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**The International Macroeconomics of Taxation and  
the Case Against European Tax Harmonization**  
*A Policymaking Framework Inspired by the Work of Assaf Razin<sup>1</sup>*

by

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*International macroeconomic theory shows that domestic tax policy in a global economy affects foreign economic conditions via complex, dynamic interactions through relative prices, tax revenues, and wealth distribution. This paper proposes a tractable quantitative framework for assessing tax policies that is consistent with this theory. The significance of the international transmission channels of tax policy is evaluated in the context of a “workhorse” two-country dynamic general equilibrium model. The model is used to assess the potential effects of the European harmonization of capital income taxes. The results show that this policy, if enacted along the lines followed in harmonizing value-added taxes, yields large capital outflows and a significant erosion of tax revenue for Continental Europe while the opposite effects benefit the United Kingdom. Welfare in the United Kingdom rises as result, while Continental Europe may incur a substantial welfare cost.*

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<sup>1</sup>This paper was written for the Economic Policy Conference in Honor of Assaf Razin organized by Elhanan Helpman and Efraim Sadka and sponsored by the Pinhas Sapir Center at Tel Aviv University. Comments and suggestions by the discussant, Michel Strawczynski, and by Jonathan Heatcote, Assaf Razin and Hans-Werner Sinn are gratefully acknowledged. The methodology proposed here is adapted from my joint work with Linda Tesar, to whom I am also grateful for many helpful conversations. Part of the analysis also borrows from work Linda and I did with Assaf on constructing macroeconomic estimates of effective tax rates.

## 1. Introduction

One of the main themes in the extensive research program of Assaf Razin is the analysis of the policy implications of the dynamic macroeconomic theory of international taxation. In joint work with Jacob Frenkel, with Elhanan Helpman, and with Efraim Sadka, Razin produced several seminal contributions that were among the first to formalize the microfoundations of the intertemporal analysis of tax policies in open economies with fully integrated goods and assets markets.<sup>2</sup> These studies were part of a growing literature that examined the effects of tax policies within the context of dynamic general equilibrium models in two-country settings or under the small open economy assumption.<sup>3</sup>

The intertemporal models of international taxation identified weaknesses in the use of the traditional static models to conduct tax policy analysis in open economies, but they also highlighted the complications involved in a theoretically-consistent assessment of the implications of tax policies. The complex dynamic issues inherent to intertemporal closed-economy models, which involve determining whether tax changes are permanent or transitory as well as anticipated or unanticipated, are significantly compounded by the effects that result from three widely-studied international transmission channels of domestic tax policies. First, the price channel (i.e., a change in domestic tax policy alters the equilibrium prices of goods and financial assets that countries trade and even the foreign prices of nontraded goods). Second, the wealth

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<sup>2</sup>This work includes Frenkel and Razin (1986a), (1986b), (1987), (1988) and (1989), Helpman and Razin (1987), Razin and Sadka (1989), (1990), and (1991), and Frenkel, Razin and Sadka (1991).

<sup>3</sup>A short list of other early contributions to this literature includes Aschauer and Greenwood (1985), Greenwood and Kimbrough (1985), Buiters (1987), and Bovenberg (1986). Frenkel and Razin (1987) and Turnovsky (1997) review the literature in detail.

channel (i.e., depending on tax incidence and the structure of financial markets, changes in tax policy can redistribute wealth, that is the holdings of physical and financial assets, across countries, across heterogenous individuals, or across generations). Third, the tax–revenue-erosion channel (i.e., as a by-product of the price and wealth channels, domestic tax changes may erode foreign tax revenues and thus force foreign tax hikes or expenditure cuts that are potentially welfare-reducing). Sustainability issues also arise because international external effects on welfare resulting from these transmission channels can lead to strategic behavior on the part of fiscal authorities and to international tax competition.

