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International Effects of Tax Reforms

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Abstract

This paper highlights the significance of open-economy considerations in the analysis of tax reforms. It focuses on domestic and international consequences of revenue-neutral conversion between income and value-added tax systems. The principal result is that the direction of changes in key macroeconomic variables consequent on such tax conversions depends critically on the current account position. For example, a conversion from an income to a value-added tax system lowers the world interest rate if the country adopting the reform runs a surplus in the current account of its balance of payments, and vice versa.

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<u>Contents</u>	<u>Page</u>
I. Introduction	1
II. The Tax Structure	3
III. World Equilibrium	7
IV. Revenue-Neutral Tax Reforms	8
1. Revenue-neutral conversion from income to consumption taxes	9
2. Revenue-neutral conversion from consumption to income taxes	13
V. Foreign Direct Investment	14
1. Tax according to source of income	17
2. Tax according to origin of tax payer	18
VI. Concluding Remarks	18
Appendices	
I. Variable Labor Supply	21
II. Income Tax with Delayed Expensing of Investment	24
Tables	
1. The Effects of Revenue-Neutral Shifts Between Consumption and Income Taxes	15
Figures	
1. Relative Demands, Relative Supplies and World Equilibrium	8a
2. The Effects of a Revenue-Neutral Tax Shift from Income Taxes to Consumption Taxes with an Initial-Period Domestic Trade- Balance Deficit	10a
3. World Equilibrium with an Integrated Market for Investment Capital	16a
References	26

Summary

This paper highlights the significance of open-economy considerations in the analysis of tax reforms. It focuses on domestic and international consequences of revenue-neutral conversions between income and value-added tax systems.

The principal conclusion of this investigation is that the direction of changes in the world rate of interest, the domestic tax-adjusted rate of interest, domestic and foreign investment, growth rates of consumption, and other key macroeconomic variables consequent on revenue-neutral tax reforms depend on whether the country adopting the tax reform runs a surplus or a deficit in the current account of its balance of payments. For example, a conversion from an income to a value-added tax system lowers the world rate of interest if the country adopting the reform runs a surplus in the current account of its balance of payments, but raises the world rate of interest if *its current account is in a deficit*.

The paper also examines the implications of such reforms in the presence of direct foreign investment and considers alternative specifications of tax treatments, one based on the source of income, and the other on the country of residence of the taxpayer. It demonstrates the robustness of the key propositions to these alternatives.



## I. Introduction

This paper, presented as the Harry G. Johnson Lecture, focuses on international dimensions of tax policies. One of the main themes appearing in Johnson's voluminous writings is the notion that in general, in view of the significant interdependencies in the world economy, a proper analysis of economic policies should be carried out within a global open-economy framework. <sup>1/</sup> For example, in the context of monetary matters, Johnson (1972, p. 11) stated that:

"I have become increasingly impressed in recent years with the conviction that the traditional division between closed-economy and open-economy theory is a barrier to clear thought, and that domestic monetary phenomena for most of the countries with which economists are concerned can only be understood in an international monetary context".

This paper applies Johnson's open-economy theme to the analysis of tax reforms. Such analysis has typically been carried out in a closed-economy framework and in what follows we attempt to highlight key considerations stemming from the open-economy perspective.

Recent years have witnessed a growing interest in the introduction of such reforms. In many countries, the impetus to tax restructuring has come from the realization that the prevailing tax structures have introduced significant distortions into the saving and investment decisions of household and firms as well as into the decisions governing labor supply and demand. Tax reforms have incorporated a wide variety of proposals. A key feature of many of them is a proposed change in the composition of the tax base from income to consumption (or, equivalently, value-added tax under which investment and exports are exempt). The move towards value-added taxes (VAT) is now widespread and has been stimulated especially by the decision in the United Kingdom in 1979 to nearly double its VAT rate. Such a move has subsequently been put on the tax-reform agenda of other countries, including Australia, Canada, Greece, Japan, New Zealand, Portugal, Spain, and Turkey. <sup>2/</sup>

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<sup>1/</sup> Harry G. Johnson's writings span the entire range of the economics discipline: from the history of economic doctrines, to public economics, trade theory, closed and open-economy macroeconomics, economic development, and policies and issues of political economy. An evaluation of Johnson's contribution is contained in Frenkel (1987) and a complete bibliography of his extensive writings appears in Longawa (1984).

<sup>2/</sup> For a recent comparative analysis of the tax systems in several European countries, Canada and Japan, see Pechman (1987), and for a discussion of recent tax reforms see Tanzi (1987).

Much of the recent research of the economic consequences of tax reforms has been conducted in a closed-economy framework. <sup>1/</sup> It has abstracted therefore from important issues that arise in the interdependent world economy. The increased integration of the world capital market has raised the extent by which tax policies in individual countries influence, and are influenced by, the rest of the world. To capture this feature and to fill a gap in the analytical literature we propose an analytical framework extending the closed-economy analysis to a two-country model of the world economy in which capital markets are fully integrated. In this framework the world capital market provides the key channel through which the effects of tax policies undertaken in one country are transmitted to the rest of the world.

The open-economy perspective to the analysis of tax policies enables a treatment of questions and issues that could not have been dealt with in a closed-economy framework. Furthermore, open-economy considerations lead to significant modifications of propositions derived previously in a closed economy model. <sup>2/</sup> The key result of this paper is that the domestic and international consequences of tax reforms characterized by revenue-neutral conversions from income to consumption taxes depend critically on the trade-balance position. The fundamental determinants of this trade-balance position include inter-country differences in saving propensities, investment opportunities, and the pattern of government spending. In this context, we distinguish between a pro-borrowing tax reform as the one which stimulates current external borrowing (national dissaving) and a pro-lending tax reform as the one which stimulates current external lending (national saving). We show that if the country which introduces the revenue-neutral conversion between income and consumption taxes runs a trade balance surplus, then the reform is pro-lending. Under such circumstances, tax conversions of this type lower the world rate of interest. On the other hand, if the economy runs a trade-balance deficit, then such tax reforms are pro-borrowing and result in a higher world rate of interest. This result is used to determine the implications of tax reforms for domestic and foreign capital formation and growth rates of consumption.

In section II we specify the tax structure and develop the analytical framework suitable for the analysis of tax conversions. In section III we present a simple general equilibrium model of a two-country world economy and develop the diagrammatic apparatus that is used in the subsequent analysis. Section IV which contains the main

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<sup>1/</sup> Examples are Boskin (1978), Bradford (1984, 1986), Hall and Rabushka (1983), and King (1987). Examples of dynamic general-equilibrium models of a closed economy are contained in Brock and Turnovsky (1981) and Judd (1987a, 1987b). A comprehensive closed-economy treatment is contained in Auerbach and Kotlikoff (1987).

<sup>2/</sup> Recent examples of the analysis of tax policies in open economies are Bovenberg (1986), Frenkel and Razin (1986, 1987, 1988) and Gordon (1986).

results of the paper is devoted to the analysis of revenue-neutral tax reforms involving income and consumption tax systems. Section V extends the analysis to a world economy in which foreign direct investment is allowed for. Section VI contains concluding remarks. The two appendices following the main text deal with variable labor supply and with alternative assumptions concerning the expensing of investment under the income-tax system.

## II. The Tax Structure

To set the stage for the analysis of revenue-neutral tax reform, we choose to represent the tax system by four types of taxes: consumption tax, income tax, international borrowing tax, and interest earnings tax. These four types of taxes are chosen because of their unique effects on spending and saving behavior. We specify the various taxes in their pure form in order to highlight the key economic mechanisms governing their effects. We thus abstract from many details present in actual tax systems.

