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The International Ramifications of Tax Reforms: Supply-Side Economics in a Global Economy

By ENRIQUE G. MENDOZA AND LINDA L. TESAR*

This paper studies tax reforms in a dynamic model of a global economy calibrated to current U.S. and European tax policies. World capital markets add consumption-smoothing and income-redistribution effects that alter closed-economy predictions. In the absence of taxes on foreign interest, welfare gains of eliminating U.S. income taxes are enlarged by up to 34 percent, at the expense of European losses caused by transitional declines in consumption and leisure, and a permanent capital outflow. In contrast, if foreign interest is taxed, the same tax reform reduces U.S. welfare 0.7 percent and increases European welfare 1.8 percent. (*JEL* H87, H21, H23, F41)

> Up to this point I have taken no account of international relations ... . When this assumption is removed, several new and large problems arise ... it may be feasible for a man subjected to taxation in a taxed area to make use of an untaxed area in such a way as to reduce the fiscal burden imposed upon him ... . New and so far unexamined dangers are threatened. It is clearly important to gauge, so far as we can, the scope and range of these in the particular case of our own country (A. C. Pigou, 1947 p. 165).

The research program on quantitative assessments of tax reforms initiated by Robert E. Lucas Jr.'s (1990) lecture on supply-side economics concluded that far-reaching tax reforms, designed to eliminate savings and investment distortions, produce large social welfare gains (see, for example, Robert G. King and Sergio T. Rebelo, 1990; Jeremy Greenwood and Gregory W. Huffman, 1991; Thomas F. Cooley and Gary D. Hansen, 1992; V. V. Chari et al., 1994). The welfare gains are large despite the transitional cost incurred in the process of expanding the capital stock from the lower level of a heavily tax-distorted economy to the higher level of a tax-reformed economy. Lucas estimated that replacing the capital income tax with a higher labor income tax would increase consumption per capita by about 1 percent per year, and Cooley and Hansen showed that the increase can exceed 2 percent if a consumption tax is used instead. Gains of this magnitude dwarf the benefits of other major policy endeavors—such as output and price stabilization—and, in Lucas's view, constitute the "largest genuinely free lunch" ever provided by quantitative welfare economics.[1]

The academic enthusiasm for revamping the tax system is shared by many policy makers in industrial countries, particularly in France, Germany, Japan, and the United States. In the United States, for instance, Congress created the Kemp Commission on Growth and Tax Reform which published a report in 1996 focusing on three major tax-reform proposals: the "universal savings allowance," which provides deductions for all income added to savings, the "flat tax," which cuts income tax

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[1] Recently, S. Rao Aiyagari (1995) showed that eliminating the capital income tax can be suboptimal if there are borrowing constraints and incomplete markets.

rates to a single 20–25 percent rate and makes up revenue losses with growth gains and higher indirect taxes, and the "consumption-tax-only," which envisages replacing completely the federal income tax with a value-added tax.

Despite the strong interest in radical tax reform on the part of researchers and policy makers, Pigou's concern for analyzing the international ramifications of tax reforms and quantifying their impact has remained largely ignored for over half a century. In fact, all existing quantitative studies in the tradition of Lucas's supply-side lecture assume that international financial markets do not exist. This is sharply at odds with the unprecedented globalization of capital markets that the world has experienced recently and with the continuing process of trade integration. The emergence of large and sophisticated global markets brings to center stage Pigou's concern for understanding how tax-reform assessments vary when the public has access to world trade. This is the central theme of this paper. In particular, the paper undertakes a quantitative examination of the effects of tax reforms from the perspective of a two-country dynamic macroeconomic model with fully integrated capital and goods markets, and calibrated to reflect current tax policies of the United States and Europe.

World financial markets play a key role in both the positive and normative aspects of tax reforms. Without access to external borrowing, households finance the accumulation of capital during the tax-reform transition by sacrificing consumption and leisure, and hence bear the large social costs associated with transitional dynamics. In contrast, world financial markets provide mechanisms for sharing the costs and benefits of tax reforms internationally, and hence produce sizable global spillovers along the lines examined in the analytical work of Jacob A. Frenkel and Assaf Razin (1992) and Greenwood and Kent P. Kimbrough (1985).

Our quantitative analysis shows that trade in world financial markets magnifies the benefits of tax reforms. The net welfare gain of a tax reform replacing the capital income tax with a consumption tax in the United States is 2.9 percent in the open-economy model, nearly 34 percent larger than in a closed-economy setting. A similar reform eliminating the labor income tax produces a welfare gain 10 percent larger for an open economy than for a closed economy. In both cases, the consumption tax increases sharply in order to satisfy the government's intertemporal budget constraint, keeping constant the levels of government expenditures and welfare payments. Most significantly, the transition paths for consumption and work effort change dramatically in the open economy. These calculations assume no change in the long-run growth rate of the economy, so the results do not rely on a permanently higher growth rate.

The international transmission of tax reforms operates through two key effects. The first is a *smoothing effect* reflected in external borrowing by U.S. households to smooth intertemporally the sacrifice of consumption and leisure implicit in the cost of the transition. As a result, the United States runs sizable trade and fiscal deficits in the short run and the cost of transitional dynamics falls sharply, from 7.6 percent in a closed economy to 3.4 percent in an open economy, when the capital income is replaced with a consumption tax. The second effect is a long-run *income-redistribution effect.* This effect captures the notion that the debt accumulated during the transition is serviced by a larger trade surplus in the long run. This mechanism transfers part of the long-run gains of the tax reform abroad. Hence the utility gain measured by comparing pre- and post-tax-reform steady states, ignoring the costs of transitional dynamics, is smaller in an open economy than in a closed economy.

The smoothing and income-redistribution effects produce international spillovers of domestic tax reforms, which affect the dynamics of foreign borrowing and the world interest rate, and hence cause large global externalities in response to unilateral tax-policy choices. In fact, the additional gains accruing to U.S. residents by borrowing internationally are matched by welfare losses in Europe, so tax reforms in an open economy are not "a genuine free lunch," as Lucas (1990) concluded. In the short run, the smoothing effect induces European households to reoptimize their portfolios from physical capital into international bonds, leading to a large capital outflow, and to consume less and work harder in order to

generate the trade surplus to match the U.S. deficit. These movements affect adversely Europe's welfare, and are only partially offset by the long-run income-redistribution effect. The latter leads to a long-run increase in European consumption and leisure, although Europe's capital stock falls permanently. These externalities thus provide incentives for strategic behavior by fiscal authorities similar to those that motivated the large theoretical literature on world tax competition (see Torsten Persson and Guido Tabellini, 1995), but to date no attempts have been made to quantify their magnitude.

We also examine how the international ramifications of tax reforms depend on the general structure of tax policies. Three important lessons emerge from this analysis. First, taxes on foreign interest income alter the incentives for external borrowing by adding a new margin of distortion between the intertemporal marginal rate of substitution in consumption and the world real interest rate. As a result, the distribution of welfare gains of tax reforms across countries can change dramatically. A tax reform that eliminates the U.S. domestic capital income tax, leaving in place a tax on foreign interest income, causes a 0.7-percent welfare loss in the United States and a 1.7-percent welfare gain in Europe. Second, a tax reform in the United States lowers European tax revenue, and hence may force Europe to increase distortionary tax rates in order to maintain intertemporal fiscal balance. In the best-case scenario in which the European policy response is to increase the consumption tax, the European welfare loss induced by the abolition of the U.S. capital income tax is doubled. Third, despite these large global externalities, it is possible to identify simple worldwide tax reforms that produce Pareto improvements. For example, the United States and Europe can obtain sizable welfare gains if they jointly undertake the elimination of the capital income tax in favor of higher consumption taxes.

The paper proceeds as follows. Section I describes the model and discusses the numerical solution method. Section II conducts tax-reform experiments, and explores the implications of alternative tax-policy scenarios and changes in key parameters. Section III concludes.

I. A Dynamic Macroeconomic Model for International Tax-Policy Analysis

A. *Households, Firms, the Public Sector, and Financial Markets*

The analytical framework is a dynamic neoclassical two-country model. Both countries produce a single composite commodity, and trade both this good and real one-period bonds, issued by the private sector in each country, in perfectly competitive international markets. The description of the model is based on home-country decisions and, when needed, foreign-country decisions are introduced using asterisks to denote foreign variables.

