot{k} + \dot{k}^* + g + g^*, \tag{6}$$

which states that the sum of private and public consumption, together with investment, in the two economies must equal total world output.

7 Since the model is one in which Ricardian equivalence holds, lump-sum tax financing is equivalent to bond financing.

8 Turnovsky (1992) makes a slightly different assumption in that he assumes that the distortionary tax rate itself varies along the transitional path in order to maintain continuous budget balance. By contrast, Lipton and Sachs (1983) assume that it is government expenditure that adjusts.

Aggregate wealth in each country is defined to be

$$W = k^d + k^{*d}; \qquad W^* = k^f + k^{*f}, \tag{7a, 7b}$$

so that aggregate world wealth is

$$W + W^* = k + k^*. \tag{8}$$

The net foreign asset position of the domestic economy, N, say, is defined as

$$N = k^{*d} - k^f. \tag{9}$$

Domestic and foreign wealth can thus be expressed as $W = k + N$; $W^* = k^* + N^*$, and we shall say that the domestic economy has a positive or negative net asset position according to whether $N \lesseqgtr 0$. Taking the time derivative of (9) and using (i) the domestic household budget constraint; (ii) the equilibrium conditions for firms, and (iii) the government budget constraints, one obtains the following expression for the change in the net foreign asset position or the current account balance:

$$\dot{N} = f(k, l) - c - g - \dot{k} + (1 - \tau_c)f_k(k, l)N, \tag{10}$$

starting from initial N_o and $k_o > 0$. This equation asserts that the rate of accumulation of net foreign assets equals domestic output less domestic absorption, plus the net international flow of earnings on foreign assets.

III. MACROECONOMIC EQUILIBRIUM

1. Short-run equilibrium

Combining the consumer optimality conditions, (2a) and (2b), with the marginal productivity condition for labour, (3b), enables one to solve for short-run consumption and employment in the form:

$$c = c(\alpha); \qquad c_\alpha < 0 \tag{11a}$$

$$l = l(\alpha, k, \tau_w); \qquad l_\alpha > 0,\ l_k > 0,\ l_\tau < 0, \tag{11b}$$

where the partial derivatives and the form of the functions reflect the additive separability of the utility function. An increase in the marginal utility of wealth induces agents to substitute labour for consumption. A higher capital stock raises the wage rate and induces more labour, while an increase in the wage tax has the opposite effect. Analogous solutions apply abroad.

Combining the arbitrage conditions, (2c) and (2d), together with the marginal productivity of capital condition, (2a), for the domestic economy and the corresponding relationships abroad implies

$$\theta = (1 - \tau_c)f_k(k, l) = (1 - \tau_c^*)f_k^*(k^*, l^*) = \theta^*. \tag{12}$$

That is, with a perfect world-capital market and source-based capital taxation, the after-tax marginal physical product of capital in the two economies must be equal, implying the corresponding equality of the short-run rates of return on consumption.[9]

2. Dynamics

The dynamic evolution of the world economy may be represented by the set of equations:

$$\frac{\dot{\alpha}}{\alpha} = \beta - (1 - \tau_c) f_k[k, l(\alpha, k, \tau_w)] \tag{13a}$$

$$\frac{\dot{\alpha}^*}{\alpha^*} = \beta - (1 - \tau_c^*) f_k^*[k, l^*(\alpha^*, k^*, \tau_w^*)] \tag{13b}$$

$$\dot{k} + \dot{k}^* = f[k, l(\alpha, k, \tau_w)] + f^*[k^*, l^*(\alpha^*, k^*, \tau_w^*)] - c(\alpha) - c^*(\alpha^*) - g - g^* \tag{13c}$$

$$\dot{N} = f[k, l(\alpha, k, \tau_w)] - c(\alpha) - \dot{k} + (1 - \tau_c) f_k[k, l(\alpha, k, \tau_w)]N - g, \tag{13d}$$

given k_o, k_o^*, N_o and the intertemporal solvency condition

$$\lim_{t \to \infty} N e^{-\int_o^t (1-\tau_c) f_k ds} = 0. \tag{13e}$$

Not all these equations are independent, since apart from possible initial jumps, α^* mirrors α and likewise k^* reflects k. The intertemporal solvency condition prevents either economy from accumulating infinite net foreign assets.

Using (13a), (13b), and (12), we see that the marginal utilities are related by $\dot{\alpha}/\alpha = \dot{\alpha}^*/\alpha^*$, implying that

$$\alpha^* = \bar{\mu}\alpha, \tag{14}$$

where $\bar{\mu}$ is constant over time, being determined by the steady-state conditions. Note that μ changes at the initial impact. Given that preferences across countries are identical, consumption paths are perfectly correlated along the transitional path. This equation implies that the ratio of the marginal utilities of consumption in the two economies, and therefore the distributions of consumption, remain fixed over time, being determined by $\bar{\mu}$.[10]

9 The implications of these arbitrage conditions under alternative tax regimes are discussed and analysed at length by authors such as Slemrod (1988), Frenkel, Razin, and Sadka (1991), Turnovsky and Bianconi (1992), and Bianconi (1995), among others.

10 Note that in this model the distribution of consumption is endogenously obtained by explicitly taking into account the initial capital stocks and net asset position that satisfy the transversality condition, (13e).

In analysing the dynamics, we assume that at any instant of time, each country's wealth and therefore aggregate world wealth is fixed by the total capital stock in existence. Each country can augment or diminish its capital stock instantaneously, however, by entering the world capital market in accordance with

$$dk_o = -dk_o^* = -dN_o. \tag{15}$$

Thus, the domestic economy can increase its initial stock of capital k_o, by selling equities abroad, thereby reducing its net foreign asset position, N_o. The reverse occurs abroad. This assumption implies that even though the world capital supply is given instantaneously, 'physical' capital is taken to be fully mobile internationally. In turn, the capital stocks are interchangeable and respond instantaneously to exogenous disturbances. This assumption, which has been widely adopted in the static trade literature, abstracts from transportation costs and allows for the possibility of an instantaneous reshuffling of physical capital between the two countries.[11]

Differentiating equation (12) with respect to t implies

$$\phi_1 \dot{k} - \phi_1^* \dot{k}^* + (\phi_2 - \phi_2^*)\dot{\alpha} = 0, \tag{16}$$

where $\phi_1 \equiv (1-\tau_c)(f_{kk} + f_{kl}l_k) < 0$, $\phi_2 \equiv (1-\tau_c)f_{kl}l_\alpha > 0$, and ϕ_1^*, ϕ_2^* are defined analogously. Thus, equations (12), (14), and (16) enable us to express k^* and $\dot{k}^*$ in terms of k and $\dot{k}$, respectively. Linearizing the world product-market-equilibrium condition, (13c), around the steady state and taking account of (12), (14), and (16), the linearized dynamic evolution of the world economy can be represented by

$$\begin{pmatrix} \dot{k} \\ \dot{\alpha} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ -\tilde{\alpha}\phi_1 & -\tilde{\alpha}\phi_2 \end{pmatrix} \begin{pmatrix} k - \tilde{k} \\ \alpha - \tilde{\alpha} \end{pmatrix}, \tag{17}$$

where

$$a_{11} = \frac{\tilde{\alpha}(\phi_1/\phi_1^*)(\phi_2 - \phi_2^*) + (f_k + f_l l_k) + (\phi_1/\phi_1^*)(f_k^* + f_1^* l_k^*)}{1 + (\phi_1/\phi_1^*)}$$

$$a_{12} = \frac{((\phi_2 - \phi_2^*)/\phi_1^*)(\tilde{\alpha}\phi_2 + \tilde{\mu}(f_1^* l_\alpha^* - c_\alpha^*)) + (f_1^* l_\alpha^* - c_\alpha^*) + \tilde{\mu}(f_l^* l_\alpha^* - c^*\alpha)}{1 + (\phi_1/\phi_1^*)},$$

and tildes denote steady-state values.[12]

11 In the international macro literature this assumption is made by Devereux and Shi (1991), Christensen and Nielsen (1992), and Turnovsky and Bianconi (1992), among others. It is also the standard assumption adopted in the two-sector growth literature. In our analysis, the two production sectors, while producing the same good, are located in different countries.