Consider a two-period model of a nonmonetary open economy producing and consuming one aggregate tradable good. The aggregation of goods into a single aggregate commodity and the abstraction from money are done in order to focus attention on intertemporal trade, that is, on international borrowing and lending. The economy is assumed to be endowed with an initial sequence of endowments,  $\bar{Y}_0$  and  $\bar{Y}_1$  where the subscripts zero and one designate the corresponding periods. The initial endowment may be consumed or, alternatively, it may be invested in intertemporal production process. Such an investment process modifies the intertemporal pattern of available outputs (GDP). Formally, output in period one,  $Y_1$ , is linked to the initial endowments through  $Y_1 = \bar{Y}_1 + F(I_0)$  where  $I_0$  denotes investment in period zero. The function  $F(I_0)$ , which transforms current investment into future output, exhibits positive, and diminishing returns. To simplify, we assume that labor supply is inelastic. <sup>1/</sup>

In this two-period model, the private sector's budget constraints are:

$$(1) \quad (1+\tau_{c0})C_0 = (1-\tau_{y0})(\bar{Y}_0 - I_0) - (1-\tau_{r0})r_{-1}B_{-1}^p + (1-\tau_{b0})(B_0^p - B_{-1}^p)$$

$$(2) \quad (1+\tau_{c1})C_1 = (1-\tau_{y1})(\bar{Y}_1 + F(I_0)) - (1-\tau_{r1})r_0B_0^p - (1-\tau_{b1})B_0^p$$

In equations (1)-(2),  $C_0$  and  $C_1$  denote first and second-period consumption,  $B_t^p$  ( $t=-1,0$ ) denotes period  $t$  borrowing (which could be positive or

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<sup>1/</sup> This assumption which is relaxed in Appendix I does not alter the qualitative results.

negative),  $I_0$  measures the losses of firms (negative dividends) corresponding to initial investment,  $F(I_0)$  measures second period dividends,  $r_t$  ( $t=-1,0$ ) denotes the world rate of interest in period  $t$ , and  $\tau_{ct}$ ,  $\tau_{yt}$ ,  $\tau_{rt}$ , and  $\tau_{bt}$  ( $t=0,1$ ) denote, respectively, the ad-valorem tax rates in period  $t$  on consumption, income, interest earnings, and new international borrowing. In this two-period model, the solvency requirement ensures that in the second period the private sector settles all debt commitments and does not incur new debt.

In equation (1), the consumption tax base is  $C_0$  and its coefficient indicates that the unit cost of consumption is one plus the corresponding ad-valorem consumption tax. This consumption tax is equivalent to a value-added tax system (VAT) under which investment and exports are exempt. The income tax base is  $(\bar{Y}_0 - I_0)$  and its coefficient is one minus the corresponding ad-valorem income tax, reflecting taxes on income from labor and existing capital ( $\bar{Y}_0$ ) and a tax rebate on negative income from current investment. This tax is a cash-flow income tax with full expensing of investment. <sup>1/</sup> The interest earnings tax base is  $r_{-1}^b B_{-1}$  and its coefficient is one minus the ad-valorem interest earnings tax. The international borrowing tax base  $(B_0^p - B_{-1}^p)$ , corresponds to the amount of new private sector net borrowing as reflected in changes in its external debt position. Its coefficient is one minus the ad-valorem international borrowing tax. <sup>2/</sup> An analogous interpretation applies to the second budget constraint in equation (2). We note that in the second (final) period there is negative new net borrowing (since past debt is repaid and no new debt is issued); therefore, the term  $\tau_{b1} B_0^p$  corresponds to a tax rebate.

As is evident from the formulation of equations (1)-(2), the four taxes are linked through an equivalence relation. This equivalency implies that the effect on the real equilibrium of any combination of the four taxes can be duplicated by a policy consisting of any three of them. Our formulation reveals that, although in a closed-economy context consumption and income taxes are equivalent, they do not remain equivalent if the economy is open to international trade, in which case an international borrowing tax must be added. The equivalence relation implies that the entire spectrum of tax systems can be spanned by these

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<sup>1/</sup> This treatment of expensing of capital outlays is modified in Appendix II in which we consider the other extreme case under which capital outlays are expensed in the final period. The issue of the timing of such expensing becomes less relevant for our analysis the higher is the share of labor income in the income-tax base.

<sup>2/</sup> As is evident, if  $\tau_{rt} = \tau_{bt}$ , then the tax base for international borrowing tax is broadened to include debt service, while if  $\tau_{rt} = \tau_{yt}$  then the tax base for income tax is broadened to include interest earnings.

four types of taxes. This property provides the rationale for our choice of the specific tax structure used in this paper. 1/

With these taxes, the periodic budget constraints of the government are:

$$(3) \quad G_0 = B_0^g + \tau_{c0}C_0 + \tau_{y0}(\bar{Y}_0 - I_0) - \tau_{r0}r_{-1}B_{-1}^p + \tau_{b0}(B_0^p - B_{-1}^p) - (1+r_{-1})B_{-1}^g$$

$$(4) \quad G_1 = \tau_{c1}C_1 + \tau_{y1}(\bar{Y}_1 + F(I_0)) - \tau_{r1}r_0B_0^p - \tau_{b1}B_0^p - (1+r_0)B_0^g$$

where  $G_t$  ( $t=0,1$ ) denotes government purchases in period  $t$  and where  $B_t^g$  ( $t=-1,0$ ) denotes government borrowing in period  $t$ . Analogously to the private sector, solvency requires that, in the second period, the government settles all debt commitments and does not incur new debt. In this formulation we have implicitly assumed that aside from domestically imposed taxes, the private-sector and the government can borrow at the same rate of interest in the world capital market. We also note that, in conformity with the national income identities, in each period, the difference between aggregate absorption and GNP equals the net accumulation of external debt (the sum of private and public-sector debts); this can be verified by adding, for each period, the private sector's and the government budget constraints. 2/

The private sector seeks to maximize life-time utility subject to the consolidated life-time budget constraint, obtained from the periodic budget constraints. Accordingly, adding equation (2), multiplied by  $(1-\tau_{b0})/((1-\tau_{r1})r_0 + 1-\tau_{b1})$  to equation (1) and dividing the resulting equation by  $(1+\tau_{c0})$  yields

$$(5) \quad C_0 + \alpha_c C_1 = \frac{(1-\tau_{y0})}{(1+\tau_{c0})} [\alpha_I(\bar{Y}_1 + F(I_0)) + (\bar{Y}_0 - I_0)] \\ - \frac{(1-\tau_{r0})r_{-1} + (1-\tau_{b0})}{(1+\tau_{c0})} B_{-1}^p$$

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1/ Analogous equivalence relationships in the international-trade literature apply to the equivalence between domestic tax cum subsidies and trade taxes and between export and import taxes, known as the Lerner's Symmetry (Lerner (1936)).

2/ It is noteworthy that according to the specification in equations (1) through (4), the government does not sell bonds to the domestic private sector. As shown in Frenkel and Razin (1988) this simplifying assumption does not affect the analysis.

where

$$\alpha_c = \frac{(1+\tau_{c1})(1-\tau_{b0})}{(1+\tau_{c0})((1-\tau_{r1})r_0 + (1-\tau_{b1}))}, \quad \alpha_I = \frac{(1-\tau_{y1})(1-\tau_{b0})}{(1-\tau_{y0})((1-\tau_{r1})r_0 + (1-\tau_{b1}))}.$$

Equation (5) is the consolidated private-sector budget constraint which incorporates the role of taxes. The key point to emphasize is that the discount factors applicable to the quantities pertaining to the future period (period one) are the tax-inclusive discount factors. <sup>1/</sup> These are the effective discount factors relevant for private-sector decisions. Accordingly,  $\alpha_c$  measures the effective intertemporal price of  $C_1$  in terms of  $C_0$ . This price reflects the prevailing tax structure. It is governed by the time profiles of the consumption tax (reflected by the ratio  $(1+\tau_{c1})/(1+\tau_{c0})$ ) and of the interest earnings and international borrowing taxes reflected by the ratio  $(1-\tau_{b0})/((1-\tau_{r1})r_0 + (1-\tau_{b1}))$ . Analogously,  $\alpha_I$  measures the effective intertemporal price of future output in terms of current output from the perspective of the firm, thus it corresponds to Tobin's Q governing investment decisions. <sup>2/</sup> This effective discount factor reflects the time pattern of the taxes on income, international borrowing, and interest earnings. In comparing the two effective discount factors  $\alpha_c$  and  $\alpha_I$  we note that  $\alpha_c$  does not depend on the taxes on income, and  $\alpha_I$  does not depend on the taxes on consumption.

Finally, we note that if the time profile of any given tax is flat (so that  $\tau_{c0}=\tau_{c1}$  or  $\tau_{y0}=\tau_{y1}$  or  $\tau_{b0}=(\tau_{b1}+r_0\tau_{r1})/(1+r_0)$ ), then this tax is nondistortionary and its impact is similar to that of a lump-sum tax. In this formulation, the "flatness" of the international borrowing tax is expressed in terms of present value, adjusted for the tax on the debt service. <sup>3/</sup> This convenient property which will be used in the subsequent analysis underlies our choice of the cash-flow formulation of the income tax.