The long-run rate of output growth is exogenous at a rate γ, which is common across countries and across expenditure flows within each country, and is driven by labor-augmenting technological change. This assumption restricts the permissible set of functional forms for preferences and technology to the class of functions that supports balanced growth. The specification of the model is simplified by transforming all variables, except employment and leisure, into stationary variables by dividing them through by the state of technological progress. The transformed variables are written in lower case. This detrending method also requires well-known redefinitions of the subjective discount factor and laws of motion for asset accumulation. The paper focuses, without loss of generality, on the competitive equilibrium of the detrended model.

Each country is inhabited by identical, infinitely lived individuals. The representative household in the home country maximizes a conventional isoelastic lifetime utility function over intertemporal sequences of consumption (c_t) and leisure (L_t):

$$(1) \quad \sum_{t=0}^{\infty} \beta^t \frac{[c_t L_t^a]^{1-\sigma}}{1-\sigma}, \quad \sigma > 1, \quad a > 0.$$

The stationary transformation of the model requires that β be defined as $\beta \equiv B(1+\gamma)^{1-\sigma}$, where B is the true subjective discount factor.

The household maximizes (1) subject to the following sequence of budget constraints, tak-

ing as given relative prices and fiscal policy variables, for each date $t = 0, \ldots, \infty$:

$$(2)\quad (1+\tau_c)c_t + (1+\gamma) \times [k_{t+1} + R_t b_{t+1} + R_t^g d_{t+1}] = (1-\tau_n)w_t N_t + [1 + (1-\tau_k)(r_t - \delta)]k_t - \Psi(k_t, x_t) + b_t + d_t.$$

The left-hand side of (2) represents the household's expenditures, which include purchases of consumption goods, inclusive of a sales tax, τ_c, capital goods, k_{t+1}, private international bonds, b_{t+1}, and domestic government bonds, d_{t+1}. For simplicity, bonds are represented as discounted bonds, so the real returns of private and public bonds are $(1/R_t) - 1$ and $(1/R_t^g) - 1$, respectively. The right-hand side of (2) is the household's disposable factor and nonfactor income. Factor income is derived from supplying capital (k_t) and labor (N_t) to firms at pre-tax rental rates w_t and r_t, and taxed at rates τ_n and τ_k, with a provision for a depreciation allowance. Installed capital depreciates at a fixed rate δ, and additions to installed capital incur capital-adjustment costs $\Psi(k_t, x_t)$, where x_t is net investment $(1+\gamma)k_{t+1} - (1-\delta)k_t$. These costs, or similar frictions like gestation lags, are required in dynamic open-economy models to differentiate physical from financial assets, and thereby prevent the instantaneous adjustment of the domestic marginal product of capital to the world interest rate (see Mendoza, 1991). Without adjustment costs, these models cannot produce transitional dynamics and predict unrealistically large swings in investment rates and current account balances. The last two terms in (2) represent nonfactor income derived from public and private bonds. This income is not taxed, but we show later that allowing for taxation of foreign interest income has important implications. Households also face a no-Ponzi-game restriction, $\text{Lim}_{T\to\infty}(\Pi_{t=0}^{T} R_t)b_T = 0$, which together with (2) implies that the present value of household disposable factor income equals that of expenditures plus any initial bond holdings b_0.

Implicit in equation (2) is the assumption that domestic capital and public debt are owned only by domestic households. This is an extreme assumption, but it has the advantage that it allows the model to support competitive equilibria in which there is free international trade in private bonds and differing capital income tax rates on residents of the two countries. We explain below that this is not possible with cross-border trading on equity or public debt (see also Frenkel et al., 1992).

The household's constraint on the allocation of time between labor and leisure is:

$$(3)\quad L_t + N_t = 1$$

where the total number of hours is normalized to one. Labor is immobile across countries.

Firms maximize profits subject to constant-returns-to-scale technological constraints, taking as given factor prices. Thus, firms employ inputs according to marginal productivity rules and earn zero profits in equilibrium. The production function is Cobb-Douglas:

$$(4)\quad F(k_t, N_t) = k_t^{1-\alpha} N_t^{\alpha}.$$

Fiscal policy is represented by an intertemporal sequence of unproductive government expenditures, g_t for $t = 0, \ldots, \infty$, and a set of tax rates. The date-t government budget constraint is:

$$(5)\quad g_t + d_t = \tau_k(r_t - \delta)k_t + \tau_n w_t N_t + \tau_c c_t + (1+\gamma)R_t^g d_{t+1}.$$

The left-hand side of (5) represents uses of government revenue (i.e., goods purchases and debt payments). The right-hand side includes tax revenue and newly issued debt. Since government purchases and tax rates are exogenous policy choices, the government is assumed to issue new debt as needed to satisfy its budget constraint. Government also faces a no-Ponzi-game constraint, $\text{Lim}_{T\to\infty}(\Pi_{t=0}^{T} R_t^g)d_T = 0$, which jointly with (5) implies that the present value of government expenditures equals the present value of tax revenue plus the initial stock of public debt d_0. Moreover, (2), (5), and

the no-Ponzi-game constraints imply that the present value of the trade balance equals b_0.

Public debt in this model is "Ricardian" in the sense that, given d_0 and policy choices on government purchases and tax rates, the competitive equilibrium can be represented with the government debt path dictated by (5), or with adjustments in lump-sum transfers to households, tr_t, by the amount required to balance the government budget constraint each period:

$$(6) \quad tr_t = \tau_k(r_t - \delta)k_t + \tau_n w_t N_t + \tau_c c_t - g_t.$$

The equivalence between the intertemporal sequences of debt and transfers is clear taking as given d_0 and noting that (5) and (6) imply $tr_t = d_t - (1 + \gamma)R_t^g d_{t+1}$. This framework also allows for a constant level of exogenous government transfers to households, representing subsidies and welfare programs, which can be denoted as T and added as an extra right-hand-side term in (2), (5), and (6).

The market-clearing conditions for the world markets of goods and bonds are:

$$(7) \quad F(k_t, N_t) + F(k_t^*, N_t^*) = c_t + c_t^* + x_t + x_t^* + \Psi(k_t, x_t) + \Psi(k_t^*, x_t^*) + g_t + g_t^*,$$

$$(8) \quad b_t + b_t^* = 0.$$

The model's competitive equilibrium is given by sequences of prices $[r_t, r_t^*, R_t, w_t, w_t^*]_{t=0}^{\infty}$ and allocations $[k_{t+1}, k_{t+1}^*, b_{t+1}, b_{t+1}^*, N_t, N_t^*, c_t, c_t^*, L_t, L_t^*, tr_t, tr_t^*]_{t=0}^{\infty}$ that satisfy the first-order conditions of the optimization problems faced by households and firms, the constraints of households and governments, and conditions (7)–(8)—given $[k_0, k_0^*, b_0, b_0^*, d_0, d_0^*]$ and the choice of fiscal instruments.

B. *The International Transmission of Tax Reforms*

The first-order conditions that characterize optimal decisions provide important intuition for understanding the international ramifications of tax reforms. The first-order conditions for investment and foreign bonds in each country, ignoring adjustment costs, are:

$$(9) \quad \frac{(1 + \gamma)U_1(c_t, L_t)}{\beta U_1(c_{t+1}, L_{t+1})} = (1 - \tau_k)(F_1(k_{t+1}, N_{t+1}) - \delta) + 1 = R_t^{-1},$$

$$(10) \quad \frac{(1 + \gamma)U_1(c_t^*, L_t^*)}{\beta U_1(c_{t+1}^*, L_{t+1}^*)} = (1 - \tau_k^*)(F_1(k_{t+1}^*, N_{t+1}^*) - \delta) + 1 = R_t^{-1}.$$

The model supports equilibria where countries trade private bonds and $\tau_k \neq \tau_k^*$. This follows from two implications of conditions (9)–(10). First, trade in bonds implies that countries face a common intertemporal relative price of consumption R_t^{-1}, and hence growth-adjusted intertemporal marginal rates of substitution in consumption are equalized. Second, the optimal portfolio allocation across capital and private bonds requires that the post-tax net marginal products of capital are also equalized across countries. As a result, differences in capital income taxes are offset by differences in pre-tax net marginal products of capital. This cannot occur if countries trade equity and tax capital income according to the residence principle (i.e., home households pay τ_k on their holdings of k and k^*). In this case, both pre-tax and post-tax returns on capital are equalized, and hence a world competitive equilibrium requires $\tau_k = \tau_k^*$. A similar result applies to world trade in public debt: equilibria with $\tau_k \neq \tau_k^*$ can be supported only if there is no world trade in public debt, as we assumed, or if public debt is internationally traded but interest payments on it are tax free. In the latter case, however, b and d would be perfect substitutes and there would not be well-defined portfolio shares assigned to each debt instrument. The assumption that neither equity or public debt are traded across countries is restrictive, but its has two advantages: it keeps the model simple and it prevents the model from being clearly at odds with the marked

differences in domestic capital income tax rates across countries that we document below.