Early attempts to develop policy applications of the dynamic macroeconomic theory of international taxation were hampered by limitations of the quantitative methods available in the mid 1980s. The articles that Assaf Razin wrote with Jacob Frenkel and Steve Symansky were pioneering efforts at developing a policymaking framework for tax analysis in open economies consistent with this new dynamic theory (see Frenkel, Razin and Symansky (1990) and (1991)). To make their quantitative framework tractable, the model they proposed adopted simplifying assumptions that limited its ability to capture in full the three international transmission channels of tax policy.<sup>4</sup> In particular, the assumptions of unitary intertemporal elasticity of substitution in consumption and linear production technologies restricted the global interaction of tax policies through the equilibrium determination of goods and factors prices, the distribution of wealth, and

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<sup>4</sup>Similar simplifying assumptions are also present in more recent quantitative studies of the effects of tax policy in open-economy general equilibrium models. For example, Eggert (1998) and Sorensen (1999) quantify the price and revenue-erosion effects of international tax competition in models in which dynamic effects are minimized for tractability. Eggert studies a two-period model and Sorensen examines a static multi-sector model similar to those used in computable general-equilibrium models of trade or public finance.

the dynamics of tax bases. Moreover, their quantitative framework had to do without an important element of the assessment of tax policies in intertemporal models, namely the computation of the welfare cost associated with the transitional dynamics of the economy triggered by tax changes (see Lucas (1990)). This was because the required numerical methods were just being developed in a parallel literature on quantitative closed-economy studies of optimal taxation.

This paper has two main objectives. The first one is methodological: to fill some of the remaining gaps in the process of building a framework that integrates the tax policy principles derived from dynamic open-economy macroeconomics with a quantitative policymaking tool.<sup>5</sup> The second is to provide an answer to a specific tax-policy question using this tool. In particular, the aim is to determine what are the effects on macroeconomic dynamics and social welfare that are likely to result from the harmonization of capital income taxes within the European Union.

The quantitative framework proposed here is a two-country variation of the workhorse model of modern macroeconomics: the neoclassical, general-equilibrium model of exogenous balanced growth driven by labor-augmenting technological change. This model is not sophisticated in several aspects, in particular those related to distributional issues, to the long-run determinants of economic growth or to the interaction between fiscal and monetary policies, but it does capture with a high degree of complexity the three channels of international transmission

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<sup>5</sup>Goulder and Eichengreen (1989) developed a framework with a similar objective aimed at quantifying the effects of trade liberalization in a setup with a detailed industry-level breakdown of production. One important difference with the analysis conducted here is that they abstracted from the revenue-erosion-effect by assuming that government budget constraints are balanced each period via lump-sum taxation.

of tax policies identified earlier. The setup of the model borrows heavily from the model proposed by Mendoza and Tesar (1998). This paper differs in that it focuses on assessing the significance of the three transmission channels of tax policy and in studying their key determinants. The paper also adopts a different treatment of the revenue-erosion effect by requiring countries to react to unintended changes in their ability to raise tax revenue by adjusting taxes on immobile factors of production (i.e., labor). This results in more costly distortions than those that result from the adjustments in indirect taxes considered by Mendoza and Tesar. The emphasis is on proposing a framework that can easily adapt to uses in policy circles, so the model is calibrated to actual data for the four largest economies of Western Europe (France, Germany, Italy and the United Kingdom), including estimates of their current tax structures.<sup>6</sup>

The quantitative analysis shows that international transmission effects via relative prices, the world distribution of wealth, and erosion of tax revenues are very significant. A modest cut in the capital income tax in the United Kingdom results in a noticeable gain in social welfare (i.e., lifetime utility) that is equivalent to a gain of 1.1 percent in the trend level of consumption per capita. However, the combined effect of the three transmission channels leads to a staggering welfare loss in Continental Europe equivalent to a fall of 3.7 percent in the trend level of consumption per capita.

These results are intended to show the large magnitude of the global transmission effects of tax changes, rather than as a reflection of the likely outcome of the tax cut by the United Kingdom. Given the large welfare loss for Continental Europe, one would expect that retaliation

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<sup>6</sup>Gauss code to simulate the model is available from the author on request.

by Continental Europe would lead to tax competition or to efforts to undertake coordinated adjustments in capital income taxes. The precedent for this is the harmonization of indirect taxes already undertaken in the European Union. Hence, the analysis shifts to consider harmonization of taxes on the income of mobile factors of production (i.e., capital) as a proxy for an “ad-hoc” coordinating mechanism to avoid harmful tax competition.