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<sup>1/</sup> If the time horizon is extended beyond the two-period framework, then these discount factors are replaced by the corresponding present-value factors. The general principles of our intertemporal analysis are, of course, applicable to such an extension.

<sup>2/</sup> It is shown in Appendix I that with variable labor supply, the same effective discount factor governs the intertemporal allocation of labor supply. It is also shown in Appendix II that in the absence of full expensing of investment outlays the effective discount factor governing investment is modified though the corresponding discount factor governing labor supply remains intact.

<sup>3/</sup> Alternatively, the "flatness" means that the initial-period international-borrowing tax rate is a weighted average of the subsequent-period international borrowing and interest earnings tax rates, where the weights are  $1/(1+r_0)$  and  $r_0/(1+r_0)$ , respectively.

### III. World Equilibrium

In this section we develop a simple general-equilibrium model of a two-country world economy. To facilitate the exposition we assume that initially all taxes, government spending, and the historically given initial debt commitments are all zero. Thus, in terms of equation (5), the domestic discount factors governing consumption and investment decisions,  $\alpha_c$  and  $\alpha_I$ , respectively are initially equal to the world discount factor  $\alpha = 1/(1+r_0)$ . These assumptions imply that the discounted sum of the economy's trade balances must be zero. That is,

$$(6) \quad [(C_0 + I_0) - \bar{Y}_0] + \frac{1}{1+r_0} [C_1 - (\bar{Y}_1 + F(I_0))] = 0$$

It follows that under such circumstances, an initial trade balance deficit must be followed by a subsequent trade balance surplus and vice versa.

In what follows, we carry out the analysis by means of a simple diagrammatic apparatus. The initial equilibrium is portrayed in Figure 1 in which the upward sloping schedule,  $S^W$ , describes the ratio,  $z$ , of current to future world GDP net of investment, as an increasing function of the rate of interest. Formally, the world relative supply (evaluated at  $r=r_0$ ) is

$$(7) \quad z^W = \frac{\bar{Y}_0 - I_0(r_0) + \bar{Y}_0^* - I_0^*(r_0)}{\bar{Y}_1 + F[I_0(r_0)] + \bar{Y}_1^* + F[I_0^*(r_0)]}$$

The positive dependence of  $z$  on the rate of interest reflects the fact that investment falls when the rate of interest rises. The world relative supply schedule,  $S^W$ , is a weighted average of the domestic country's relative supply schedule,  $S$  (where  $S = [\bar{Y}_0 - I_0(r)]/[\bar{Y}_1 + F[I_0(r)]]$ ) and the foreign country's relative supply schedule,  $S^*$ , (where

$$S^* = [\bar{Y}_0^* - I_0^*(r)]/[\bar{Y}_1^* + F[I_0^*(r)]]).$$

$$(8) \quad S^W = \mu_S S + (1-\mu_S)S^*$$

where the domestic country's weight is:

$$(9) \quad \mu_S = \frac{\bar{Y}_1 + F[I_0(r)]}{\bar{Y}_1 + F[I_0(r)] + \bar{Y}_1^* + F[I_0^*(r)]}$$

The downward sloping schedules in Figure 1 plot the desired ratio of current to future consumption as a decreasing function of the rate of interest. These schedules embody the simplifying assumption that the utility functions are homothetic. The domestic and foreign relative demands are denoted by  $D$  and  $D^*$ , respectively, and their values at the

point in which  $C_0/C_1 = C_0^*/C_1^* = 1$  indicate, respectively one plus the subjective rates of time preference,  $1+\rho$  and  $1+\rho^*$ . The elasticities of the relative-demand schedules are the corresponding intertemporal elasticities of substitution in consumption. Analogously to the construction of the world relative supply, the world relative demand  $D^W = C_0^W/C_1^W = (C_0 + C_0^*)/(C_1 + C_1^*)$ , is a weighted average of the two countries' relative demands,  $D = C_0/C_1$  and  $D^* = C_0^*/C_1^*$ . Accordingly,

$$(10) \quad D^W = \mu_d D + (1-\mu_d) D^*$$

where the domestic country's weight is

$$(11) \quad \mu_d = \frac{C_1}{C_1 + C_1^*}.$$

The initial equilibrium is exhibited by point A in Figure 1. As shown, the world rate of interest is  $r_0$  and the world consumption ratio (indicating the reciprocal of the growth rate of world consumption) is  $C_0^W/C_1^W$ . The domestic and foreign consumption ratios corresponding to this equilibrium are  $C_0/C_1$  and  $C_0^*/C_1^*$ , as indicated by points B and C, respectively. We also note that the domestic and foreign relative supplies associated with this equilibrium are  $z$  and  $z^*$  as indicated by points D and E, respectively. As is evident, these levels of relative supplies are associated with the equilibrium levels of domestic and foreign investment. Finally, since point B lies to the right of point D, while point C lies to the left of point E, the domestic economy runs an initial period trade balance deficit while the foreign economy runs a corresponding trade balance surplus. This pattern of trade imbalances is implied from the assumed zero level of the predetermined initial debt position. As indicated by equation (6), this configuration of trade imbalances is reversed in the subsequent period. We also note that this pattern of trade imbalances implies that the equilibrium domestic relative demand weight,  $\mu_d$ , falls short of the corresponding relative supply weight,  $\mu_s$ . <sup>1/</sup>

#### IV. Revenue-Neutral Tax Reforms

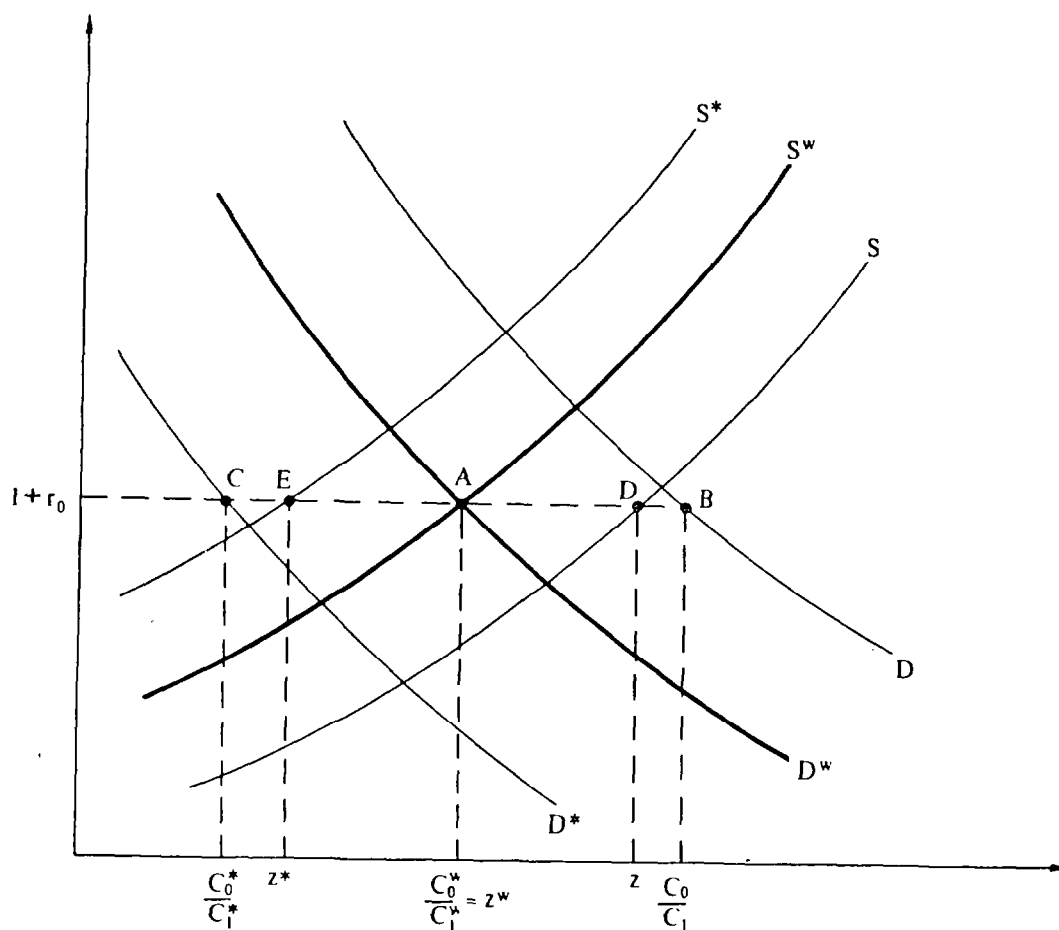
In this section, we prepare the analytical groundwork suitable for the analysis of revenue-neutral tax reforms. Such reforms are characterized by a change in the composition of a given tax revenue among

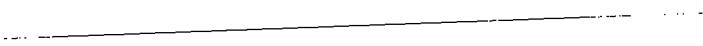
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<sup>1/</sup> This follows from the fact that in equilibrium the denominators of  $\mu_s$  and  $\mu_d$  are equal to each other. Thus, if the domestic economy runs a trade surplus in the second period (so that  $C_1 < Y_1 + F(I_0)$ ) then  $\mu_d < \mu_s$ .