To understand the international transmission of tax reforms, consider next the implications of a permanent, unanticipated cut in the home-country capital income tax. Conditions (9)–(10) imply that, for a given world interest rate $R_t^{-1} - 1$, the tax cut increases the net-of-tax domestic marginal product of capital, and hence arbitrage with the bond market implies that k_{t+1} must rise to restore equilibrium. There is no direct "arbitrage" effect on foreign capital, since equity is not traded globally, but to the extent that domestic households borrow from abroad to finance the increase in k_{t+1} they induce a capital outflow from the foreign country. Moreover, since we are dealing with two large countries, when one country changes its net foreign debt it also alters the world interest rate. Interest rate changes are temporary, however, because the long-run interest rate r is pinned down by the steady-state condition $r = \rho - \gamma\sigma$, where ρ is the rate of time preference, defined as $\rho \equiv B^{-1} - 1$.

The above intuition implies that transitional and long-run changes in international borrowing, and transitional changes in the interest rate, are the channels for global transmission of tax reforms in the model. We condense these channels into a *smoothing effect* and an *income-redistribution effect.* The first effect refers to the resources that a county obtains from world markets to lessen the cost of the transitional dynamics in the initial stages of a tax reform, and can be measured by transitional changes in net exports—which combine both interest rate changes and changes in net foreign asset positions. The second effect reflects the redistribution of income across countries that occurs because a country that accumulates foreign debt during the transitional dynamics maintains a long-run trade surplus to service that debt. Since the long-run interest rate is invariant to tax changes, this second effect captures only long-run changes in foreign asset positions.

Note that an implication of the above-mentioned effects is that the benefits that a tax-reforming country extracts from world capital markets depend on how its borrowing decisions affect R_t. In the extreme case of a small open economy, without adjustment costs, R is constant and a cut in τ_k is matched by an immediate and large increase in x_t entirely financed by external borrowing. A small country will borrow more, and at a lower cost, than a large country because for the small country the world supply of capital is infinitely elastic.

Labor income taxes and consumption taxes also have international implications, but they are less direct. Changes in these tax rates operate first through the consumption-leisure trade-off:

$$\frac{U_2(c_t, L_t)}{U_1(c_t, L_t)} = \frac{(1 - \tau_n)}{(1 + \tau_c)} w_t. \tag{11}$$

Given Cobb-Douglas production technologies, the resulting distortions on labor supply affect the marginal products of both capital and labor, and the effect on the former triggers the international transmission mechanisms described earlier. Note also that τ_n and τ_c jointly distort the marginal rate of substitution between consumption and leisure, but their impact on tax revenue, household income, and welfare differs, as shown below.

C. *Income Tax Reforms: Calibration and Solution Method*

We study tax reforms in which the government undertakes a permanent, unanticipated reduction in time-invariant factor income taxes at $t = 0$.[2] Government expenditures and exogenous welfare transfers remain fixed at the levels g_0 and T, respectively. The revenue lost due to income tax cuts is replaced by increasing τ_c so that the present value of tax revenue equals that of government expenses (assuming, without loss of generality, that $d_0 = 0$). The government adjusts tr_t (or issues debt) along the transition path as needed to make up

[2] We follow Lucas (1990) and Cooley and Hansen (1992) in limiting the analysis to changes in time-invariant tax rates. Cooley and Hansen provide evidence suggesting that the extra gains made with time-variant taxes relative to time-invariant taxes can be small.

for any shortfall or excess of tax revenue over expenses. Following Lucas (1987, 1990), the net welfare effect of the reforms is measured as the constant percentage increase in c_t, for $t = 0, \ldots, \infty$, that leaves households indifferent between the lifetime utility obtained by remaining in the pre-reform equilibrium, and the lifetime utility obtained by undertaking the tax reform, inclusive of the transitional dynamics of c_t and L_t. This net gain is also decomposed into a long-run gain, measured by comparing lifetime utility across pre- and post-tax-reform steady states, and the short-run cost of the transitional dynamics.

Numerical solutions of the tax-reform experiments involve the computation of: (a) long-run, balanced-growth equilibria before and after the tax reform, and (b) transitional dynamics between pre- and post-tax-reform steady states. The computation of the pre-reform equilibrium is based on a calibration exercise similar to those undertaken in closed-economy studies. In contrast, the computation of the post-tax-reform, balanced-growth equilibrium and the transitional dynamics differs markedly from closed-economy studies because in the open economy the two must be solved simultaneously. This is because, while closed-economy models feature explicit steady-state solutions invariant to initial conditions, in open-economy models there are no explicit steady-state solutions for the allocations of consumption and private bonds across countries, and the dynamics and post-tax-reform steady state of b vary with initial conditions. David Lipton et al. (1982) and Lipton and Jeffrey Sachs (1983) examined similar cases in which steady-state foreign asset positions are part of a two-point boundary problem in the context of dynamic, open-economy IS-LM models.

Calibration of the Pre-tax-Reform Equilibrium.—The following conditions summarize the long-run equilibrium of the home country along the balanced-growth path:

$$\frac{k}{y} = \frac{\beta(1-\alpha)(1-\tau_k)}{(1+\gamma) - \beta[1-\delta(1-\tau_k)]}, \tag{12}$$

$$\frac{x}{y} = (\gamma + \delta)\frac{k}{y}, \tag{13}$$

$$\frac{c}{y} = 1 - \frac{x}{y} - \frac{g}{y} - \frac{tb}{y}, \tag{14}$$

$$N = \frac{\dfrac{1-\tau_n}{1+\tau_c}\alpha}{a\dfrac{c}{y} + \dfrac{1-\tau_n}{1+\tau_c}\alpha}. \tag{15}$$

Condition (12) is the steady-state version of the Euler equation for capital, and expresses the capital-GDP ratio, k/y, as a function of preference and technology parameters and τ_k. Equation (13) is the law of motion for capital accumulation, and determines the steady-state investment rate, x/y, as a function of γ, δ, and k/y. Condition (14) uses the budget constraints to define the consumption-output ratio, c/y, as a function of x/y and the GDP shares of government purchases and net exports (g/y and tb/y, respectively). Since along the balanced-growth path $tb/y = (\beta - 1)b/y$, the private debt ratio b/y is a simple transformation of tb/y. Condition (15) follows from (11) and sets N as a function of c/y, τ_n, τ_c, α, and a. In preparation for the analysis of Section II, note that (15) also determines N_t at any date in the equilibrium path, with c/y replaced by c_t/y_t. Note also that τ_k affects both x/y and, through its effect on c/y, the supply of labor, while τ_n and τ_c do not affect x/y.

Formally, equations (12)–(15) are an underidentified system of four equations with five unknowns (k/y, x/y, c/y, tb/y, and N). Equations (12)–(13) are block recursive and determine k/y and x/y exactly as in a closed-economy model, but (14)–(15) cannot determine c/y, tb/y, and N. Thus, balanced-growth equilibria of these variables are not pinned down by steady-state conditions. The calibration of the pre-tax-reform equilibrium circumvents this problem by taking tb/y from the data. More precisely, the system (12)–(15) is solved for δ, β, a, and c/y, given the values of other preference and technology parameters, tax rates, and long-run averages of k/y, x/y, tb/y, g/y, and N taken from actual data. The home country is calibrated to U.S. data, and the foreign country corresponds to European aggregates measured as arithmetic averages of data for France, Germany, Italy, and the

TABLE 1—PARAMETER VALUES AND PRE-TAX-REFORM, STEADY-STATE ALLOCATIONS

Parameter values:

Technology and preferences:

δ	α	γ	η	B	σ	a
0.0161	0.64	0.0039	10	0.993	2	2.675

Fiscal policy parameters (in percent)[a]

	United States	Europe
τ_k	41.5	34.3
τ_n	29.1	38.2
τ_c	4.4	15.8
g/y[b]	19.0	21.0

Pre-tax-reform, balanced-growth allocations (GDP ratios):

	United States		Europe	
	Data	Model	Data	Model
c/y	0.65	0.65	0.60	0.59
x/y[c]	0.17	0.17	0.17	0.18
tb/y	−0.01	−0.01	0.01	0.01
Tax revenue	0.28	0.30	0.36	0.41
Net transfers[d]	0.14	0.12	0.24	0.20

Notes: Figures in "Data" columns are averages for the 1968–1991 period, based on national accounts and tax revenue data from *OECD National Accounts* and *Revenue Statistics.*

[a] Tax rates are 1991 estimates computed as in Mendoza et al. (1994).