12 We have parameterized the model and solved it numerically using identical functional forms and plausible parameter values. This numerical analysis is based on the following specifications: preferences are represented by $U = \ln c + \ln(1-l) + v[g - (1/2)g^2]$, with $v = 0.7$; see Aschauer (1985). The rate of time preference is $\beta = 0.05$, implying a steady-state real interest rate of 5 per cent. Production is Cobb-Douglas, $y = k^s l^{1-s}$, where $s = 0.36$.

The dynamics described by (17) are a saddlepoint, with the stable eigenvalue being denoted by $\lambda < 0$.[13] Starting from an initial capital stock, k_o, the stable solution is

$$k(t) = \tilde{k} + (k_o - \tilde{k})e^{\lambda t} \tag{18a}$$

$$\alpha(t) = \tilde{\alpha} - \left(\frac{\tilde{\alpha}\phi_1}{\lambda + \tilde{\alpha}\phi_2}\right)(k_o - \tilde{k})e^{\lambda t}. \tag{18b}$$

These two equations can be shown to define a negatively sloped stable locus in $k - \alpha$ space.[14]

To determine the accumulation of net foreign assets, we consider (13d) and apply the procedure discussed by Sen and Turnovsky (1990) and Turnovsky (1991). This involves linearizing this equation about its steady state, substituting from (18a) and (18b) and invoking the intertemporal solvency condition, (13e). Starting from an initial stock of net foreign assets, N_o, the stable adjustment consistent with intertemporal solvency is

$$N(t) = \tilde{N} + \frac{\Omega}{\lambda - \beta}(k_o - \tilde{k})e^{\lambda t} \tag{19a}$$

with

$$N_o - \tilde{N} = \frac{\Omega}{\lambda - \beta}(k_o - \tilde{k}) \tag{19b}$$

and where

$$\Omega \equiv f_k + f_l l_k - \lambda - \frac{\tilde{\alpha}\phi_1(f_l l_\alpha - c_\alpha)}{\lambda + \tilde{\alpha}\phi_2} + \frac{\lambda\phi_1}{\lambda + \tilde{\alpha}\phi_2}\tilde{N}.$$

The expression Ω describes the instantaneous effect of an increase in the domestic capital stock on the domestic current account. This operates through two channels. First, the expression

$$f_k + f_l l_k - \lambda - \frac{\tilde{\alpha}\phi_1(f_l l_\alpha - c_\alpha)}{\lambda + \tilde{\alpha}\phi_2} \equiv \frac{\partial}{\partial k}(f - \dot{k} - c)$$

13 λ is the negative root to the characteristic equation of the dynamic system (17) and is given by

$$\lambda = \{(a_{11} - \tilde{\alpha}\phi_2) - \sqrt{(\tilde{\alpha}\phi_2 - a_{11})^2 - 4\tilde{\alpha}(a_{12}\phi_1 - a_{11}\phi_2)}/2.$$

Our simulation indicates a value of $\lambda = -0.0562$ with a half-life of about 5.4 periods; see, for example, Barro and Sala-i-Martin (1992).

14 The stable locus will have a negative slope if and only if $\lambda + \alpha\phi_2 < 0$. This can be shown to hold (at least as long as ϕ_2 and ϕ_2^* are not too different from one another) by considering the characteristic equation of (17). In our simulation, $\lambda + \alpha\phi_2 = -0.0585$.

represents the impact of a change in the domestic capital stock on the trade balance. This leads to a declining current account balance if the country is a net exporter of capital, and an increase otherwise. In the special case where the two economies have identical technologies, tax structures, and preferences, the trade balance effect is zero and hence $sgn(\Omega) = -sgn(\tilde{N})$. That is, if in equilibrium the economy is a net exporter of capital, as it accumulates capital, it acquires foreign assets. The opposite applies for a capital-importing economy. The quantity $\Omega/(\lambda-\beta)$ describes the extent to which the rate of foreign asset accumulation is tied to that of capital. While this relationship may be of either sign, we shall assume

$$\left|\frac{\partial \dot{N}}{\partial \dot{k}}\right| = \left|\frac{\Omega}{\lambda - \beta}\right| < 1, \tag{20}$$

an assumption that is supported by our numerical simulations.[15]

The solutions (18a), (18b), and (19a) express the dynamics from the viewpoint of the domestic economy. The solution for the foreign capital stock and foreign marginal utility of wealth, however, are readily obtained from (12), (14), and (16).

3. *Steady state*

The steady state, attained when $\dot{k} = \dot{k}^* = \dot{N} = \dot{\alpha} = \dot{\alpha}^* = 0$, reduces to the following:

$$(1-\tau_c)f_k[\tilde{k}, l(\tilde{\alpha}, \tilde{k}, \tau_w)] = (1-\tau_c^*)f_k^*[\tilde{k}^*, l(\tilde{\alpha}^*, \tilde{k}^*, \tau_w^*)] = \beta \tag{21a}$$

$$f[\tilde{k}, l(\tilde{\alpha}, \tilde{k}, \tau_w)] + f^*[\tilde{k}^*, l(\tilde{\alpha}^*, \tilde{k}^*, \tau_w^*)] = c(\tilde{\alpha}) + c^*(\tilde{\alpha}^*) + g + g^* \tag{21b}$$

$$\beta\tilde{N} = c(\alpha) + g - f[\tilde{k}, l(\tilde{\alpha}, \tilde{k}, \tau_w)] = f^*[\tilde{k}^*, l^*(\tilde{\alpha}^*, \tilde{k}^*, \tau_w^*)] - c^*(\tilde{\alpha}^*) - g^* \tag{21c}$$

$$N_o - \tilde{N} = \frac{\Omega}{\lambda - \beta}(k_o - \tilde{k}). \tag{21d}$$

This system of equations jointly determines $\tilde{k}$, $\tilde{k}^*$, $\tilde{\alpha}$, $\tilde{\alpha}^*$, and $\tilde{N}$ in terms of the domestic and foreign government expenditures, domestic and foreign distortionary tax rates, and the initial stocks of assets k_o, N_o. Equations (21a) are the steady-state arbitrage conditions, which in the long run involve equating the after-tax rates of return on capital to the (common) given consumer rate of time preference. These two equations determine the respective steady-state capital-labour ratios in the two economies in terms of the tax on capital in that country, preferences, and technology. Equation (21b) specifies world goods market equilibrium. Equations (21c) state that the total of private plus public consumption in each economy is

15 Our simulations suggest $(\Omega/(\lambda - \beta)) \approx 0.04$, strongly supporting the restriction imposed in (20). Further support is provided by empirical evidence suggesting that the relationship between investment and the current account is weak; see, for example, Feldstein and Horioka (1980). In any event, the restriction imposed in (20) has no influence on the stability properties of the model, since these are determined separately by the system (17).

constrained by the value of its output plus the earnings on its ownership on foreign capital if it is a net capital exporter, or what it owes on the latter if it is a net capital importer. In the two-country world economy the two countries are mirror images of one another, so that (21b) and (21c) are not entirely independent.