FIGURE 1

# RELATIVE DEMANDS, RELATIVE SUPPLIES AND WORLD EQUILIBRIUM





different tax bases. It is obtained through alterations in the various tax rates designed to keep total tax revenue in each period intact. This specification ensures that the requirement of revenue neutrality is conceptually distinct from the government solvency constraint. If such a period-by-period neutrality requirement was not imposed then, as long as government outlays are fixed, the government solvency constraint would only necessitate that the various tax rates are adjusted so as to keep the discounted sum of government revenue intact. Under such circumstances, tax-rate changes result in periods with budget deficits being offset by corresponding budget surpluses (of equal present value) in other periods. 1/

We focus on the implications of tax policies on the saving-investment balance, on the world rate of interest and on other key macroeconomic variables in the world economy. To isolate the main factors governing the consequences of such revenue-neutral tax reforms, we consider a reform that replaces one tax system by another while maintaining all other taxes intact. The tax reform can be thought of as consisting of two components. First, it involves a permanent reduction of a prevailing tax and a permanent equiproportional rise of another tax. Second, it involves further adjustments in the newly introduced tax aimed at restoring the initial level of tax revenue in each period. Evidently under such circumstances the first component of the reform does not alter the effective discount factors governing intertemporal decisions concerning consumption, investment and labor supply. As a result the dynamic characteristics of the real equilibrium remain intact. However, with trade imbalances, this intertemporally-neutral change in the tax structure creates periodic governmental budgetary imbalances. To ensure revenue neutrality the second component of the reform introduces further tax adjustments. To simplify we henceforth assume that the historically given initial debt commitment as well as government spending are zero, and that initially all tax rates are also zero. Throughout the analysis we focus on tax reforms involving conversions between income and consumption tax systems. 2/

#### 1. Revenue-neutral conversion from income to consumption taxes

Consider a revenue-neutral tax reform that substitutes a consumption-tax system for an income-tax system. The introduction of permanent consumption taxes at the rate  $\tau_c$  accompanied by the

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1/ For an analysis of the effects of budget deficits arising from intertemporal tax shifts, see Frenkel and Razin (1988).

2/ For simplicity we focus on income tax on non-interest earnings though our analysis can be easily extended to deal with taxes on interest income. To conserve space we do not consider reforms involving an international-borrowing tax system. For an analysis of such a system see Frenkel and Razin (1987, 1988).

equiproportional reduction in income taxes alter the periodic government tax revenue,  $T_t$ , by

$$(12) \quad T_0 = \tau_c (C_0 - \bar{Y}_0 + I_0)$$

$$(13) \quad T_1 = \tau_c (C_1 - \bar{Y}_1 - F(I_0)).$$

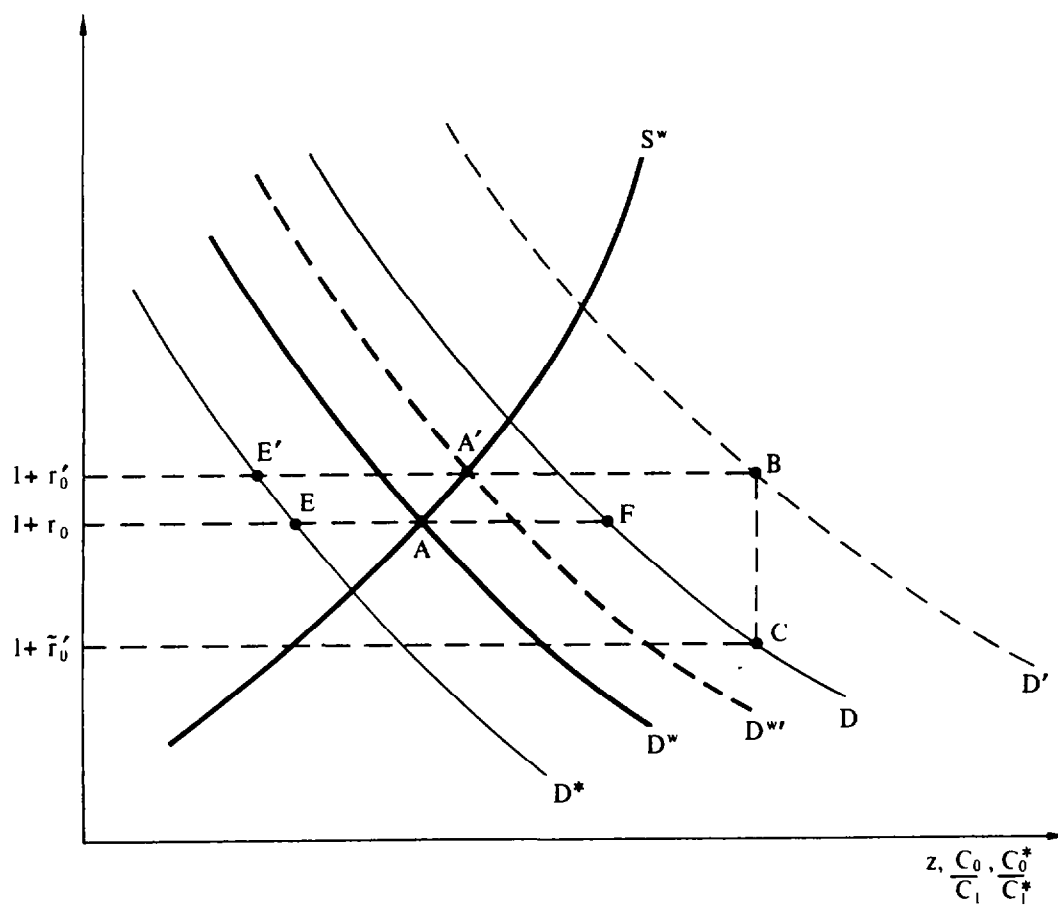
As formulated, the periodic tax revenue is the product of the ad-valorem consumption-tax rate and the economy's trade balance position. Since the discounted sum of the trade balances is zero (see equation (6)) it follows that the discounted sum of the tax revenues is also zero and thus government solvency remains intact. However, this tax shift is not revenue neutral if there are trade imbalances. As is evident from equation (12) this tax shift creates a current-period government budget surplus if the domestic economy runs a current-period trade-balance deficit and vice versa. Obviously, as indicated by equation (13) this pattern of budgetary and trade imbalances is reversed in the subsequent period. The second component of the tax reform aims at restoring revenue neutrality in each period. Since the economy has adopted a consumption tax system, it is assumed that the restoration of revenue neutrality is achieved through appropriate further adjustments in the consumption tax rates.

Suppose that the domestic economy runs an initial-period trade-balance deficit. Under such circumstances the first component of the tax reform results in an initial-period government budget surplus and in a corresponding future-period deficit. To restore revenue neutrality the current-period consumption tax rate,  $\tau_{c0}$ , must be lowered while the corresponding future-period rate  $\tau_{c1}$ , must be raised. This pattern of tax rates, breaks the flatness of the time profile of the consumption tax so that  $\tau_{c0} < \tau_{c1}$ . The new configuration of the consumption tax rates raises  $\alpha$  --the effective discount factor applicable to consumption decisions--so that  $\alpha_c = [(1+\tau_{c1})/(1+\tau_{c0})]\alpha$  exceeds the world discount factor  $\alpha = 1/(1+r_0)$ . Since income taxes remain flat, the effective discount factor applicable to investment decisions remains intact, so that  $\alpha_I = \alpha$ .