Tax harmonization is modeled as an agreed common tax rate on capital income that is a linear combination of the tax rates currently in place in Continental Europe and in the United Kingdom. The already-harmonized rates of indirect taxation are kept unchanged and, as a result, tax-revenue-erosion effects need to be offset by adjustments in the distortionary tax rate on the labor income.<sup>7</sup> The experiment also assumes that the existing levels of government purchases and entitlement payments (which are lower in the United Kingdom than in Continental Europe) are kept constant at all times. At current tax rates, tax harmonization implies a capital tax cut for the United Kingdom and a tax hike for Continental Europe -- the current U.K. effective capital income tax rate is about 47 percent while the average of effective capital income tax rates for France, Germany and Italy is nearly 28 percent.<sup>8</sup>

The model predicts that under the above conditions harmonization of capital income taxes is not a good idea. The best-case scenario is one in which Continental Europe increases its capital income tax to match the U.K.’s. Welfare in the United Kingdom increases by an amount

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<sup>7</sup>Tax harmonization as modeled here is not the outcome of tax competition or of “efficient” cooperation setting tax rates that represent some explicit cooperative equilibrium amongst national tax authorities. For a quantitative analysis of cooperative and noncooperative solutions to international tax competition see Mendoza and Tesar (2001).

<sup>8</sup>These are the 1996 estimates of effective tax rates computed using the method proposed by Mendoza, Razin and Tesar (1994).

equivalent to a 1.3 percent increase in trend consumption per capita, while welfare in Continental Europe increases only by 0.1 percent. The labor income tax is reduced by 1.1 percentage points in the United Kingdom and by 5.7 percentage points in Continental Europe. Any harmonized capital income tax set lower than the current U.K. tax rate increases the welfare gain for the United Kingdom but reduces it for Continental Europe. At harmonized tax rates set 5 percentage points or more below the U.K. tax, Continental Europe suffers a welfare loss. In the case in which the harmonized tax rate is set to the average of current U.K. and Continental Europe tax rates, the welfare gain for the U.K. is 2 percent but the loss for Continental Europe is 2.7 percent. Adjusting to the tax-revenue-erosion effect requires the United Kingdom to raise its labor tax by 1.8 percentage points while the labor tax in Continental Europe remains nearly unchanged.

The above results reflect the fact that, since the U.K. starts with the high capital tax and Continental Europe with the low tax, cutting the U.K. tax and raising the tax in Continental Europe induces important efficiency gains in favor of the United Kingdom. Cutting the U.K.'s capital income tax attracts capital into this economy, increasing its capital stock and its ability to raise tax revenue over time (so that small adjustments in the labor tax are enough to preserve intertemporal fiscal balance). The opposite occurs in Continental Europe. The higher capital income tax is not an effective means of increasing tax revenue in the face of the capital outflows that follow, and if the outflows are sufficiently large (i.e., the lower is the harmonized tax rate relative to the current U.K. tax rate), Continental Europe may end up increasing its labor income tax as well in order to preserve intertemporal fiscal balance. If the tax rate is harmonized so that Continental Europe raises its tax to match the existing U.K. tax, the "relative efficiency loss" is minimized and as a result this is the best-case scenario for Continental Europe.

The rest of the paper proceeds as follows. Section 2 presents the structure of the model and discusses the solution method and the calibration of parameter values. Section 3 uses the model to examine the implications of European capital tax harmonization. Section 4 reflects on some important caveats of the analysis and presents general conclusions.

## **2. A Dynamic General Equilibrium Model of Taxation in Open Economies**

The model is a modest variation of the two-country dynamic general equilibrium models of fiscal policy that originated in Assaf Razin's work from the 1980s, as reviewed in the introduction. The model features two perfectly-competitive, representative-agent economies with perfectly-integrated goods markets and perfect mobility of financial capital. Tax policy analysis is conducted by taking as given pre-determined time paths of government outlays and studying the effects of cuts in particular taxes subject to the constraint that other taxes need to be raised in order to satisfy the governments' intertemporal budget constraints.