Having obtained this steady state, consumptions, $\tilde{c}$, $\tilde{c}^*$ and employments $\tilde{l}$, $\tilde{l}^*$ then follow from (11) and its foreign counterpart, while $\bar{\mu}$ is obtained from (14). Finally, the steady-state government budget constraints in the two economies,

$$g = f_l[\tilde{k}, l(\tilde{\alpha}, \tilde{k}, \tau_w)]l(\tilde{\alpha}, \tilde{k}, \tau_w)\tau_w + f_k[\tilde{k}, l(\tilde{\alpha}, \tilde{k}, \tau_w)]\tilde{k}\tau_c + T \tag{21e}$$

$$g^* = f_l^*[\tilde{k}^*, l^*(\tilde{\alpha}^*, \tilde{k}^*, \tau_w^*)]l^*(\tilde{\alpha}^*, \tilde{k}^*, \tau_w^*)\tau_w^* + f_k^*[\tilde{k}^*, l^*(\tilde{\alpha}^*, \tilde{k}^*, \tau_w^*)]\tilde{k}^*\tau_c^* + T^*, \tag{21f}$$

determine one of the tax rates, (τ_w, τ_c, T) and $(\tau_w^*, \tau_c^*, T^*)$, in each economy, respectively, depending upon the chosen form of government expenditure financing.

4. Determination of initial distribution of world capital stock

As noted earlier, the steady state depends upon the initial stocks, k_o, N_o (or equivalently k_o, k_o^*). This is a feature characteristic of international macroeconomic models having perfect markets and a constant rate of time discount; see Sen and Turnovsky (1990). Formally, it is a consequence of the constancy of $\alpha^*/\alpha = \bar{\mu}$ over time. While the initial aggregate stock of capital, $k_o + k_o^*$, is predetermined, as the sum of previously accumulated world wealth, the initial *allocation* of this aggregate capital stock is endogenously determined by the efficiency condition (12). More specifically, k_o, k_o^* and $\alpha(o)$ are jointly determined in terms of $\bar{\mu}$ and the distortionary tax rates by

$$(1 - \tau_c)f_k[k_o, l(\alpha(o), k_o, \tau_w)] = (1 - \tau_c^*)f_k^*[k_o^*, l^*(\alpha(o)\bar{\mu}, k_o^*, \tau_w^*)], \tag{12'}$$

together with (18b) at time zero, and the fact that $k_o + k_o^*$ is fixed. An interesting aspect of the present model is that because of the dependence of the initial allocation of capital on $\bar{\mu}$, the short-run and long-run equilibria become simultaneously determined.

IV. EFFECTS OF FISCAL EXPANSIONS

Table 1 summarizes the expressions describing the effects of an unanticipated increase in domestic government expenditure, $(dg > 0)$, financed under the alternative types of tax increase. The table is broken down into three components describing the long-run effects, the short-run effects, and the responses along the transitional adjustment paths, respectively. For expositional simplicity, these effects have been computed under the assumptions that (i) agents in the two economies have identical tastes; (ii) the economies have identical technologies; (iii) the initial equilibrium is one in which there are no distortionary taxes, so that any existing government expenditures are financed by lump-sum taxes. Under these conditions one can show that at the initial equilibrium, the consumption, employment, output, capital stocks, and so on in the two economies will be identical. The only source of an imbalance in asset holdings arises because of different sizes in the governments of the two economies. One can show under the present assumption that $\tilde{N} = (1/2\beta)(g - g^*)$. Thus, the domestic economy will be a net exporter of capital in the initial steady state if $g > g^*$ and a net importer otherwise. This is because with identical private consumption and production levels in the two economies, a higher level of expenditure by the domestic government, say, means that the domestic economy is running a trade balance deficit, which needs to be financed by positive earnings on its net holdings of foreign capital in order for the overall current account to remain in balance.

Under the assumption of zero initial distortionary taxes, the equilibrium is Pareto efficient. With the adjustments in the tax rates corresponding to the various modes of financing requiring the budget to remain balanced across steady states, the corresponding changes in the tax rates (from zero in the case of the two distortionary taxes) under the three schemes being considered are as follows: (i) Lump-sum taxes; $dT = dg$; (ii) Taxes on capital income; $d\tau_c = dg/\tilde{k}\tilde{f}_k$; (iii) Taxes on wage income; $d\tau_w = dg/\tilde{l}\tilde{f}_l$.

Lump-sum tax financing ensures that the government budget remains balanced at all times during the transition. That is not the case with either (ii) or (iii), however, since the income on which the distortionary tax is being levied during the transition does not correspond to the new steady-state level. In either case, we assume that any discrepancy in the expenditures and the revenues generated by the distortionary tax during the transition is financed by a (time-varying) lump-sum tax, thereby ensuring that the government budget remains in balance at all times.

1. Lump-sum tax financing

The long-run, short-run, and transitional effects of an expansion in domestic government expenditure under the base case of lump-sum tax financing are summarized in the first column of the three parts of table 1.[16] The intuition underlying these results can be understood most easily by discussing the case where $\Omega = 0$, so that the initial equilibrium is one in which both the trade account and the current account are in balance.

The initial effect of an increase in g financed by higher lump-sum taxes levied on domestic residents is to reduce the long-run permanent income. The fact that their long-run wealth is going to decline raises their initial marginal utility of wealth $\alpha(o)$, inducing them both to increase their supply of labour and to reduce their consumption. The higher labour supply increases the productivity of domestic domiciled capital, inducing domestic investors to repatriate their capital and for-

16 We shall restrict ourselves to considering the effects of an increase in domestic government expenditures. By symmetry, the effects of an increase in foreign government expenditure on the domestic economy are similar, and the effects of a worldwide increase in government expenditure can be readily obtained by aggregating the two country-specific effects.