Armed with this information we analyze in Figure 2 the effects of this tax reform. The initial equilibrium is portrayed by point A at which the world rate of interest is  $r_0$  (as in Figure 1). The rise in the effective discount factor applicable to consumption (that is, the reduction in the corresponding effective rate of interest) induces an intertemporal substitution in domestic demand towards current-period consumption. Thus, for each and every value of the world rate of interest, the domestic (relative) demand schedule shifts to the right from D to D'. The proportional vertical displacement of the schedule equals the proportional tax-induced rise in the effective discount factor. This proportion is  $(1+\tau_{c1})/(1+\tau_{c0})$ . Associated with the new levels of domestic demand, the new world relative demand  $(C_0+C_0^*)/(C_1+C_1^*)$

FIGURE 2

THE EFFECTS OF A REVENUE-NEUTRAL TAX SHIFT  
FROM INCOME TAXES TO CONSUMPTION TAXES  
WITH AN INITIAL-PERIOD DOMESTIC  
TRADE-BALANCE DEFICIT





also shifts to the right from  $D^W$  to  $D^{W'}$  in Figure 2. This shift reflects the substitution from future to current-period consumption in the domestic economy. <sup>1/</sup> Furthermore, the proportional displacement of the world relative demand schedule is smaller than the corresponding displacement of the domestic relative demand schedule. <sup>2/</sup>

In contrast with the effects of the tax reforms on the relative demand schedules, this reform, which does not affect the effective discount factor applicable to investment decisions, leaves the world relative supply schedule intact. The new equilibrium obtains at the intersection of the (unchanged) world relative supply schedule,  $S^W$ , and the new world relative demand schedule,  $D^{W'}$ . This equilibrium is indicated by point, A' in Figure 2 at which the world rate of interest rises from  $r_0$  to  $r'_0$ .

To determine the incidence of this change on the domestic effective rate of interest, we subtract from  $1+r_0$  the distance BC representing the tax-induced percentage change in the effective discount factor. This yields  $1 + \tilde{r}'_0$  in Figure 2. As is evident  $\tilde{r}'_0$  is lower than the initial world rate  $r_0$  since the vertical displacement of the  $D^W$  schedule is smaller than the magnitude represented by the distance BC.

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<sup>1/</sup> Our assumptions that the initial undistorted equilibrium was with a current-account balance imply that the real-income effects induced by the departure from the flat tax pattern and by changes in the world rate of interest are dominated by the substitution effect.

<sup>2/</sup> To verify this point we note that

$$\hat{D}^W = \frac{C_0}{(C_0 + C_0^*)} \hat{D} + \left[ \frac{C_0}{(C_0 + C_0^*)} - \frac{C_1}{(C_1 + C_1^*)} \right] \hat{C}_1, \text{ where a "hat" denotes a}$$

proportional change in the variable. Accordingly, the proportional change in the world relative demand is composed of two components. The first consists of the product of the proportional change of the domestic relative demand and a fraction (the relative share of current-period home consumption in the world consumption), and the second consists of the product of the proportional change in future-period consumption and a term measuring the difference between the relative shares of current and future-periods home consumption in world consumption. This latter bracketed term reflects the difference between the domestic and foreign saving propensities. If the current period trade-balance deficit arises from a relative low domestic saving propensity, then this bracketed term is positive. We also note that  $C_1$  negative since the change in the time profile of consumption taxes induces a substitution away from future period consumption. It follows that under such circumstances  $\hat{D}^W < \hat{D}$  and, therefore, the displacement of the D schedule exceeds that of the  $D^W$  schedule.

In view of the rise in the world rate of interest, both domestic and foreign investment fall, and the rate of growth of foreign consumption, as indicated by the move from point E to point E' in Figure 2, rises. On the other hand, the fall in the domestic effective rate of interest applicable to consumption lowers the rate of growth of domestic consumption as indicated by the move from point F to point C. Thus, this tax reform crowds out both domestic and foreign investment and results in a negative correlation between the rates of growth of domestic and foreign consumption.

The foregoing analysis assumed that the country introducing the tax reform runs an initial-period trade-balance deficit. If on the other hand the initial trade account position was that of a surplus then, as implied by equations (12) and (13) the first component of the tax reform which maintains the real equilibrium intact, results in a current-period government budget deficit and in a corresponding surplus in the future period. To restore the initial levels of tax revenue, the second component of the tax reform consists of a further rise in the current-period tax rate  $\tau_{c0}$  and in a reduction of the future tax rate  $\tau_{c1}$ . This change in the time profile of consumption taxes lowers the effective discount factor applicable to consumption decisions and induces an intertemporal substitution in domestic demand towards future-period consumption. Accordingly the domestic and the world relative demand schedules shift to the left. 1/ An analogous analysis to the one underlying Figure 2 shows that in that case the world rate of interest falls and the domestic effective rate of interest applicable to consumption rises. As a result, in contrast with the situation in which the initial trade-balance position was in deficit, in the presence of an initial surplus in the balance of trade the tax reform crowds in both domestic and foreign investment, lowers the rate of growth of foreign consumption while raising the growth rate of domestic consumption. This analysis underscores the critical importance of the trade-balance position in determining the domestic and international effects of such a tax reform.

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1/ We note that as in the previous case the proportional displacement of the D schedule exceeds that of the  $D^W$  schedule if the initial-period trade balance surplus arises from a domestic saving propensity that is relatively higher than the foreign propensity so that  $C_1/C_0$  exceeds  $(C_1+C_1^*)/(C_0+C_0^*)$ . This can be verified by observing that in that case

$$(-\hat{D}^W) = \frac{C_1}{C_1+C_1^*} (-\hat{D}) + \left( \frac{C_1}{C_1+C_1^*} - \frac{C_0}{C_0+C_0^*} \right) \hat{C}_0.$$

As is evident, the proportional change in  $D^W$  (in absolute value) is equal to a fraction times the proportional change in D (in absolute value) plus a negative term (since  $\hat{C}_0 < 0$ ), so that  $(-)\hat{D}^W$  falls short of  $(-)\hat{D}$ .

## 2. Revenue-neutral conversion from consumption to income taxes

Consider now a revenue-neutral tax reform that substitutes an income-tax system for a consumption-tax system. The consequences of this tax policy are not just the opposite to those shown in the preceeding analysis since, as will be seen, the economic mechanisms governing the effects of such a tax reform are fundamentally different.

As in the previous section it is convenient analytically to divide the tax reform into two components. The first consisting of the adoption of permanent income taxes (at the rate  $\tau_y$ ) accompanied by an equiproportional reduction of consumption taxes.<sup>y</sup> This component leaves the real equilibrium of the system intact. With the adoption of an income-tax system, the second component of the reform consists of further adjustments of income taxes necessary to restore revenue neutrality of the government budget in each period. The changes in the periodic tax revenue,  $T_t$ , induced by the first component of the reform are:

$$(14) \quad T_0 = \tau_y (\bar{Y}_0 - I_0 - C_0)$$

$$(15) \quad T_1 = \tau_y (\bar{Y}_1 + F(I_0) - C_1).$$

As before, these changes consist of the product of the ad-valorem tax rate and the corresponding period trade-balance position. Thus, the first component of the tax reform maintains the overall solvency of the government but, in the presence of trade imbalances, it alters the periodic values of government tax revenue. Suppose that the domestic economy runs an initial-period trade-balance surplus. Under such circumstances the first component of the tax reform results in an initial-period government budget surplus and in a corresponding future-period deficit. To restore revenue neutrality the initial-period income tax rate,  $\tau_{y0}$ , must be lowered while the future-period rate,  $\tau_{y1}$ , must be raised. These changes lower the effective discount factor relevant for investment decisions,  $\alpha_I = [(1-\tau_{y1})/(1-\tau_{y0})]\alpha$  and, thereby discourage domestic investment at the prevailing world discount factor. Accordingly, in terms of Figure 1 in which the initial equilibrium is described by point A, the tax policy displaces the domestic relative supply schedule downwards (the proportional displacement is equal to  $(1-\tau_{y1})/(1-\tau_{y0})$  which measures the percentage change in  $\alpha_I$ ). The proportional downward displacement of the world relative supply schedule is smaller than the corresponding displacement of the domestic relative supply schedule.

The new equilibrium obtains at the intersection of the (unchanged) world relative demand schedule and the new world relative-supply schedule. Accordingly, the world rate of interest falls and the effective interest rate applicable to domestic investment rises.