[b] Government expenditures (including public investment) at the general government level.

[c] Private investment rate. Data not available for Italy. The figure shown for Europe is the average of the private investment-GDP ratio in France, Germany, and the United Kingdom.

[d] Subsidies and all current transfers. Data for Italy and the UK are for the 1980–1988 period.

United Kingdom. Long-run GDP ratios are based on data from the OECD's *National Accounts* and *Revenue Statistics* and on estimates reported by Cooley and Hansen (1992).

The parameter values used to calibrate the model at a quarterly frequency are shown in Table 1. The values of g/y and g/y^* are easily derived from the data, and are estimated at 19 percent for the United States and 21 percent for Europe, including public investment. In contrast, obtaining macroeconomic estimates of tax rates is difficult due to complex international differences in tax codes (credits, exemptions, deductions, etc.) and to the progressivity and nonlinearity of tax schedules. In previous work with Assaf Razin (Mendoza et al., 1994), we estimated tax rates for Europe and the United States over the 1968–1990 period by combining detailed tax revenue statistics with information from the aggregate balance sheets of households, corporations, and government from national income accounts. Figure 1 plots the estimated tax rates. We set the pre-tax-reform tax rates equal to 1990 values. The estimates suggest that τ_k is larger in the United States than in Europe (41.5 percent compared to 34.3 percent) and, conversely, τ_n and τ_c are larger in Europe than in the United States (15.8 versus 4.4 percent for the consumption tax and 38.2 versus 29.1 percent for the labor income tax). These tax rates capture the widely accepted view that,

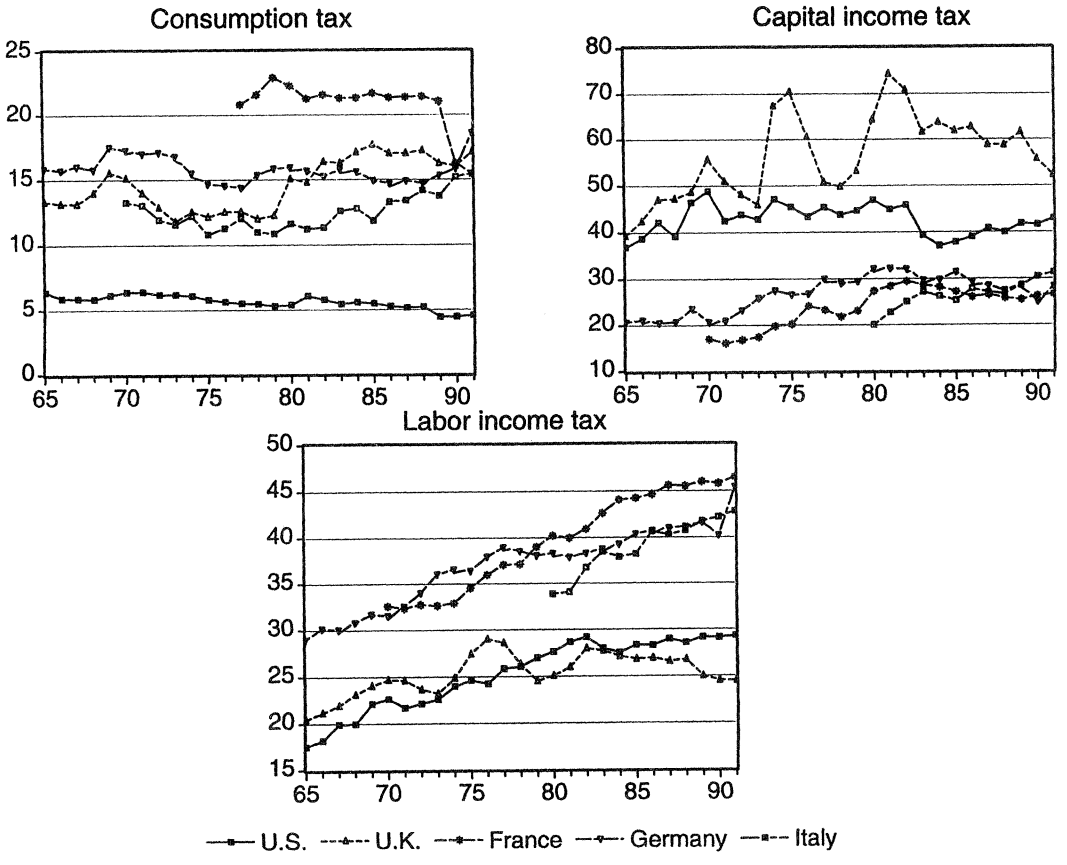

FIGURE 1. EFFECTIVE TAX RATES IN EUROPE AND THE UNITED STATES

compared to Europe, the United States taxes consumption and labor income less heavily than capital income.

The rest of the calibration follows standard practice in real-business-cycle analysis (see Chs. 1 and 7 of Cooley, 1995). The per capita GDP growth rate is set to $\gamma = 1.56$ percent per annum (0.39 percent per quarter) and the intertemporal elasticity of substitution is set at $^1/_2$ (i.e., $\sigma = 2$). We measured the annual x/y ratio, adjusted to exclude public investment, at 0.17, which is similar to the estimate Cooley and Hansen (1992) obtained for the post-war ratio of fixed nonresidential investment relative to corporate GDP. The quarterly k/y ratio is set to 2.16 (8.62 annually), which is also in line with the figure Cooley and Hansen used (2.13). We also followed these authors in setting the labor share, α, at 0.64. Given these ratios and parameter values, and the tax rates, conditions (14) and (15) imply values of δ equal to 1.61 and B equal to 0.99 (where $\beta \equiv B(1 + \gamma)^{1-\sigma}$). The implied value of r is 6.1 percent per annum. Given x/y and g/y, conditions (14) and (15) jointly determine a value of a consistent with a labor allocation equal to 20 percent of time, and a ratio c/y consistent with $tb/y = -1$ percent, both conforming to U.S. data. This implies $a = 2.675$ and $c/y = 0.65$. Preference and technology parameters are set identical across the United States and Europe to highlight the effects of asymmetries in fiscal policy. Thus, we adopt the same values of a, α, β, δ, σ, and B for Europe and allow k/y^*, x/y^*, and N^* to adjust accordingly.

Table 1 also reports the measures of c/y, g/y, x/y, tb/y, and the GDP ratios of tax revenue and net government transfers for both countries in the data and in the model. The calibration was set to mimic the U.S. ratios g/y, x/y, and tb/y, but all other ratios are endogenous solutions of the steady-state system of the model. Hence, the fact that the model's ratios are roughly in line with the data suggests that the pre-tax-reform equilibrium is a reasonable platform for tax-reform analysis. Note that in the data tax revenue exceeds government purchases by over 10 percentage points of GDP, in part because net government transfers to households amount to 14 and 24 percent of GDP in the United States and Europe, respectively. These transfers measure subsidies and payments on account of large welfare, healthcare, and other entitlement programs. As explained, the model captures this fact by allowing for an exogenous rebate of a part of tax revenue that is kept constant at the pre-tax-reform level in the tax-reform experiments. Consequently, the transitional fluctuations in net transfers computed below correspond exactly to adjustments in the stock of public debt.

The model also features capital adjustment costs of the following convex, quadratic form:

$$\Psi(k_t, x_t) = \frac{\eta}{2}\left(\frac{x_t}{k_t} - z\right)^2 k_t \tag{16}$$

where $z = x/k$, so that adjustment costs are zero in steady state. The value of η is set so that the average convergence rate of GDP to the long-run, balanced-growth path corresponds to empirical estimates that set conditional growth-convergence coefficients at about 2–3 percent (see Robert J. Barro and Xavier Sala-i-Martin, 1995).[3] This implies $\eta = 10$. Barro and Sala-i-Martin (1995) noted that this approach can yield values of η that exceed empirical evidence from investment equations by a wide margin. However, adjustment costs can also be interpreted as a proxy for other frictions absent from the model—such as the existence of a nontraded goods sector—which slow down aggregate capital accumulation. Mendoza and Tesar (1995) show that a two-country model with nontraded goods, calibrated setting η to the value used in the study of international business cycles by Mendoza (1991), produces similar results for tax-reform assessments as the present model. We focused on the one-sector model here for expositional ease and examined the sensitivity of the numerical simulations to changes in the value of η.