TABLE 1
Increase in domestic government expenditure

	Financed by		
	Lump-sum tax T	Capital income tax τ_c	Wage income tax τ_w
A. Steady-state effects			
$\tilde{k}$	$\dfrac{\psi - \frac{\beta}{2}\left(1 + \frac{\Omega}{\lambda - \beta}\right)}{\psi(\psi - \beta)} > 0$	$(1 - \delta_c)\dfrac{\psi - \frac{\beta}{2}\left(1 + \frac{\Omega}{\lambda - \beta}\right)}{\psi(\psi - \beta)} < 0$	$(1 - \delta_w)\dfrac{\psi - \frac{\beta}{2}\left(1 + \frac{\Omega}{\lambda - \beta}\right)}{\psi(\psi - \beta)}$
$\tilde{k}^*$	$\dfrac{\frac{\beta}{2}\left(1 - \frac{\Omega}{\lambda - \beta}\right)}{\psi(\psi - \beta)} < 0$	$-(1 - \delta_c)\dfrac{\frac{\beta}{2}\left(1 - \frac{\Omega}{\lambda - \beta}\right)}{\psi(\psi - \beta)} > 0$	$-(1 - \delta_w)\dfrac{\frac{\beta}{2}\left(1 - \frac{\Omega}{\lambda - \beta}\right)}{\psi(\psi - \beta)}$
$\tilde{k} + \tilde{k}^*$	$\dfrac{1}{\psi} > 0$	$(1 - \delta_c)\dfrac{1}{\psi} < 0$	$(1 - \delta_w)\dfrac{1}{\psi}$
$\tilde{N}$	$\dfrac{\left(1 - \frac{\Omega}{\lambda - \beta}\right)}{2(\psi - \beta)} < 0$	$-(1 - \delta_c)\dfrac{\left(1 - \frac{\Omega}{\lambda - \beta}\right)}{2(\psi - \beta)} > 0$	$-(1 - \delta_w)\dfrac{\left(1 - \frac{\Omega}{\lambda - \beta}\right)}{2(\psi - \beta)}$
$\tilde{\mu}$	$\dfrac{\frac{\phi_1}{\phi_2}\left(\psi - \frac{\beta\Omega}{\lambda - \beta}\right)}{\alpha\psi(\psi - \beta)} < 0$	$(1 - \delta_c)\dfrac{\frac{\phi_1}{\phi_2}\left(\psi - \frac{\beta\Omega}{\lambda - \beta}\right)}{\alpha\psi(\psi - \beta)} - \dfrac{1}{\alpha\phi_2 k}$	$(1 - \delta_w)\dfrac{\frac{\phi_1}{\phi_2}\left(\psi - \frac{\beta\Omega}{\lambda - \beta}\right)}{\alpha\psi(\psi - \beta)} + \dfrac{1}{lf_l}$
$\tilde{l}$	$\left(\dfrac{\tilde{l}}{\tilde{k}}\right)\left(\dfrac{d\tilde{k}}{dg}\right)_T > 0$	$\left(\dfrac{\tilde{l}}{\tilde{k}}\right)\left(\dfrac{d\tilde{k}}{dg}\right)_{\tau_c} + \dfrac{1}{f_{kl}k}$	$\left(\dfrac{\tilde{l}}{\tilde{k}}\right)\left(\dfrac{d\tilde{k}}{dg}\right)_{\tau_w}$
$\tilde{l}^*$	$\left(\dfrac{\tilde{l}}{\tilde{k}}\right)\left(\dfrac{d\tilde{k}^*}{dg}\right)_T < 0$	$\left(\dfrac{\tilde{l}}{\tilde{k}}\right)\left(\dfrac{d\tilde{k}^*}{dg}\right)_{\tau_c} > 0$	$\left(\dfrac{\tilde{l}}{\tilde{k}}\right)\left(\dfrac{d\tilde{k}^*}{dg}\right)_{\tau_w}$

TABLE 1 (*Continued*)

	Financed by		
	Lump-sum tax T	Capital income tax τ_c	Wage income tax τ_w
$\tilde{l}+\tilde{l}^*$	$\left(\frac{\tilde{l}}{\tilde{k}}\right)\frac{1}{\psi}>0$	$(1-\delta_c)\left(\frac{\tilde{l}}{\tilde{k}}\right)\frac{1}{\psi}+\frac{1}{f_{kl}k}$	$(1-\delta_w)\left(\frac{\tilde{l}}{\tilde{k}}\right)\frac{1}{\psi}$
$\tilde{\alpha}$	$-\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}}{dg}\right)_T>0$	$-\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}}{dg}\right)_{\tau_c}+\frac{1}{\phi_2 k}$	$-\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}}{dg}\right)_{\tau_w}+\frac{\tilde{\alpha}}{lf_l}$
$\tilde{\alpha}^*$	$-\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}^*}{dg}\right)_T<0$	$-\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}^*}{dg}\right)_{\tau_c}>0$	$-\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}^*}{dg}\right)_{\tau_w}$
$\tilde{c}$	$-\frac{1}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}}{dg}\right)_T<0$	$-\frac{1}{U_{cc}}\left(\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}}{dg}\right)_{\tau_c}-\frac{1}{\phi_2 k}\right)$	$-\frac{1}{U_{cc}}\left(\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}}{dg}\right)_{\tau_w}-\frac{\tilde{\alpha}}{lf_l}\right)$
$\tilde{c}^*$	$-\frac{1}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}^*}{dg}\right)_T>0$	$-\frac{1}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}^*}{dg}\right)_{\tau_c}<0$	$-\frac{1}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\left(\frac{d\tilde{k}^*}{dg}\right)_{\tau_w}$
$\tilde{c}+\tilde{c}^*$	$-\frac{1}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\frac{1}{\psi}<0$	$-\frac{(1-\delta_c)}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\frac{1}{\psi}+\frac{1}{U_{cc}\phi_2 k}$	$-\frac{(1-\delta_w)}{U_{cc}}\left(\frac{\phi_1}{\phi_2}\right)\frac{1}{\psi}+\frac{\tilde{\alpha}}{U_{cc}lf_l}$

These expressions assume (i) identical preferences, (ii) identical technologies, and (iii) zero initial distortionary taxes.

$$\psi \equiv \frac{f}{k}+\frac{U_{ll}}{U_{cc}}\frac{l}{kf_l}>\beta>0;\quad \delta_c \equiv \frac{f_l}{f_{kl}k}-\frac{1}{\phi_2 U_{cc}k}(>1);\quad \delta_w \equiv -\frac{\tilde{\alpha}}{U_{cc}f_l l}\ \substack{>\\<}\ 1.$$

TABLE 1 (*Continued*)