It can be verified that if the domestic economy runs an initial trade-balance surplus the tax reform crowds out domestic investment and crowds in foreign investment and lowers the rates of growth of domestic, foreign and world consumption. In contrast, if the domestic economy runs an initial-period trade deficit the tax reform raises the world rate of interest, thereby crowding out foreign investment, while it lowers the domestic effective rate of interest applicable to investment decisions, thereby crowding in domestic investment. The reform also raises the rates of growth of consumption at home and abroad.

The key effects of the revenue-neutral shifts between consumption and income taxes are summarized in Table 1. It is noteworthy that the effects of the tax reform on the world rate of interest and, thereby, on foreign investment and consumption growth depend only on the initial-period trade-balance position and not on whether the tax conversion was *from income to consumption tax or from consumption to income tax*. On the other hand the effects of the reform on the domestic economy depend on both the trade-balance position and the specific nature of the conversion.

#### V. Foreign Direct Investment

Throughout the preceeding analysis we have assumed that in each country capital formation arises from investment decisions of their own residents. The absence of international mobility of capital goods implies that with country-specific income taxes the productivity of investment projects need not be equalized internationally even though the rates of return on financial investment was equalized due to the full integration of world financial capital markets. In this section we extend the formulation by allowing for direct investment abroad. This extension modifies the analysis of the implications of alternative tax policies for the international allocation of investment. <sup>1/</sup>

Once we allow for international mobility of productive capital, the world pool of capital as inputs into the production process is allocated internationally so as to equalize the (tax adjusted) marginal productivities of investment capital across countries. Under such circumstances, the world relative supply schedule,  $S^W$ , reflects the equilibrium international allocation of investment associated with the equality of the (tax adjusted) marginal productivities of investment capital across countries.

The analysis (with zero taxes) is carried out with the aid of Figure 4 which is the counterpart to Figure 1. Panel II of Figure 4 describes the domestic and foreign marginal productivities of investment

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<sup>1/</sup> Similar considerations apply to situations in which labor is internationally mobile.

Table 1. The Effects of Revenue-Neutral Shifts  
Between Consumption and Income Taxes

	$r_0$	$\tilde{r}_0^c$	$\tilde{r}_0^I$	$I_0$	$I_0^*$	$g_c$	$g_c^*$	$g_c^w$
Conversion of Income for Consumption Taxes with initial-period								
Trade deficit	+	-	+	-	-	-	+	-
Trade surplus	-	+	-	+	+	+	-	+
Conversion of Consumption for Income Taxes with initial-period								
Trade deficit	+	+	-	+	-	+	+	+
Trade surplus	-	-	+	-	+	-	-	-

Note:  $r_0$ ,  $\tilde{r}_0^c$  and  $\tilde{r}_0^I$  denote, respectively, the world rate of interest and the domestic effective rates governing consumption and investment decisions.  $I_0$  and  $I_0^*$  denote, respectively, domestic and foreign investment, and  $g_c$ ,  $g_c^*$  and  $g_c^w$  denote, respectively, the domestic, the foreign and the world rates of growth of consumption.

capital,  $F'(I_0)$  and  $F'{}^*(I_0^*)$ , as functions of the corresponding levels of investment. The negative slopes of these schedules reflect the assumption of diminishing marginal productivities. The schedule  $D^W$  portrays the world demand for investment as a negative function of the rate of interest. This schedule is derived as the horizontal sum of the domestic and foreign marginal productivities of investment capital,  $F'(I_0)$  and  $F'{}^*(I_0^*)$ . Panel III portrays the negatively sloped schedule, J, describing the relation between the level of world investment,  $I_0^W$ , and the world relative supply,  $S^W$ . This relation is

$$(16) \quad S^W = \frac{\bar{Y}_0^W - I_0^W}{\bar{Y}_1^W + H(I_0^W)} \quad \text{where}$$

$$\bar{Y}_0^W = \bar{Y}_0 + \bar{Y}_0^*, \quad \bar{Y}_1^W = \bar{Y}_1 + \bar{Y}_1^*, \quad I_0^W = I_0 + I_0^*,$$

$$H(I_0^W) = \text{Max}_{\{I_0, I_0^*\}} F(I_0) + F'{}^*(I_0^*) \text{ subject to } I_0 + I_0^* = I_0^W.$$

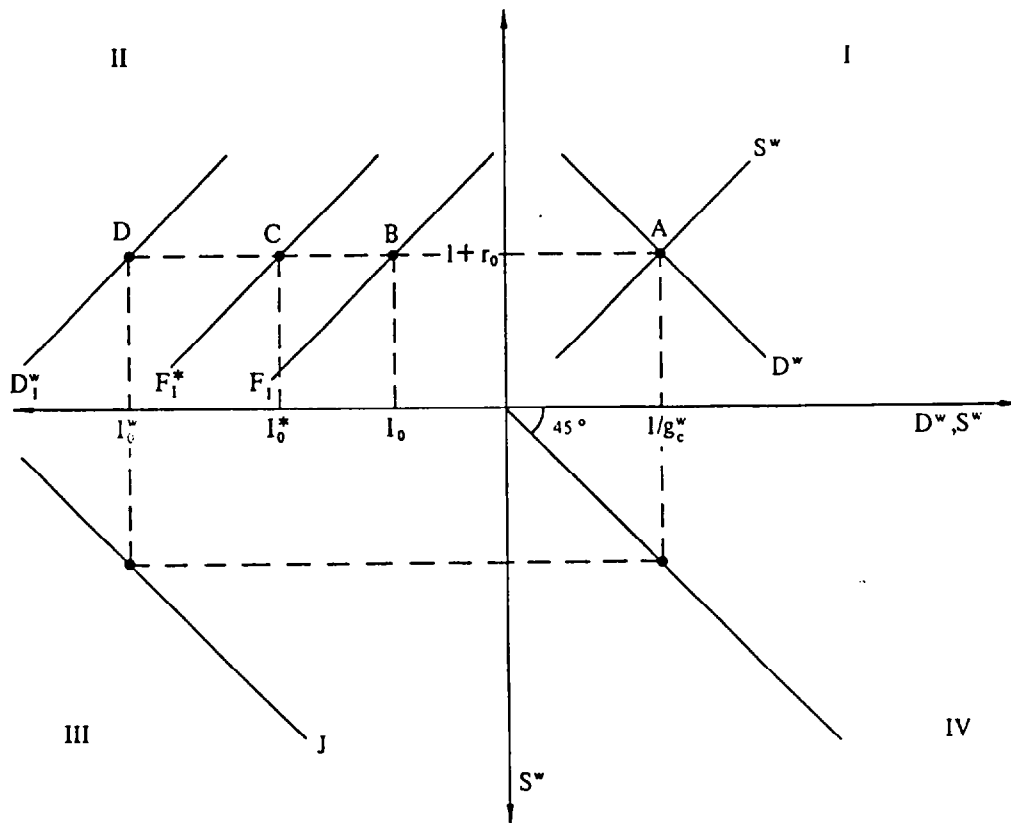
Accordingly, the world relative supply equals to the ratio of the current-period world GDP net of investment to the future-period maximized value of world GDP where maximization is carried out with respect to the international allocation of world investment. The 45 degree line in Panel IV transforms this information to Panel I. Finally, the positively sloped  $S^W$  schedule in Panel I combines the negative relation between the level of world investment and the rate of interest (from Panel II) and the negative relation between the world relative supply and world investment (in Panel III). Obviously, by construction, the  $S^W$  schedule reflects the consequences of the underlying assumption that the world market for investment capital is fully integrated. Analogously to the analysis in Figure 1, the downward sloping  $D^W$  schedule is the world relative demand.

The initial equilibrium is characterized by points A, B, C and D in Figure 3. Associated with this equilibrium, the world rate of interest is  $r_0$ , the rate of growth of world consumption is  $g_0^W$ , the levels of investment in the domestic and the foreign economies are  $I_0$  and  $I_0^*$ ,

respectively, and their sum is  $I_0^W$ . With the integrated world market for investment capital, investment in each country can be carried out by residents of both the domestic as well as the foreign economies. Finally, the equilibrium rates of growth of domestic and foreign consumption can be read from the individual-countries' relative demand schedules (not drawn) as in Figure 1.

The introduction of taxes into the market modifies the equilibrium in a manner which depends on the specific tax treatment of direct foreign investment. A thorough analysis of this issue is beyond the scope of this paper. In what follows we sketch, however, some

FIGURE 3  
WORLD EQUILIBRIUM WITH AN INTEGRATED  
MARKET FOR INVESTMENT CAPITAL





implications of two simple specifications of tax treatments, (according to the source of income and the origin of the tax payer) which span a spectrum of alternative real-world treatments.