Transitional Dynamics.—The solution of the transitional dynamics of a tax reform requires the simultaneous solution of the paths of foreign debt accumulation and the net foreign asset positions in the post-reform steady state. We propose a method that ensures that post-reform, steady-state bond positions are consistent with debt-accumulation dynamics, starting from initial conditions corresponding to the pre-reform equilibrium. The method blends the King-Plosser-Rebelo (KPR) linear approximation algorithm with an iterative "shooting" routine on foreign debt.[4] We take an initial guess of the long-run bond positions to which countries converge after the tax reform (typically the pre-tax-reform positions), solve (12)–(15) for k/y, x/y, c/y, and N, and linearize around the implied balanced-growth allocations. Then we simulate the transitional dynamics for 2,500 periods using KPR and setting as initial conditions the pre-reform values of the state variables k_0, k_0^*, and b_0. The simulations produce a path of foreign debt dynamics that converges to some long-run bond positions. If these differ from the initial guess, the new results are adopted as a new guess and the process is repeated. The process converges rapidly, in four or five iterations, but the difference between the initial guess and the final outcome can be quite large. For instance, application of the KPR method assuming that the pre- and post-reform bond positions are identical produces welfare gains for the tax reforms examined in Section II about $^1/_3$ smaller

[3] The average convergence rate is $1/T \sum_{t=0}^{T} \ln(y_{t+1}/y)/\ln(y_t/y)$, where y_t reaches the steady state at T.

[4] An alternative to the KPR method is to solve the sequence of Euler equations as in Cooley and Hansen (1992). This is computationally expensive in models with a large number of state variables. Our algorithm can mimic closely the results of the Cooley-Hansen tax-reform experiments.

than the true values. The income-redistribution effect is also underestimated by a large margin—the correct long-run trade balance is a *surplus* of 3.8 percent of GDP, compared to a *deficit* of 1 percent in the incorrect solution.

The solution method requires a second "shooting" routine to ensure that the intertemporal government budget constraint is satisfied. The algorithm checks whether the present values of government expenses and tax revenue are equal. If this equality fails, τ_c is adjusted according to a rule that updates the tax rate as needed to balance the latest estimate of the government's intertemporal budget constraint. Note that, in the long run, the adjustment in τ_c is smaller the larger the rise in c and the larger the rise in y relative to c (i.e., the larger the raise in the base of the consumption tax and the larger the "supply-side" effect enhancing income tax revenue collection). In the short run, however, tax revenue declines with respect to the pre-tax-reform level, and this requires a larger increase in τ_c the larger the transitional declines in consumption and factor incomes. The algorithm starts again with the shooting routine on bonds using the updated τ_c, and the process is repeated until it converges to consistent solutions for both τ_c and long-run bond positions. We assume for now that the foreign country uses lump-sum taxes to offset any global fiscal effects of the home-country tax reform. Later we explore the implications of assuming τ_c^* is adjusted to maintain intertemporal fiscal balance abroad.

II. The International Effects of U.S. Income Tax Reforms

A. *Elimination of U.S. Factor Income Taxes*

The quantitative exploration begins with the analysis of a unilateral reduction in U.S. factor income taxes for both the two-country case and the case in which the U.S. economy is modelled as a closed economy. Since tax-reform proposals differ markedly on the allocation of tax cuts across labor and capital, we consider two basic tax reforms: a reform that replaces the capital income tax with the consumption tax, keeping the labor income tax constant, and a reform that replaces the labor income tax with the consumption tax, leaving constant the capital income tax. This strategy is also intended to illustrate how the international implications of two major income tax reforms differ. As we show, the global spillovers are most relevant in the case of capital income tax reforms, and hence much of the subsequent analysis will focus on this case.

The top part of Table 2 shows the effects of the elimination of the capital income tax. The reform reduces τ_k to zero from its current value in the United States (41.5 percent). Consider first the case in which the United States is a closed economy. The model predicts that τ_c needs to rise to 16.3 percent to maintain fiscal balance. Welfare is 9.8 percent higher in the post-reform steady state than in the pre-reform steady state, but the transition to this new steady state implies a hefty social cost of 7.6 percent. Still, the net welfare gain of the reform is a sizable 2.2 percent.[5] The impact effects show that the tax reform causes c_0 to fall by 8.3 percent and L_0 to rise slightly by 0.1 percentage points. The rise in the consumption tax increases the relative price of labor relative to leisure, causing a substitution effect favoring a fall in labor supply. On the other hand, the adverse income effect reflected in the falling share of consumption relative to output at date 0 favors an increase in labor supply. The two effects almost neutralize each other [see (15)] and result in the small rise in L_0. The fall in the consumption-output ratio is due to the increase of 7.3 percentage points in x_0/y_0, as the process of capital accumulation in the transition to the new long-run equilibrium begins. This process causes a temporary increase in r_0 of 3 basis points in annual terms.

Consider now the results of the open-economy model. The effects of the tax reform are radically different in the following four key dimensions.

(1) *Intertemporal smoothing.*—The cost of the transition is sharply reduced by intertemporal smoothing through borrowing on international capital markets. On impact, tb_0/y_0 falls

[5] This estimate is comparable with the 2.8-percent gain obtained by Cooley and Hansen (1992) for a similar experiment replacing τ_k with τ_c under a slightly different parameterization.

TABLE 2—MACROECONOMIC EFFECTS OF INCOME TAX REFORMS IN THE UNITED STATES

	Closed economy		Open economy			
	United States		United States		Europe	
Variable	Impact effect	Long-run effect	Impact effect	Long-run effect	Impact effect	Long-run effect
Replacing the U.S. capital income tax with a consumption tax						
New tax rates						
τ_k	0.000	0.000	0.000	0.000		
τ_c	16.333	16.333	14.775	14.775		
Welfare effects						
Transitional cost		−7.644		−3.415		−4.860
+ steady-state gain		9.805		6.309		4.036
= net change		2.161		2.894		−0.824
Percentage changes						
y	−0.456	13.490	−2.795	19.326	4.262	−5.037
c	−8.343	6.991	−3.858	7.099	−4.031	1.082
k	0.000	52.371	0.000	60.206	0.000	−5.037
Percentage point changes						
tb/y	—	—	−9.886	3.817	9.969	−4.944
x/y	7.260	5.899	11.205	5.899	−3.547	0.000
r	0.030	0.000	0.016	0.000	0.016	0.000
L	0.144	0.778	0.867	−0.221	−1.192	0.891
Replacing the U.S. labor income tax with a consumption tax						
New tax rates						
τ_n	0.000	0.000	0.000	0.000		
τ_c	29.375	29.375	28.795	28.795		
Welfare effects						
Transitional cost		−1.697		−0.696		−1.042
+ steady-state gain		4.835		4.148		0.791
= net change		3.138		3.452		−0.251
Percentage changes						
y	5.921	8.760	5.390	10.045	1.031	−0.998
c	7.684	11.335	8.811	11.500	−0.936	0.215
k	0.000	8.760	0.000	10.045	0.000	−0.998
Percentage point changes						
tb/y	—	—	−1.935	0.878	2.247	−0.940
x/y	0.079	0.000	0.887	0.000	−0.880	0.000
r	0.006	0.000	0.004	0.000	0.004	0.000
L	−1.904	−1.774	−1.713	−2.013	−0.286	0.177

Notes: y = gross domestic produce (GDP), c = consumption, k = capital stock, tb/y = trade balance-GDP ratio, x/y = investment-GDP ratio, r = real interest rate, and L = leisure hours. Figures are changes relative to pre-tax-reform, balanced-growth allocations at quarterly frequencies, except the interest rate, which is annualized. Initial levels in closed and open economies differ slightly because the latter is calibrated to reflect a trade deficit of 1 percent of GDP. Adjusting for this difference has negligible effects.

by almost 10 percentage points to finance the increase in investment and smooth consumption. The fall in c_0 is about $1/2$ the size of the decline in the closed-economy case, and r_0 rises by only half as much. The cost of the transitional dynamics falls from 7.6 percent to 3.4 percent.

(2) *Income-redistribution effect.*—The income-redistribution effect results in a smaller steady-state gain in the open economy because the United States runs a permanent trade surplus of 3.8 percent of GDP to service its foreign debt. Still, the welfare gain net of transitional dynamics reaches 2.9 percent, exceeding the 2.2 percent of the closed economy by about $1/3$.

(3) *Dynamics of labor supply.*—The impact and long-run effects on labor and leisure differ markedly from the closed-economy case. In the closed economy, L_0 remains nearly constant. In contrast, international borrowing allows L_0 to rise nearly 1 percentage point in the open economy. In the long run, leisure in the closed economy rises by 0.8 percentage points, while in the open economy leisure falls about $1/4$ of a percentage point. The extra output the open economy needs in order to maintain the trade surplus that services its enlarged external debt implies that labor supply must be higher, and hence leisure smaller, when world markets are considered [see equations (14) and (15)].