	Financed by		
	Lump-sum tax T	Capital income tax τ_c	Wage income tax τ_w
B. Short-run effects			
k_o	$\dfrac{\left(\psi - \dfrac{\beta\Omega}{\lambda-\beta}\right)}{2\psi(\psi-\beta)} > 0$	$(1-\delta_c)\dfrac{\left(\psi - \dfrac{\beta\Omega}{\lambda-\beta}\right)}{2\psi(\psi-\beta)} < 0$	$(1-\delta_w)\dfrac{\left(\psi - \dfrac{\beta\Omega}{\lambda-\beta}\right)}{2\psi(\psi-\beta)}$
k_o^*, N_o	$\dfrac{-\left(\psi - \dfrac{\beta\Omega}{\lambda-\beta}\right)}{2\psi(\psi-\beta)} < 0$	$-(1-\delta_c)\dfrac{\left(\psi - \dfrac{\beta\Omega}{\lambda-\beta}\right)}{2\psi(\psi-\beta)} > 0$	$-(1-\delta_w)\dfrac{\left(\psi - \dfrac{\beta\Omega}{\lambda-\beta}\right)}{2\psi(\psi-\beta)}$
$\alpha(o)$	$\left(\dfrac{d\tilde{\alpha}}{dg}\right)_i - \dfrac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\left(\dfrac{dk_o}{dg} - \dfrac{d\tilde{k}}{dg}\right)_i \quad i = T,\ \tau_c,\ \tau_w;$		$\left(\dfrac{d\alpha(o)}{dg}\right)_T > 0;$
$\alpha^*(o)$	$\left(\dfrac{d\tilde{\alpha}^*}{dg}\right)_i - \dfrac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\left(\dfrac{dk_o^*}{dg} - \dfrac{d\tilde{k}^*}{dg}\right)_i \quad i = T,\ \tau_c,\ \tau_w;$		$\left(\dfrac{d\alpha^*(o)}{dg}\right)_T > 0;$
$c(o)$	$\dfrac{1}{U_{cc}}\left(\dfrac{d\alpha(o)}{dg}\right)_T < 0$	$\dfrac{1}{U_{cc}}\left(\dfrac{d\alpha(o)}{dg}\right)_{\tau_c}$	$\dfrac{1}{U_{cc}}\left(\dfrac{d\alpha(o)}{dg}\right)_{\tau_w}$
$c^*(o)$	$\dfrac{1}{U_{cc}}\left(\dfrac{d\alpha^*(o)}{dg}\right)_T < 0$	$\dfrac{1}{U_{cc}}\left(\dfrac{d\alpha^*(o)}{dg}\right)_{\tau_c}$	$\dfrac{1}{U_{cc}}\left(\dfrac{d\alpha^*(o)}{dg}\right)_{\tau_w}$
$l(o)$	$\dfrac{\phi_2}{f_{kl}}\left(\dfrac{d\alpha(o)}{dg}\right)_T + \dfrac{\phi_2\tilde{\alpha}}{f_l}\left(\dfrac{dk_o}{dg}\right)_T > 0$	$\dfrac{\phi_2}{f_{kl}}\left(\dfrac{d\alpha(o)}{dg}\right)_{\tau_c} + \dfrac{\phi_2\tilde{\alpha}}{f_l}\left(\dfrac{dk_o}{dg}\right)_{\tau_c}$	$\dfrac{\phi_2}{f_{kl}}\left(\dfrac{d\alpha(o)}{dg}\right)_{\tau_w} + \dfrac{\phi_2\tilde{\alpha}}{f_l}\left(\dfrac{dk_o}{dg}\right)_{\tau_w} + \dfrac{\phi_2\tilde{\alpha}}{lf_lF_{kl}}$

TABLE 1 (*Concluded*)

	Financed by		
	Lump-sum tax T	Capital income tax τ_c	Wage income tax τ_w
$l^*(o)$		$\frac{\phi_2}{f_{kl}}\left(\frac{d\alpha^*(o)}{dg}\right)_i + \frac{\phi_2\tilde{\alpha}}{f_l}\left(\frac{dk_o^*}{dg}\right)_i$	$i = T,\ \tau_c,\ \tau_w$
C. Transitional effects			
$\left.\begin{matrix}\tilde{k} - k_o \\ \tilde{k}^* - k_o^*\end{matrix}\right\}$	$\frac{1}{2\psi} > 0$	$\frac{(1-\delta_c)}{2\psi} < 0$	$\frac{(1-\delta_w)}{2\psi}$
$\tilde{N} - N_o$	$\frac{\Omega}{2(\lambda-\beta)\psi}$	$\frac{(1-\tau_c)\Omega}{2(\lambda-\beta)\psi}$	$\frac{(1-\tau_w)\Omega}{2(\lambda-\beta)\psi}$
$\left.\begin{matrix}\tilde{\alpha} - \alpha(o) \\ \tilde{\alpha}^* - \alpha^*(o)\end{matrix}\right\}$	$-\left(\frac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\right)\frac{1}{2\psi} < 0$	$-\left(\frac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\right)\frac{(1-\delta_c)}{2\psi} > 0$	$-\left(\frac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\right)\frac{(1-\delta_w)}{2\psi}$
$\left.\begin{matrix}\tilde{c} - c(o) \\ \tilde{c}^* - c^*(o)\end{matrix}\right\}$	$-\left(\frac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\right)\frac{1}{2U_{cc}\psi} > 0$	$-\left(\frac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\right)\frac{(1-\delta_c)}{2U_{cc}\psi} < 0$	$-\left(\frac{\tilde{\alpha}\phi_1}{\lambda+\tilde{\alpha}\phi_2}\right)\frac{(1-\delta_w)}{2U_{cc}\psi}$
$\left.\begin{matrix}\tilde{l} - l(o) \\ \tilde{l}^* - l^*(o)\end{matrix}\right\}$	$\frac{\tilde{\alpha}\phi_2[f_{lk}(\lambda+\tilde{\alpha}\phi_2) - f_l\phi_1]}{f_l f_{kl}(\lambda+\tilde{\alpha}\phi_2)2\psi}$	$\frac{\tilde{\alpha}\phi_2[f_{lk}(\lambda+\tilde{\alpha}\phi_2) - f_l\phi_1]}{f_l f_{kl}(\lambda+\tilde{\alpha}\phi_2)}\left(\frac{1-\delta_c}{2\psi}\right)$	$\frac{\tilde{\alpha}\phi_2[f_{lk}(\lambda+\tilde{\alpha}\phi_2) - f_l\phi_1]}{f_l f_{kl}(\lambda+\tilde{\alpha}\phi_2)}\left(\frac{1-\delta_w}{2\psi}\right)$

eigners to invest in the domestic economy. In order for equilibrium in the capital market to prevail, the productivity of foreign domiciled capital must increase. In part, this occurs automatically through the initial outflow of the foreign capital stock, the reduced supply of which will raise the productivity of the capital that remains abroad. The fact that the tax increase associated with the higher government expenditure falls directly on domestic residents results in $\alpha(o)$ increasing more than $\alpha^*(o)$, so that $\bar{\mu}$ falls initially and remains constant along the transition.

With the world stock of capital fixed in the short run, the increase in k_o is met by an equivalent reduction in k_o^*, which helps to restore the marginal productivity of foreign capital and maintain equilibrium in the capital market, without $\alpha^*(o)$'s having to rise as much as $\alpha(o)$. The international movement of capital implies that the net foreign asset position of the domestic economy declines initially as a result of the initial exchange of assets. With identical individuals and $\Omega = 0$, there is no further accumulation of foreign assets during the transition.

The rise in the domestic marginal productivity of capital above its long-run equilibrium level causes capital to be accumulated until the capital-labour ratio is restored to its fixed long-run equilibrium level implied by (21a). Thus, in the domestic economy the initial increase in the capital stock is accompanied by a further continuous increase as the new equilibrium is approached. In the foreign economy the initial reduction in the capital stock is immediately offset by a continuing increase, in response to the higher rate of return to capital in that economy as well. Thus, the aggregate world capital stock rises over time, as both countries accumulate capital, leading to a new steady-state equilibrium in which the world capital stock is increased. The capital stock abroad, however, remains below its initial equilibrium (before the fiscal expansion), so that the long-run adjustment involves a reallocation of capital towards the domestic economy.