#### V.1. Tax According to Source of Income

Consider first an international tax arrangement by which investors pay taxes on their total income (including earning on foreign investment) in their country of residence while they are exempt from foreign taxes. Under such circumstances the effective discount factors applicable to investment by domestic and foreign residents are

$$(17) \quad \alpha_I = \frac{1-\tau_{y1}}{1-\tau_{y0}} \alpha \quad , \quad \alpha_I^* = \frac{1-\tau_{y1}^*}{1-\tau_{y0}^*} \alpha \quad .$$

Since under the assumed tax treatment the location of investment does not influence the investors' tax liabilities, it follows that in equilibrium the international equalization of the tax-adjusted marginal productivities of investment capital also implies that the unadjusted marginal productivities are also equalized. Accordingly,

$$(18) \quad F'(I_0) = F'^*(I_0^*)$$

Armed with this information consider a revenue-neutral shift from income to consumption taxes. Following a similar procedure as in the previous sections we recall that the first component of the reform, consisting of a permanent equiproportional replacement of income by consumption taxes, leaves the real equilibrium intact. This component of the reform alters the periodic government tax revenue by

$$(19) \quad T_0 = \tau_c (C_0 - \bar{Y}_0 - I_{H0} + I_{F0})$$

$$(20) \quad T_1 = \tau_c (C_1 - (\bar{Y}_1 + F(I_0))) + F'^*(I_0^*)I_{F0} - F'_I(I_0)I_{H0}^*$$

Where  $I_{H0}$  and  $I_{F0}$  denotes the levels of domestic residents' investment at home and abroad, respectively, and  $I_{H0}^*$  denotes the level of foreign residents' investment in the home country. Accordingly total investment in the home country is  $I_0 = I_{H0} + I_{H0}^*$  and total investment in the foreign country is  $I_0^* = I_{F0} + I_{F0}^*$  where  $I_{F0}^*$  denotes foreign residents' investment in their own country. As is evident the budgetary imbalances arising from the first component of the tax reform depends on the imbalances in the (non-interest) current account positions. The second component of the reform, consisting of further adjustment of the consumption taxes so as to restore revenue neutrality, alters the relative demand schedule in Figure 4 in a manner identical to the one analyzed in Figure 2 of Section IV.1 while leaving the relative supply

schedule intact. Evidently, the direction of the change in the key economic variables is the same as indicated in the top panel of Table 1.

If the reform substitutes income for consumption taxes then, as before, the first component of the reform leaves the real equilibrium intact while the second component, designed to correct the budgetary imbalances through further adjustments of income taxes, alter the real equilibrium through changes in the effective discount factor governing investment by domestic residents. In analogy to the results shown in the bottom panel of Table 1, the qualitative effects of the reform on the key economic variables depend on the initial-period (non-interest) current-account position. The main difference, however, is that in the present case the levels of investment in the domestic and the foreign economies are positively correlated. This positive correlation reflects the assumed tax arrangement by which tax liabilities do not depend on the location of investment.

## V.2. Tax According to Origin of Tax Payer

Consider next an international tax arrangement by which the investors' tax liabilities depend only on the location of investment and not on their country of residence. In that case the effective discount factors,  $\alpha_{HI}$  and  $\alpha_{FI}$  applicable to investment in the domestic and the foreign countries, respectively, are:

$$(21) \quad \alpha_{HI} = \frac{1 - \tau_{y1}}{1 - \tau_{y0}} \alpha, \quad \alpha_{FI} = \frac{1 - \tau_{y1}^*}{1 - \tau_{y0}^*} \alpha.$$

The international equalization of the tax-adjusted marginal productivities implies that

$$(22) \quad \alpha_{HI} F'(I_0) = \alpha_{FI} F'^*(I_0^*).$$

Evidently, this formulation of the tax treatment does not alter the analysis of a shift between income to consumption taxes but it impacts on the analysis of the effects of a shift from consumption to income taxes. The main difference is that the levels of domestic and foreign investment are negatively correlated. This negative correlation reflects the assumed tax arrangement by which the investors' tax liabilities depend only on the location of investment. In this respect the results of the tax reform under this tax arrangement resemble those shown in Table 1 for the case of no direct foreign investment.

## VI. Concluding Remarks

This paper highlights the significance of open-economy considerations in the analysis of tax reforms. When the open-economy considerations are ignored then under some conditions, income and consumption taxes are known to be equivalent in the sense that the

economic effects of each one can be replicated by the other. Obviously, under such conditions shifts between income and consumption tax systems are irrelevant. This equivalence between the two tax systems breaks down once one allows for discrepancies between national income and national spending, as permitted by international borrowing and lending. Accordingly for the open economy the tax systems are linked through another equivalence relation involving four tax systems: income tax, consumption tax, international borrowing tax and external interest-earning tax.

In this paper we analyzed the domestic and international consequences of tax reforms associated with shifts between income and consumption tax systems. Since such tax reforms involve only two of the four tax systems connected through the equivalence relationship, their effects on the economic system are not neutral. The paper identifies the key factors, mechanisms and channels through which such tax reforms exert their effect.

The principal result is that the direction of the changes in interest rates, domestic and foreign investment, growth rates of consumption and other key macroeconomic variables consequent on revenue-neutral tax reforms depends critically on the economy's current-account position. It is shown that for any given configuration of current-account imbalances the international consequences of tax reforms are independent of whether the reform replaces consumption tax for income-tax systems or vice versa. On the other hand, the implications for the domestic economy depend critically on whether the tax reform replaces a consumption-tax system for an income-tax system or, conversely, whether the reform replaces an income for consumption tax systems.

We cast the analysis of tax reform in a manner that sheds light on the domestic and international consequences of budget deficits. Specifically, an implication of our analysis is that under a consumption-tax system a budget deficit lowers the world rate of interest while under an income-tax system the same deficit raises the world rate of interest. 1/

By highlighting the international consequences of domestic tax reforms and by identifying the channels through which the effects of such reforms are transmitted to the rest of the world, our analysis provides a clear rationale for international coordination of tax policies.

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1/ For a detailed analysis of the international effects of budget deficits see Frenkel and Razin (1988). It can also be shown that the effects of tax shifts between an international-borrowing tax system and a consumption tax system also depend critically on the imbalances in current account.

Finally, our analysis of the consequences of tax reforms focused on issues in positive economics. However, being grounded on solid microeconomic foundations, the analytical framework developed in this paper is capable of addressing also normative issues. <sup>1/</sup> Accordingly, extensions of the analysis would evaluate alternative tax systems in terms of their consequent excess burdens associated with distortionary taxes as well as in terms of the inter and intra-generational distribution of welfare associated with the dynamic patterns of tax policies.

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<sup>1/</sup> For a recent normative analysis of excess burdens associated with tax policies in a closed-economy context see Judd (1987a, 1987b) and for a corresponding closed-economy analysis of intergenerational distribution of welfare in a context of a life-cycle model see Summers (1981), Auerbach and Kotlikoff (1983) and Seidman (1984).

### Variable Labor Supply

In this appendix, we extend the stylized model to allow for a variable labor supply. To allow for endogenous labor supply and variable output, we modify the utility function and the production function.

Normalizing total endowment of time in each period  $t$  to unity, let the fraction of time spend on labor be  $l_t$ . Correspondingly, the fraction of time left for leisure is  $1 - l_t$ . We assume that lifetime utility is a function of four "goods:" ordinary consumption ( $C_0, C_1$ ), and leisure consumption ( $1-l_0, 1-l_1$ ). To facilitate the exposition, suppose that the utility function is separable between ordinary consumption and leisure, and let each subutility be homothetic. These assumptions imply that the utility-maximizing ratio of consumption in the two consecutive periods depends only on the rate of interest; likewise, the utility-maximizing ratio of leisure in the two consecutive periods depends only on the ratio of wages (net of tax).