(4) *Adjustment in the consumption tax.*—The higher long-run levels of labor supply and the capital stock in the open economy imply higher levels of GDP and consumption, which yield higher labor income and consumption tax revenues allowing the government to maintain budget balance with a smaller increase in τ_c. This occurs despite larger transitional declines in tax revenue resulting from the short-run falls in labor supply and consumption. The result is that τ_c increases to 14.8 percent in the open economy, about 1.5 percentage points less than in the closed economy.

Figure 2 plots the transitional dynamics induced by the tax reform. The series plotted are percent deviations from the pre-reform steady state for the United States, as a closed economy (dashed line), as an open economy (solid line), and for Europe (dotted line). The model produces simulations for 2,500 quarters, but the plots show only the first 200 quarters. The dynamics of consumption, leisure, utility, the capital stock, GDP, and net exports reflect the intuition developed above, and illustrate the smooth dynamics typical of neoclassical models with isoelastic preferences and technologies. In addition, the figure plots the dynamics of tax revenue and the fiscal balance. Tax revenue falls more and the fiscal deficit widens more during the transition of the open economy than in the closed economy. Interestingly, these results show that the capital income tax reform produces large external and fiscal deficits that persist for over a decade. Thus, tax reform can produce the "twin deficits" phenomenon, and rationalize large fiscal and trade deficits as natural equilibrium outcomes of economic reform.

The open-economy model also predicts that the U.S. capital income tax reform has major consequences abroad. These are observed in the transitional dynamic paths for Europe and in the corresponding columns of Table 2. The additional welfare gain enjoyed by U.S. residents due to international borrowing is matched by a welfare loss in Europe. European consumption and leisure fall on impact by 4 percent and 1.2 percentage points, respectively, and Europe also suffers a permanent decline in its capital stock (of about 5 percent in the long run) resulting from the outflow of financial capital into the United States. Although European households cannot invest directly in the U.S. capital stock, they help finance the accumulation of U.S. capital by shifting the composition of their savings from investing in their own capital to international bonds. Thus, the reduction in the U.S. capital income tax leads to a global reallocation of capital via the bond market. The smoothing and income-redistribution effects are the causes of these externalities, the magnitude of which can be measured by the impact and long-run effects of the reform on the U.S. trade balance and the world interest rate reviewed earlier.

Consider next the implications of the labor income tax reform, summarized in the bottom panel of Table 2. The U.S. labor income tax falls from 29.1 percent to 0 and the consumption tax increases from 4.4 percent to around 29 percent in both closed and open economies.

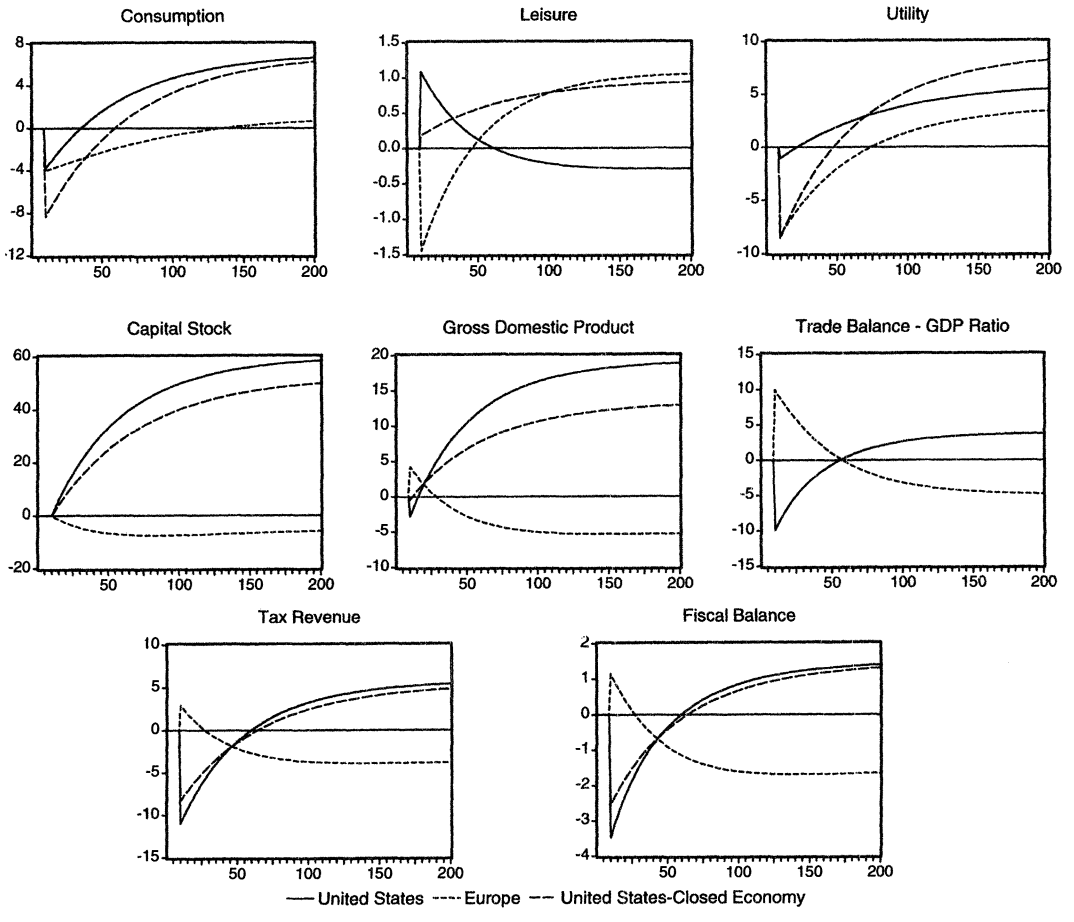

FIGURE 2. TRANSITIONAL DYNAMICS OF A CAPITAL INCOME TAX REFORM IN THE UNITED STATES

Notes: Tax revenue and fiscal balance are in percent of GDP. Data plotted are deviations in percent of pre-tax-reform equilibrium, except trade balance-GDP ratio, tax revenue, and fiscal balance, which are percentage-point deviations relative to pre-tax-reform equilibrium.

The results differ from those of the capital income tax reform in three important respects. First, since neither τ_c or τ_n affect the long-run investment rate and the intertemporal-consumption decision margin, this tax reform has no effect on the investment-output ratio in the long run, and has only small effects during the transition. Accordingly, the smoothing and income-redistribution effects triggered by this reform are significantly weaker, as can be seen in the much smaller effects on the trade balance-output ratio and the interest rate—although qualitatively the consequences of international borrowing are the same as before. Second, because both τ_n and τ_c affect the same decision margin (the leisure-consumption choice), and both labor income and consumption are equivalent to about two-thirds of national income, the elimination of τ_n requires a much larger increase in τ_c than the elimination of τ_k. Third, the labor tax is more distortionary than the capital tax, in the sense that eliminating the former produces larger welfare gains in both closed and open economies. This occurs because, although the steady-state welfare gain of the capital tax reform is about two times larger than that of the labor tax reform, the cost of transitional dynamics is nearly five

TABLE 3—MACROECONOMIC EFFECTS OF ELIMINATING THE U.S. CAPITAL INCOME TAX: ALTERNATIVE SCENARIOS

	Home country					Foreign country				
		Impact effects		Long-run effects			Impact effects		Long-run effects	
Model economy	Welfare change	*tb/y*	*c*	*tb/y*	*c*	Welfare change	*tb/y*	*c*	*tb/y*	*c*
Benchmark case	2.894	−9.886	−3.858	3.817	7.099	−0.824	9.969	−4.031	−4.944	1.082
Alternative tax policies										
World tax reform ($\tau_c = 15.9$, $\tau_c^* = 25.7$)	2.441	−1.551	−7.361	0.809	7.114	0.830	1.645	−7.824	−0.871	5.439
Adjusting τ_c^* ($\tau_c^* = 18.4$)	2.921	−10.224	−3.706	3.953	7.093	−1.695	10.385	−5.458	−5.206	−0.787
Tax on bonds ($\tau_b = 1.05$)[a]	−0.676	−8.126	−7.108	6.150	3.046	1.680	8.016	−2.686	−7.865	1.715
Sensitivity analysis										
Costless investment	3.760	−40.412	−3.977	2.472	8.517	−1.822	40.570	−6.036	−3.045	0.681
Inelastic labor supply	3.271	−8.237	−2.153	2.427	8.143	−0.370	7.920	−5.602	−2.580	4.330
Zero trade deficit[b]	2.743	−9.959	−4.057	3.756	6.920	−0.702	10.404	−4.020	−5.299	1.122

Notes: Impact effects correspond to changes in the date of the tax reform and long-run effects are changes in post-tax-reform, balanced-growth allocations, both relative to the pre-tax-reform, balanced-growth equilibrium. *c* is the percentage change in consumption and *tb/y* is the change in the net exports-GDP ratio measured in percentage points.