The initial increase in the domestic marginal utility of wealth, accompanied by the initial increase in domestic capital induces an instantaneous increase in domestic employment. Over time, as capital is accumulated, the marginal utility of wealth declines. These two influences have offsetting influences on the supply of labour in the domestic economy. Under reasonable conditions, one can show that the wealth effect will dominate and employment in the domestic economy will decline during the transition, although in the new long-run equilibrium it must increase in proportion to the domestic capital stock.[17] The initial response of the labour supply abroad is also ambiguous, although it will decline in the long run. Thus, during the transition the capital stock and employment in both economies adjust in opposite directions over time, although in the long run aggregate world employment rises in proportion to the rise in the aggregate world capital stock.

It is evident from this scenario that while the domestic fiscal expansion may

17 A necessary and sufficient condition for employment to decrease uniformly during the transition is that $\sigma/s + (c/f)/\eta_c > 0$, where σ is the elasticity of substitution in production; s is the share of output earned by capital; c/f is the share of output that is consumed; and η_c is the elasticity of the marginal utility of consumption. This condition is satisfied in the case of a Cobb-Douglas production function and a logarithmic utility function, as in our numerical simulations.

stimulate the domestic economy, it has predominantly negative influences on activity abroad. Capital stock is always below its original level, and while it is possible for employment to rise in the short run, it too will decline. This source of negative transmission occurs through the capital market and is very different from that discussed in the earlier literature by Branson and Rotemberg (1980), Corden and Turnovsky (1983), and others.[18]

What happens to consumption is of obvious importance. The initial increases in the marginal utility of wealth in the two economies, $\alpha(o)$ and $\alpha^*(o)$, cause initial reductions in consumption in the two economies, as consumers substitute work for consumption. The greater increase in the marginal utility in the domestic economy implies a greater reduction of domestic consumption, which is a consequence of the crowding out generated by the additional domestic government expenditure. Over time, as capital is accumulated in both economies and the respective marginal utilities, α and α^*, decline, the consumption levels rise. While the new steady-state level of domestic consumption remains below its original level (remaining crowded out by domestic government expenditure), the steady-state level of consumption rises abroad. This rise is dominated by the decline in domestic consumption, however, so that overall world consumption falls in the long run.

These effects are based on the assumption that $\Omega = 0$, so that the initial equilibrium is one in which both the trade account and current account are in balance. In this circumstance the fiscal shock generates a discrete initial *stock shift*, even though subsequent *net flows* are zero. The reason is that $\Omega = 0$ implies $dN = 0$ and hence $dk^{*d} = dk^f$. Thus, as domestic capital varies, the cross-hauling of assets allows for the efficient allocation of capital across countries. If $\Omega \neq 0$, then $dN \neq 0$ and the induced net flows offset some of the initial stock shift.

Suppose now that $\Omega < 0$, so that the domestic economy is now a net exporter of capital in the initial equilibrium. Indeed, the initial equilibrium is one in which the domestic economy runs a trade deficit, financed by positive earnings from capital abroad. In this case, both the expansionary effects in the domestic economy and the contractionary effects in the foreign economy, resulting from an increase in domestic government expenditure, are reduced. The reason for this is seen from (19a). As capital is accumulated by the domestic economy, foreign assets are accumulated, so that some of the domestic wealth is exported abroad. This is contractionary for the domestic economy and expansionary abroad, offsetting the effects we have been discussing. As long as (20) holds, these effects resulting from the induced capital flows are dominated by the adjustments described above, and the responses we have been discussing will continue to hold.

One final point worth observing is that the magnitudes of the transitional effects

18 The impact and long-run multipliers of government expenditure on domestic and foreign output in our simulation are $dy(0)/dg|_{dT} = 0.4644$, $d\tilde{y}/dg|_{dT} = 0.5191$, $dy^*(0)/dg|_{dT} = -0.1012$, and $d\tilde{y}^*/dg|_{dT} = -0.0464$. Thus, in this model, under plausible parameterization, domestic government expenditure multipliers under lump-sum tax financing are well below unity. The negative transmission effects abroad are also implicit in the paper by Backus, Kehoe, and Kydland (1994), where the model is along the same lines as the one in this paper.

described in table 1.C are identical for the two economies. This is a consequence of the symmetry assumptions upon which this table is based. Under these conditions, the only difference in the responses of the two economies will result from the asymmetry of the initial shock (in this case a fiscal disturbance to the domestic economy) and the corresponding long-run adjustments this induces.

2. Capital income tax financing

Capital income tax financing is described in column 2 of table 1. An increase in domestic government expenditure now has two components. The first is the direct expenditure effect, similar to that associated with lump-sum tax financing, which we have just been discussing. But in addition, there is now an induced effect, resulting from the accompanying increase in the tax rate on capital. This impinges on the domestic economy in two places. First, it has an impact on the steady-state marginal product of capital condition (24a) applicable to the domestic economy. There it is seen that the increase in the capital income tax reduces the steady-state after-tax marginal physical product of capital, reducing the long-run capital-labour ratio in the domestic economy. This is a contractionary effect from the viewpoint of the domestic economy. Second, it also has an impact through the short-run arbitrage condition (12). This reduces the relative competitiveness of domestic capital to investors, thereby reducing the initial amount, dk_o, that they will be induced to shift to the domestic economy. This is also contractionary.

From table 1 it is seen that the net stimulative effect of an increase in government expenditure, dg, financed by a tax on capital (starting with an initial tax on capital equal to zero), is

$$(1-\delta_c)dg \equiv \left(1-\left[\frac{f_l}{f_{kl}k}-\frac{1}{\phi_2 U_{cc}k}\right]\right)dg,$$

where the term in square brackets represents the total contractionary effect on the domestic economy. Letting $\sigma \equiv f_k f_l/ff_{kl}$ = elasticity of substitution, $s \equiv f_k k/f$ = share of output earned by capital, $\eta_c \equiv U_{cc}c/U_c < 0$ = elasticity of the marginal utility of consumption, $\eta_l \equiv U_{ll}l/U_l < 0$ = elasticity of the marginal utility of labour, and c/f = share of output devoted to consumption, we can establish

$$\delta_c \equiv \frac{\sigma}{s}-\frac{c/f}{(1-s)\eta_c}+\left(\frac{\eta_l}{\eta_c}\right)\frac{\sigma(c/f)}{s(1-s)}. \tag{22}$$

Under any plausible conditions (22) implies $\delta_c > 1$, implying that the contractionary effect dominates. On the one hand, the lower permanent income resulting from the higher tax will raise the marginal utility of wealth, inducing more labour and raising the marginal product of domestic capital, as is the case for the lump-sum tax. But the higher tax on capital induces firms to substitute labour for capital, and this tends to have the opposite effect. Indeed, (22) suggests that the latter effect will dominate, so that the long-run stock of domestic capital will fall under capital taxation. This will be so for the Cobb-Douglas production function ($\sigma = 1$); but it will hold under much weaker conditions as well. For example, it will still hold if $\sigma > s \approx 0.35$, and it may even hold if $\sigma = 0$ and the production function is one of fixed proportions. In our simulation, $\delta_c = 9.06$, well above unity, enabling us to maintain, for practical purposes, the assumption $\delta_c > 1$.