With variable labor supply it is convenient to include in the definition of lifetime spending the imputed spending on leisure. Correspondingly, the definition of wealth includes the imputed value of labor endowment. Thus, the lifetime budget constraint is

$$\begin{aligned}
 (A.1) \quad & C_0 + (1-\tau_{y0})(1-l_0)w_{l0} + \alpha [C_1 + (1-\tau_{y1})(1-l_1)w_{l1}] \\
 & = (1-\tau_{y0})w_{l0} + (1-\tau_{y0})(r_{k0}K_0 - I_0) \\
 & + \alpha \{ (1-\tau_{y1})w_{l1} + (1-\tau_{y1})r_{k1}[K_0 + K(I_0)] \} \\
 & - (1 + r_{-1})B_{-1}^p = W_0,
 \end{aligned}$$

where  $\tau_{yt}$ ,  $w_{lt}$ , and  $r_{kt}$  denote, respectively, the income tax, the wage rate, and the rental rate on capital in period  $t$  ( $t=0,1$ ), and where  $K_0$  denotes the initial endowment of capital. As indicated in (A.1), the individual lifetime (full) income--that is, the individual wealth ( $W_0$ )-- is the discounted sum of the value of time endowment (net of taxes) and of capital income (net of initial debt commitment). Capital income in the current period is the rental on existing capital,  $r_{k0}K_0$ , minus investment,  $I_0$ ; correspondingly (altering somewhat our notation in the text) the stock of capital in the subsequent period is  $K_0 + K(I_0)$ , where the function  $K(I_0)$  reflects cost of adjustments associated with investment.

Maximizing of the utility function subject to the lifetime budget constraint yields the demand functions for ordinary consumption and for leisure in each period. These demand functions depend on the three relative prices (net wages in each of the two periods and the discount factor) and on wealth. Accordingly, the labor supply functions (which are inversely related to the leisure demand functions) can be written as

$$(A.2) \quad l_0 = l_0[(1 - \tau_{y0})w_{10}, \alpha, \alpha(1 - \tau_{y1})w_{11}; W_0],$$

$$(A.3) \quad l_1 = l_1[(1 - \tau_{y0})w_{10}, \alpha, \alpha(1 - \tau_{y1})w_{11}; W_0].$$

The assumption that leisure is not a Giffen good implies that a rise in the current period net wage raises  $l_0$  and a rise in the (discounted value of) future net wage raises  $l_1$ . Assuming that the amounts of leisure consumed in two consecutive periods are gross substitutes implies that for a given level of wealth, a current tax cut lowers future labor supply while a future tax cut lowers current labor supply.

In each period, the level of outputs  $Y_0$  and  $Y_1$  depends on labor and capital inputs. In order to simplify the exposition, we assume linear production functions. Thus, let

$$(A.4) \quad Y_0 = a_0 l_0 + b_0 K_0,$$

$$(A.5) \quad Y_1 = a_1 l_1 + b_1 [K_0 + K(I_0)].$$

The assumption that factor markets are competitive implies that in equilibrium the wage rates and the rental rate equal the corresponding marginal productivities of labor and capital, respectively. Thus

$$(A.6) \quad w_{10} = a_0, \quad w_{11} = a_1, \quad r_{k0} = b_0, \quad r_{k1} = b_1.$$

To analyze the equilibrium of the system, we assume that the foreign economy has a similar structure of production, consumption, and taxes. The initial equilibrium of the system is described by point A in Figure 2. As before, the downwards sloping schedules D and D\* denote the domestic and foreign relative demands for (ordinary goods) consumption in the two periods, and the schedule  $D^W$  is the weighted average of the domestic and foreign relative demands. The negative slopes of the schedules reflect the intertemporal substitution arising from changes in the rate of interest. The positively sloped schedule,  $S^W$ , reflects the response of  $z$  to the rate of interest, where, as before,  $z$  measures the ratio of world GDP net of investment and government spending in the two consecutive periods.

That is

$$(A.7) \quad z = \frac{(a_0 l_0 + b_0 K_0 - I_0) + (a_0^* l_0^* + b_0^* K_0^* - I_0^*)}{a_1 l_1 + b_1 [K_0 + K(I_0)] + a_1^* l_1^* + b_1^* [K_0^* + K(I_0^*)]}$$

The  $S^W$  schedule is drawn with a positive slope for convenience. In fact, changes in the rate of interest affect the intertemporal prices of leisure and of ordinary goods as well as wealth. These changes may alter the supply of labor in a way that more than offsets the effect of the induced changes in investment on  $z$ . In that case, the  $S^W$  schedule is negatively sloped, but as long as it is steeper than the world relative demand schedule, our interest rate analysis remains intact.

A revenue-neutral tax reform that substitutes an income-tax system for a consumption-tax system exerts effects that are similar to those in Section IV.2 in the paper. As in that case the adjustments of income tax rates necessary to restore revenue neutrality in each period (which depend on the economy's trade-balance position) alter the time profile of income taxes. As indicated by equations (A.1) -(A.2), the change in the time profile of income taxes alter the periodic labor supply and, thereby, alter the relative output supply function  $S^W$ .

The change in the income-tax profile has no effect on the relative-demand schedules since by the assumed separability and homotheticity they only depend on the effective interest rate. The shifts in the relative-supply schedules induced by the tax reform are governed by the effect of the tax reform on investment as well as on the amount of work. Since both operate in the same direction, the essence of the analysis in Section IV.2 with respect to the world rate of interest remains unchanged.

The opposite conversion from income to consumption taxes involves changes in the time profile of consumption taxes (necessary to restore revenue neutrality) and thereby result in relative demand shifts similar to those analyzed in Section IV.1. The diagrammatic analysis of Figure 2 must, however, be somewhat modified to allow for the change in the relative supply schedules induced by changes in labor supply consequent on the altered effective discount factor applicable to consumption decisions involving ordinary goods as well as leisure.

# Income Tax with Delayed Expensing of Investment

In the main text we have assumed that the income tax system is a cash-flow system with full expensing of investment. In this appendix we modify the specification of the income tax system and consider the other extreme in which current period investment is not expensed but the allowance for depreciation of capital is delayed to the final period. This modification alters the periodic budget constraints (1) - (4). To illustrate, consider the case in which the only two taxes are consumption and income taxes. Under such circumstances the private sector budget constraints are

$$(A.8) \quad (1 + \tau_{co}) C_0 = (1 - \tau_{yo}) \bar{Y}_0 - I_0 - r_{-1} B_{-1}^p + (B_0^p - B_{-1}^p)$$

$$(A.9) \quad (1 + \tau_{c1}) C_1 = (1 - \tau_{y1}) (\bar{Y}_1 + F(I_0)) + \tau_{y1} I_0 - (1 + r_0) B_0^p$$

and the corresponding consolidated life-time budget constraint is

$$(A.10) \quad C_0 + \alpha_c C_1 = \frac{1 + r_0 - \tau_{y1}}{(1 + r_0)(1 + \tau_{co})} [\alpha_I F(I_0) - I_0] \\ + \frac{1 - \tau_{yo}}{1 + \tau_{co}} [\bar{Y}_0 + \alpha_L \bar{Y}_1] - \frac{1 + r_{-1}}{1 + \tau_{co}} B_{-1}^p$$

where

$$(A.11) \quad \alpha_c = \frac{1 + \tau_{c1}}{1 + \tau_{co}} \alpha, \quad \alpha_I = \frac{1 - \tau_{y1}}{1 + r_0 - \tau_{y1}}, \\ \alpha_L = \frac{1 - \tau_{y1}}{1 - \tau_{yo}} \alpha, \quad \text{and} \quad \alpha = \frac{1}{1 + r_0}.$$

In equations (A.10) and (A.11)  $\alpha_c$ ,  $\alpha_I$  and  $\alpha_L$  are the effective discount factors applicable to consumption, investment, and labor-supply decisions.

As is evident the effective discount factor  $\alpha_I$  is not influenced by the current-period income tax rate  $\tau_{yo}$ ; this reflects the assumption that investment outlays are not expensed during the current period. Since  $\alpha_I$  depends positively on  $\tau_{y1}$ , it follows that a shift from income tax to consumption tax (that is, a reduction in  $\tau_{y1}$ ) raises the effective discount factor  $\alpha_I$  and, thereby, encourages investment. We note that in contrast with the cash-flow income tax with full expensing of investment the qualitative results in the present case do not depend on the trade-balance position as long as the supply of labor is fixed. With variable labor supply (analyzed in Appendix I) the current period income tax rate  $\tau_{yo}$  influences the relative supply function through its

influence on the effective discount factor  $\alpha_L$ . In that case the necessary changes in the income tax rates associated with the adoption of an income-tax system reflect as before the trade-balance position.

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