[a] This scenario assumes that prior to the tax reform the home country applies the "residence" principle, so that τ_b is set to equate the tax rates on domestic capital income and foreign interest income. The tax reform eliminates τ_k but retains τ_b at the same level of 1.05 percent.

[b] This scenario assumes zero trade deficits in the pre-reform steady state and is calibrated by setting the initial bond positions to 0.

times larger. Consumption falls sharply during the transition of the capital tax reform while it increases sharply in the case of the labor tax reform. The opposite movements are observed in leisure, but given the assumed substitutability of consumption and leisure and the wage elasticity of the latter, households prefer the outcome with the sharp initial consumption boom associated with the labor tax reform.

B. *Key Determinants of the Global Spillovers of Tax Reforms*

The previous analysis showed that a unilateral reduction in factor income taxes by one country has significant implications worldwide. This result was established in an environment where the United States replaced income taxes with consumption taxes, holding constant other key parameters of domestic and foreign tax policy. Thus, the next critical step is to study how the outcome of the analysis varies when these considerations are introduced.

The top panel of Table 3 reports results for three alternative tax-policy scenarios, all for the case of the U.S. capital income tax reform. The benchmark results of Table 2 are also provided to facilitate comparisons. The first alternative tax-policy setting considers the fact that, since the U.S. tax reform reduces European welfare, the tax reform is likely to be "unsustainable," in the sense that it would trigger a response by Europe's tax authority and would likely lead to a game of global tax competition. Examining this issue in detail is

beyond the scope of this paper, but we nevertheless show that it is possible to design a simple worldwide tax reform that constitutes a Pareto improvement over current tax systems.[6] This is done in the second row of Table 3, which assumes that both the United States and Europe replace capital income taxes with higher consumption taxes. Europe makes a 0.8-percent welfare gain, instead of a loss, and the United States still gains 2.4 percent. The impact and long-run effects of this reform on the trade balance-GDP ratio are much weaker than in the benchmark case because both countries are undergoing the transition to a larger steady-state capital stock. Hence, both countries have incentives to borrow internationally and world financial markets do less to mitigate the costs of the transition. This also implies that the interest rate must rise more in order to clear world markets. Note, however, that this "coordinated tax reform" does not represent a solution to either cooperative or noncooperative tax competition—except for a cooperative outcome based on an additive world welfare function parameterized arbitrarily with the appropriate welfare weights.

The second major change in the tax-policy setting that we examine involves relaxing the assumption that Europe has access to lump-sum taxation as a means to offset the impact of the U.S. tax reform on European tax revenue (which is not trivial, as shown in Figure 2). The third row of Table 3 thus deals with the case in which Europe adjusts its consumption tax to maintain the present value of its tax revenue identical to the unchanged present value of its government expenses. Clearly, Europe must be worse off because it now absorbs the fiscal impact of the U.S. tax reform using distortionary taxes—Europe's welfare loss doubles to nearly 1.7 percent, as τ_c^* rises from 15.8 to 18.4 percent. Thus, the benchmark case from Table 2 is an ideal scenario that gives Europe the privilege of responding to the budgetary effects of U.S. tax reforms using nondistortionary taxes. We showed that even in that case the global externalities are very large, and that relaxing this assumption only magnifies them.

The last important consideration regarding the tax-policy stance is to relax the assumption that foreign interest income is not taxed. This is critical for two reasons. First, the assumption is very unrealistic. The majority of industrial countries tax all individual capital income according to the residence principle [see Frenkel and Razin (1992) and Frenkel et al. (1992)], so income from foreign securities is taxed at similar rates as domestic capital income. Second, opening the economy to trade in financial assets implies that tax policy has a new margin of distortion—the wedge between the intertemporal marginal rate of substitution in consumption and the world interest rate.

The fourth row of Table 3 considers a case in which the United States applies the "full" residence principle to domestic capital and foreign interest incomes in the pre-tax-reform equilibrium (i.e., τ_k applies to both foreign interest and domestic capital incomes). Because we assumed discounted bonds, the easiest manner to introduce a foreign interest tax is via a tax on bond purchases τ_b, so that the amount of resources invested into foreign bonds in equation (2) becomes $(1 + \gamma)R_t(1 + \tau_b)B_{t+1}$. The value of τ_b consistent with the pre-reform value $\tau_k = 41.5$ percent is $\tau_b = 1.05$ percent. Note that, for reasons argued in Section I, subsection B, residence-based taxation and global trade in bonds require that τ_b be set at the same rate in both countries. In addition, although the tax on bonds distorts both the short- and long-run real interest rates, the reform we examine maintains τ_b unchanged. This ensures that there is a transitory increase in the world interest rate, while the long-run real interest rate is the same before and after the reform (as in all other experiments).

The results of the experiment with tax on bonds show that the distortion on the incentives for international borrowing alter the world distribution of the gains of the tax reform. The welfare effects now amount to a loss of 0.7 percent for the United States and a gain of 1.7 percent for Europe. Inspection of the transitional dynamics shows that the

[6] In Mendoza and Tesar (1995) we study the equilibria of tax-competition games under cooperative and noncooperative behavior that are triggered by the global externalities of tax reforms.

transitional increase in the rate of interest is larger when the tax on bonds is present (2.2 basis points versus 1.6 basis points in the benchmark case), and the increased cost of borrowing results in a smaller trade deficit and a larger decline in consumption for the United States along the transition path. The smaller trade deficit on impact reflects the fact that the U.S. economy is borrowing less, but the long-run trade surplus grows to 6.2 percent, compared to 3.8 percent without the tax on bonds. This occurs because the long-run cost of servicing the debt is higher with the tax on bonds—the long-run interest rate is now given by $r \approx \rho + \tau_b - \gamma\sigma$. In short, the tax on bonds weakens the smoothing effect and strengthens the income-redistribution effect, and since the former benefits the tax-reforming country and the latter the foreign country, there is a redistribution of welfare gains favoring Europe. Moreover, there is an additional fiscal effect because the larger transitional decline in consumption implies that the consumption tax must be increased more in order to satisfy the intertemporal budget constraint of the government—τ_c reaches 19.3 percent versus 14.8 percent without the tax on bonds.

If one reconsiders the labor tax reform in the presence of a tax on bonds, there is still a sizable redistribution of the welfare gains—U.S. welfare increases 2.8 percent instead of 3.1 percent, and European welfare increases 0.3 percent instead of falling 0.3 percent. In this case, however, the international transmission channels are weaker, and in fact contribute to make the U.S. tax reform sustainable by producing a welfare gain for European households without causing a welfare loss in the United States.

In addition to the overall tax-policy environment, the international implications of tax reforms depend on the structure of preferences and technology, in particular on the curvature of the cost-of-adjustment function, η, the leisure exponent, a, and the initial stock of foreign assets, b_0. The second panel of Table 3 conducts sensitivity analysis for these three key parameters in the case of the U.S. capital income tax reform.

First we examine the implications of sharply lowering η, to a value nearly 22 times smaller than in the benchmark. Predictably, both smoothing and income-redistribution effects are much stronger, and the welfare gain (loss) of the home (foreign) country is larger. When adjustment costs are trivial, k and b are near-perfect substitutes, and hence as the tax reform increases the post-tax domestic marginal product of capital, households borrow as much as necessary to enlarge k immediately so as to reset this marginal product at the level of the world interest rate. The latter rises more than before during the transition, because the home country is relatively large in the world market, but still the home country's trade deficit as a share of GDP widens by more than 40 percentage points on impact, more than four times as in the benchmark. Note, however, that adjustment costs are needed only to throw enough "sand in the wheels" of capital accumulation on the margins represented by conditions (9)–(10), and that this is accomplished with adjustment costs that are trivial relative to the size of the economy. In the benchmark case, U.S. adjustment costs converge rapidly, and monotonically, to zero from a maximum of only 0.8 percent of GDP on the date the tax reform is introduced. We conclude, therefore, that while the positive effects of the tax reform are highly dependent on the value of η, the U.S. (European) welfare gains (losses) range between 2.9 and 3.8 (-0.8 and -1.8) for very large variations in the curvature of adjustment costs.