Assuming that the contractionary effects dominate, the adjustments described in the case of lump-sum tax financing are reversed. Thus, the net effect of an increase in domestic government expenditure is now an initial outflow of capital leading to a contraction in the domestic capital stock and an expansion abroad. The accumulation of capital in the foreign country is mirrored by a long-run increase in employment abroad. The long-run response of employment in the domestic economy responds to two effects. While the reduction in capital will cause employment to fall, the substitution towards labour resulting from the higher tax on capital has a positive effect. On balance, the latter effect can be shown to dominate, so that overall, long-run employment in the domestic economy rises.[19]

The fact that the partial effect of a higher capital tax is contractionary is not surprising, but the fact that it actually is sufficiently large to dominate the expenditure effect, so that the overall effect of the increased government expenditure is negative, is rather striking. For example, our simulation yields impact and long-run multipliers on domestic output, which are negative and greater that one in absolute value, the so-called 'supply-side multipliers'; see Baxter and King (1993).[20] This is a consequence of the burden imposed by distortionary capital income taxation on the accumulation of domestic capital, as measured by the parameter, δ_c. The result stems, at least in part, from the assumption that the initial equilibrium is one of zero distortionary taxes, as a result of which the increase in capital taxes necessary to finance the additional expenditure is large. If, instead, the initial equilibrium was from one having pre-existing distortionary taxes, the required marginal increase in the capital income tax rate would likely be smaller, since some of the additional revenues would be financed by higher activity at the initial rates. While this would likely reduce δ_c, it is still quite plausible that the contractionary effect would dominate, as Turnovsky (1992) showed for a closed economy.

3. Wage income tax financing

This is reported in column 3 of table 1. As is the case for capital taxation, government expenditure financed by a tax on labour income has a direct expenditure effect and an induced effect that operates through the accompanying increase in the tax rate on labour. This impinges on the economy through the labour supply decision, (11b). An increase in the tax on wage income lowers the supply of labour, thereby reducing the marginal productivity of capital and generating a contractionary effect

19 The simulations support this assertion, because the capital income tax necessary to finance the additional government expenditure is about 33.5 per cent. This reduces the domestic capital stock by a little less than one-half, and since the elasticity of substitution of capital and labour is unity, the substitution effect clearly dominates.

20 Specifically, our simulation yields impact and long-run multipliers on domestic and foreign output: $dy(0)/dg|_{d\tau_c} = -1.0423$, $d\tilde{y}/dg|_{d\tau_c} = -1.7729$, $dy^*(0)/dg|_{d\tau_c} = 0.7425$, $d\tilde{y}^*/dg|_{d\tau_c} = 0.3746$.

on the domestic economy.

From table 1 it is seen that the net stimulative effect of an increase in government expenditure, dg, financed by a tax on wage income (starting with zero initial distortionary taxes), is

$$(1 - \delta_w)dg = \left(1 + \frac{\tilde{\alpha}}{U_{cc}f_l\tilde{l}}\right) dg,$$

where the second term represents the contractionary effect. This can be written as

$$\delta_w = -\frac{1}{\eta_c}\left(\frac{c/f}{1-s}\right). \tag{23}$$

In contrast to the case δ_c, there is much less presumption that $\delta_w > 1$ in an open economy. Assuming a logarithmic utility function, for example, and $s = 0.36$, in order for the contractionary effect to dominate, the ratio of consumption to output must be > 0.64, which need not necessarily hold. This contrasts with a closed economy, in which, since there is no trade in foreign assets, the condition $c/f = 1$ is automatically met in steady state, when capital accumulation ceases. Trade in foreign assets allows the country to be a net exporter of capital, and this may permit the economy to maintain the c/f ratio below 0.64. Thus, a wage-tax-financed increase in government expenditure may be either expansionary or contractionary from the standpoint of the domestic economy; for that reason we make no presumption about the likely signs of the expressions appearing in column 3 of table 1.[21]

V. WELFARE EFFECTS

We now turn to analysing the effects of government expenditure on economic welfare. In considering this aspect, the criterion we shall consider is the welfare of the representative agent in both the domestic and foreign economies, as measured by their respective utility functions. We shall consider both the time path of instantaneous utility and the overall accumulated welfare over the agent's infinite planning horizon. We shall focus primarily on the case of lump-sum tax-financed expenditure.

It suffices to spell out the details for the domestic economy. The instantaneous level of utility of the domestic representative agent at time t, $Z(t)$, say, is specified to be

$$Z(t) = U(c(t), l(t), g), \tag{24a}$$

21 In our simulation $c/f > 0.92$, implying $\delta_w = 1.37 > 1$. The impact and long-run government expenditure multipliers are $dy(0)dg|_{d\tau_w} = -0.2036$, $d\tilde{y}/dg|_{d\tau_w} = -0.2268$, $dy^*(0)/dg|_{d\tau_w} = 0.0435$, $d\tilde{y}^*/dg|_{d\tau_w} = 0.0203$. While the domestic multipliers are negative, they are well below unity, reflecting the fact that the distortionary effect of the wage income tax is moderate relative to that of the capital income tax.

where, it will be recalled, the utility function U is taken to be additively separable in its three arguments. Overall level of utility of the agent is thus

$$W = \int_o^\infty U(c, l, g)e^{-\beta t}dt = \int_o^\infty Z(t)e^{-\beta t}dt. \tag{24b}$$

The purpose is to consider the effects of government expenditure on both $Z(t)$ and W when c and l follow the equilibrium paths described by (11a) and (11b) and α and k evolve along (18a) and (18b).

If we differentiate (24a), the following impacts of an increase in domestic government expenditure on the time path of instantaneous welfare in the domestic economy can be derived:

$$\frac{dZ(o)}{dg} = U_g + U_c\left(\frac{dc(o)}{dg} - f_l\frac{dl(o)}{dg}\right) \tag{25a}$$

$$\dot{Z}(t) = U_c(\dot{c}(t) - f_l\dot{l}(t)) > 0 \tag{25b}$$

$$\frac{d\tilde{Z}}{dg} = U_g + U_c\left(\frac{d\tilde{c}}{dg} - f_l\frac{d\tilde{l}}{dg}\right). \tag{25c}$$

The initial reduction in consumption and increase in employment stemming from the increase in domestic government expenditure is welfare reducing and offsets at least in part any direct benefits it yields. Over time, as consumption increases and employment falls (and leisure increases), welfare improves. Steady-state welfare (25c) is thus higher than the initial short-run welfare (25a), although with reduced steady-state consumption and employment still below their previous equilibrium levels, the changes in private behaviour induced by the government expenditure lead to losses that need to be weighed against the direct benefits provided. The effects on the instantaneous welfare abroad are provided by analogous expressions, with the only difference being that there is no direct impact effect corresponding to U_g.

A linear approximation to the overall level of domestic welfare, represented by (24b), is obtained by observing that along the equilibrium path $Z(t)$ can be approximated by

$$Z(t) \approx \tilde{Z} + (Z(o) - \tilde{Z})e^{\lambda t}. \tag{26}$$

Substituting (26) into (24b) and integrating, yields

$$W \approx \frac{\tilde{Z}}{\beta} + \frac{Z(o) - \tilde{Z}}{\beta - \lambda}. \tag{27}$$

The first term is the capitalized value of the instantaneous level of welfare at steady state. It is the level of welfare that would obtain if the steady state were attained instantaneously. The remaining term reflects the adjustment to this, arising from the fact that the steady state is reached only gradually along the transitional path.

Differentiating (27) with respect to g, after some algebraic manipulation, one can derive

$$\frac{dW}{dg} = \frac{U_g}{\beta} - \frac{U_c}{\beta}\left(1 - \frac{\beta}{2\psi}\left[1 + \frac{\Omega}{\lambda - \beta}\right]\right) - \frac{U_c}{2\psi}, \tag{28a}$$

where $\psi(> \beta)$ is defined in table 1. Written in this way, the response of the overall intertemporal measure of domestic welfare consists of three components. The first describes the positive marginal benefit of the additional government expenditure, which, being maintained indefinitely, is capitalized at the discount rate, β. The second represents the steady-state losses resulting from (i) the private consumption being displaced by the government expenditure and (ii) the disutility resulting from the higher steady-state employment. The third term measures the discounted utility gains along the transitional path. These gains are subtracted because they are already contained in the second measure. The resulting expression is reported in table 2.

The corresponding expression describing the effect on foreign welfare is given by

$$\frac{dW^*}{dg} = \frac{U_c}{2\psi}\left(1 - \frac{\Omega}{\lambda - \beta}\right) - \frac{U_c}{2\psi}, \tag{28b}$$

which is similarly broken down into the steady-state effect, given by the first effect and the welfare along the transitional path. These are offsetting, and the net effect of an increase in domestic government expenditure on foreign welfare, reported in table 2, depends simply upon $-(U_c/2\psi)(\Omega/(\lambda - \beta))$. If we ignore this term, (28b) implies that the subsequent utility gains along the transitional path (as consumption and leisure increase abroad) exactly offsets, in discounted utility terms, the losses incurred by the initial reduction in consumption and leisure.

The term $-(U_c/2\psi)(\Omega/(\lambda{-}\beta))$ represents the transfer in welfare between the two economies that occurs as the net foreign asset position changes over time. Suppose that the equilibrium is one in which the domestic economy is a net supplier of capital, so that $\Omega < 0$. As the domestic economy accumulates foreign assets over time, activity increases abroad, although as we have seen, the reduction in leisure that it entails is welfare deteriorating in so far as the foreign economy is concerned. The domestic economy thus confers a negative externality in terms of welfare on the foreign economy. We should acknowledge, however, that since this is a model of full employment, the negative externality (transmission) is associated with an expansion in foreign employment and in this respect is fundamentally different from the negative transmission of the earlier models, which were associated with a decline in activity and employment.

If we aggregate the welfare effects in the two economies, we can see from table 2 that the net effect of the domestic fiscal expansion on aggregate world welfare is simply

TABLE 2
Increase in domestic government expenditure: overall welfare effects

Domestic economy	Foreign economy	World economy
$\frac{dW}{dg}$	$\frac{dW^*}{dg}$	$\frac{dW}{dg}+\frac{dW^*}{dg}$
A. Financed by lump-sum tax		
$\frac{U_g}{\beta}-\frac{U_c}{\beta}\left(1-\left(\frac{\Omega}{\lambda-\beta}\right)\frac{1}{2\psi}\right)$	$-\frac{U_c}{2\psi}\left(\frac{\Omega}{\lambda-\beta}\right)$	$\frac{1}{\beta}(U_g-U_c)$
B. Financed by capital income tax		
$\frac{U_g}{\beta}-\frac{(1-\delta_c)U_c}{\beta}\left(1-\left(\frac{\Omega}{\lambda-\beta}\right)\frac{1}{2\psi}\right)-\delta_c\frac{U_c}{\beta}$	$-(1-\delta_c)\frac{U_c}{2\psi}\left(\frac{\Omega}{\lambda-\beta}\right)$	$\frac{1}{\beta}(U_g-U_c)$
C. Financed by wage income tax		
$\frac{U_g}{\beta}-\frac{(1-\delta_w)U_c}{\beta}\left(1-\left(\frac{\Omega}{\lambda-\beta}\right)\frac{1}{2\psi}\right)-\delta_w\frac{U_c}{\beta}$	$-(1-\delta_w)\frac{U_c}{2\psi}\left(\frac{\Omega}{\lambda-\beta}\right)$	$\frac{1}{\beta}(U_g-U_c)$

$$\frac{dW}{dg}+\frac{dW^*}{dg}=\frac{1}{\beta}(U_g-U_c). \tag{29}$$

Thus, the net effect on world welfare is just equal to the capitalized difference of the direct utility of government expenditure and that of the private world consumption, which it is displacing.

Table 2 summarizes the expressions for welfare corresponding to all three forms of tax financing. We shall not discuss these expressions in detail, other than to make two observations. The first is that the welfare spillovers in all cases depend upon Ω, although whether this confers a positive or negative externality abroad depends upon the method of finance. Second, the aggregate effect on world welfare, reported in column 3, is the same in all cases. This is a consequence of the fact that the initial equilibrium is one with no distortionary taxes.[22]

VI. CONCLUSIONS

In summary, in this paper we have analysed the international transmission effects of government expenditure, financed by alternative forms of taxation in a two-country one-good world with endogenously supplied capital and labour. The general message to emerge from our analysis is that the form of financing dramatically

22 If the starting point is an equilibrium with no distortionary taxes, it is well known that the introduction of such a tax involves no welfare loss to the first order. It does, however, affect the intertemporal distribution of welfare gains along the welfare path, as well as the distribution of the gains internationally. These results are due to the fact that although the introduction of the tax affects incentives, since it is infinitesimally small, its overall intertemporal welfare effects are negligible. For a more detailed discussion of this type of result in the context of a tariff for a small economy see Brock and Turnovsky (1993).

alters the quantitative and qualitative characteristics of both the domestic impact of government expenditure, as well as its transmission abroad. One of the appealing features of this analysis is the simple characterization of the alternative forms of financing in terms of the multiplicative tax factor $(1-\delta_i, i = c, w)$, thus facilitating the comparison between them.

While the results have been discussed at length, the following specific conclusions merit highlighting.

i. An expansion in government expenditure financed by a lump-sum tax has positive effects on employment and production in the domestic economy but corresponding negative impacts abroad.
ii. In the case where the government finances its expenditures using a tax on capital, these effects are almost certainly reversed; it has a contractionary effect on domestic activity and an expansionary effect abroad.
iii. The case where the expenditure is financed by a tax on labour income is an intermediate one. While it also tends to have the opposite qualitative effects on the two economies, it is equally plausible for it to expand the domestic economy while having a negative impact abroad, or vice versa.
iv. The impact of an expansion in domestic government on foreign welfare operates through the transfer of foreign assets over time, as the capital stock in the domestic economy changes in response to this fiscal shock. Negative transmission of activity does not necessarily mean a decline in foreign welfare. Whether the domestic economy confers a positive or negative externality in terms of welfare on the foreign country depends upon whether the domestic economy is a net supplier of capital and the mode of expenditure financing.

Several extensions of the theoretical model are worth noting: (i) the consideration of a multi-country world, which under the types of symmetry assumptions we have made should be analytically tractable; (ii) the extension to a two-good, two-country framework; (iii) the explicit introduction of risk; to mention a few. More important, the fact that government expenditure in one country generates externalities abroad raises the possibility of strategic behaviour by the two governments vis-à-vis their respective expenditure policies. This issue, which has been analysed by Turnovsky (1988) in a pure real-trade model, and by Devereux (1991) in a model closer to the present one, certainly is an important area for future research.

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