The case of $a = 0$, which effectively makes labor supply inelastic at the level of the time endowment, is examined next (second row of the bottom panel of Table 3). This experiment demonstrates the importance of the interaction between consumption and leisure in the outcome of tax reforms. Setting $a = 0$ weakens both smoothing and income-redistribution effects, as reflected in the smaller impact and long-run changes in the U.S. trade balance-GDP ratio relative to the benchmark case. Despite these weaker effects, the U.S. welfare gain is larger, and the European loss smaller, than in the benchmark case. This somewhat counterintuitive result follows from two effects:

(1) Lowering a in the United States enlarges the welfare gains of the tax reform for similar reasons as in a closed economy (see Lucas,

1990). The system (12)–(15) implies that a lower a allows a given capital income tax cut to generate more output and consumption in the long run at a lower utility cost in terms of foregone leisure. By (12), the cut in τ_k increases k/y by an amount that is invariant to the value of a and is the same for closed and open economies. In the open economy, c/y falls both because the rise in k/y increases the investment-output ratio and because the tax cut leads to an increase in the net exports-GDP ratio to service the external debt. Given c/y, (15) implies that N is decreasing in a, so the long-run labor supply increases when a falls, and, given k/y, this results in larger output. Welfare increases because with the lower a the increase in consumption is valued more than the fall in leisure. In addition, the increased N and c provide a wider tax base, and hence imply that the increase in τ_c needed to maintain fiscal solvency is smaller.

(2) Lowering a^* along with a weakens the global spillovers of the tax reform because there can be no long-run outflow of physical capital away from Europe. Europe's long-run ratio k^*/y^* is pinned down by the foreign-country version of (12), so the ratio does not change because τ_k^* is unchanged, and with a Cobb-Douglas technology this ratio satisfies $k^*/y^* = (k^*/N^*)^{(1-\alpha)}$. Given that N^* is inelastic and k^*/y^* is constant, it follows that k^* and y^* are invariant to a U.S. tax reform. There is still a short-run capital outflow from Europe triggered by U.S. borrowing and temporarily higher world interest rates. Moreover, since with $a = 0$, output in both countries is predetermined on the date of the reform, the brunt of the adjustment required to generate the 7.9 European trade surplus on impact is absorbed by a larger transitional decline in European consumption.

The welfare impact of the weaker international transmission can be isolated by measuring the excess of the open-economy welfare gains over the closed-economy welfare gains for common values of a. With $a = 2.675$, the difference is nearly $^3/_4$ of a percentage point, while with $a = 0$ the difference narrows to 0.55 percentage points.

Interestingly, the dynamics of convergence to the balanced-growth path for European GDP and capital in the experiment with $a = 0$ are not monotonic, in sharp contrast to the benchmark case illustrated in Figure 2. Both European output and capital decline in the initial stages of the transition and then increase until they converge to their pre-tax-reform levels. Continuity implies that these nonmonotonic dynamics remain a feature of the model for low values of a. Thus, it is in principle possible to rationalize the observed nonmonotonicity of output and investment dynamics across countries (see Chari et al., 1996) as an outcome of the global externalities of tax-policy changes.

The last row of Table 3 examines the case in which the U.S. pre-tax-reform foreign asset position is zero, instead of the amount consistent with a 1-percent, long-run trade deficit as a fraction of GDP. This implies that the United States undertakes the tax reform starting from balanced trade, and is equivalent to reducing U.S. financial wealth from $b_0 = 0.62$ (which is consistent with $tb/y = -0.01$) to $b_0 = 0$. Since the present value of the household's expenditures must equal the present value of income plus financial wealth, the reduction in b_0 has an adverse effect on the U.S. welfare gain. The effect is quantitatively small because the initial bond positions and trade deficits in the benchmark case were small. However, since trade and foreign asset positions vary widely across countries and over time, and since the relevant value of b is the one prevailing *exactly* on the date of the tax reform (not an historical average), these results suggest that initial foreign asset positions are a key factor determining the outcome of tax reforms. For example, if the model is simulated assuming that $b_0 = 3$ instead of 0.62, which implies an initial U.S. trade deficit of 5 percent of GDP, the U.S. (European) net welfare gain (loss) increases (falls) to 3.5 (-1.3) percent.

Finally, it is worth noting that despite the sizable welfare gains produced by the tax reforms we examined, there still remains a very large social cost associated with the need to raise revenue through distortionary taxation. In a hypothetical scenario in which the current structure of distortionary taxes could be replaced with lump-sum taxation worldwide, the United States and Europe would make net welfare gains of nearly 13 and 20 percent, respectively.

III. Conclusions

This paper examines the positive and normative effects of tax reforms in the context of a two-country dynamic macroeconomic model with fully integrated capital and goods markets. International capital markets alter the response of the economy to tax reforms through two effects: (a) a *smoothing effect*, reflected in increased external borrowing to finance the expansion of the capital stock while smoothing consumption and leisure, and (b) an *international income-redistribution effect*, reflected in the long-run trade surplus needed to service the external debt accumulated for smoothing purposes. The model is calibrated to reflect the current stance of tax policy in Europe and the United States, assuming standard specifications for preferences and technology, and simulated to quantify the international implications of reforms replacing income taxes with higher consumption taxes. The model is solved numerically using a linear-approximation method augmented with shooting routines to determine solutions of competitive equilibria in which the world redistribution of financial wealth triggered by tax reforms is properly quantified.

The smoothing and income-redistribution effects imply that measures of the normative and positive implications of tax reforms are markedly different in open economies than in closed economies. The net welfare gains of eliminating U.S. income taxes can be up to 34 percent larger in the open-economy model and the cost of the macroeconomic transitional dynamics can be cut by more than half. Also, the excess welfare gain in the United States is obtained at the expense of a fall in European welfare. The enhanced efficiency of the U.S. economy, resulting from the reduction in tax distortions, leads European households to reallocate their savings from their own capital stock to international bonds and to sacrifice consumption and leisure during the transition. They recover only a fraction of the welfare cost of these adjustments via the income-redistribution effect.

Further analysis reveals that knowledge of the complete structure of direct and indirect taxes across countries is critical for assessing the outcome of tax reforms. In particular, taxes on interest income from external assets add a new margin of distortion by driving a wedge between the world real interest rate and the intertemporal marginal rate of substitution in consumption. Through this wedge, taxation of foreign interest income weakens the smoothing effects and strengthens the income-redistribution effect. As a result, a country undertaking a unilateral tax reform can transfer the benefits of the reform to a foreign country with unchanged taxes.

Our quantitative investigation demonstrates that unilateral tax reforms induce significant externalities on the rest of the world, which would lead fiscal authorities to engage in potentially damaging international tax competition. We do not study tax competition, but we do identify simple worldwide tax reforms yielding Pareto-efficient outcomes that leave households worldwide better off than under present tax structures. Moreover, the numerical methods developed here provide the basic ingredients for computing solutions of international tax-competition games, which we are producing in work in progress (see Mendoza and Tesar, 1995). Further research on how our quantitative results are altered by distributional issues across generations and income groups, the introduction of stochastic shocks or policy uncertainty, and endogenous government expenditure choices, all of which have been found important in theoretical work, are worth pursuing.

The international effects of tax reforms are particularly sensitive to three elements of the model's structure. First, capital-adjustment costs affect significantly the quantitative features of transitional dynamics of macroeconomic aggregates, although they are less relevant for welfare implications. In contrast, the elasticity of labor supply is key for both positive and normative implications of the model. If labor is inelastic, a domestic tax reform cannot lead to a permanent outflow of physical capital from abroad, and hence smoothing and income-redistribution are sharply weakened. The third key parameter is the net foreign asset position of the tax-reforming nation on the date the reform is implemented. A large net creditor in global markets has a stock of financial wealth that can be depleted to smooth consumption and leisure, without causing long-run income redistribution on account of permanently higher payments to service foreign debt.

Finally, some of our findings have interesting implications for other aspects of open-economy policy analysis that have been the focus of recent debate. First, tax reform produces at the outset large and persistent trade and fiscal deficits for the reforming nation, which are sustainable in the sense of being consistent with long-run solvency. Hence, large fiscal and external imbalances in countries embarked in far-reaching economic reforms can be equilibrium outcomes, and aiming to reduce them can be highly undesirable. Second, nonmonotonic convergence of macroeconomic aggregates to balanced-growth paths, which violate the predictions of the conventional closed-economy, balanced-growth framework, can emerge as a result of the international externalities induced by changes in economic distortions of particular nations.

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