The model differs from those in the literature of the 1980s in that the specification of preferences and technology is modified to conform to those consistent with the neoclassical general-equilibrium model of exogenous balanced growth driven by labor-augmenting technological change (see King, Plosser and Rebelo (1988)). This framework, and variants close to it, have been widely-used in quantitative closed-economy applications to study macroeconomic effects of fiscal and monetary policies (see King and Rebelo (1990) Cooley and Hansen (1992) and Chari, Christiano and Kehoe (1994)).

The assumption that long-run growth is exogenous implies that assessments of changes in the tax structure are conducted abstracting from any effects that tax policy may have on economic growth over the long run. This is at odds with the *qualitative* predictions of a large

class of endogenous growth models, but it is in line with their *quantitative* predictions and with the evidence indicating that long-run growth seems independent of the variations of tax rates observed in the data, despite significant efficiency gains on investment rates (see Lucas (1990) and Mendoza, Milesi-Ferretti and Asea (1997)). Note, however, that despite negligible growth effects, the welfare implications of tax policies that result from efficiency gains or losses can still be very large (see Lucas (1990), Cooley and Hansen (1992) and Mendoza and Tesar (1998)).

The model examined here also differs from the early models in Frenkel and Razin (1986b) and (1987) and Helpman and Razin (1987) in that their models focused on non-Ricardian real effects of changes in lump-sum taxes by adopting the Blanchard-Yaari setup of overlapping generations. In these models, households have a shorter life horizon than governments so a cut in current taxes induces a wealth transfer from individuals born in the future (i.e., those that are alive to pay future taxes but not to enjoy current tax cuts) to those currently alive. In contrast, the model in this paper considers conventional non-Ricardian distortionary taxes on factor incomes and consumption in an infinite-horizon environment. Wealth effects are still present but in the form of cross-country wealth redistributions in the size and location of capital stocks.

### *2.1 Structure of the Model*

The exogenous rate of labor-augmenting technological change is the same in each country and is given by  $\gamma$ . The long-run rate of output growth is therefore the same in the two countries and is also equal to  $\gamma$ , and expenditure flows grow at that same rate in steady state in each country. This long-run balanced-growth assumption restricts the permissible set of functional forms that can be used to represent utility and production functions to those that

satisfy the properties identified in King, Plosser and Rebelo (1988). As usual, all variables in the model, except leisure and labor, are rendered stationary by expressing them as a ratio of the state of technology (the transformed variables are written in lower case), and the familiar transformations of the subjective discount rate and the asset-evolution equations apply. The paper focuses, without loss of generality, on the competitive equilibrium of the detrended model. Since these are standard procedures, the details are omitted. Also in line with standard practice, foreign variables are identified by asterisks.

Each country is inhabited by identical, infinitely-lived households. They maximize a conventional isoelastic lifetime utility function over intertemporal sequences of consumption ( $c$ ) and leisure ( $\ell$ ):

$$\sum_{t=0}^{\infty} [\beta(1+\gamma)^{1-\sigma}]^t \left( \frac{(c_t \ell_t^a)^{1-\sigma}}{1-\sigma} \right), \quad \sigma > 1, \quad a > 0, \quad 0 < \beta < 1. \quad (1)$$

In this expression,  $\beta$  is the households' subjective discount factor,  $1/\sigma$  is the intertemporal elasticity of substitution in consumption, and  $a$  is a coefficient that governs the intertemporal elasticity of labor supply for a given value of  $\sigma$ . Note that the stationary transformation of the model implies an effective discount factor given by  $\beta(1+\gamma)^{1-\sigma}$  instead of  $\beta$ .

Households maximize (1) subject to the following sequence of budget constraints, taking as given all relative prices and fiscal policy variables:

$$(1+\tau_c)c_t + (1+\gamma)(k_{t+1} + q_t b_{t+1} + q_t^s d_{t+1}) + \left( \frac{\eta}{2} \left( \frac{x_t}{k_t} - z \right)^2 - 1 \right) k_t = \quad (2)$$

$$(1-\tau_L)w_t L_t + (1-\tau_K)(r_t - \delta)k_t + b_t + d_t + e_t$$

for  $t = 0, \dots, \infty$ . The left-hand-side of (2) measures household expenditures. These are made of purchases of consumption goods, which include an ad-valorem sales tax  $\tau_C$ , new capital goods,  $k_{t+1}$ , private international bonds,  $b_{t+1}$ , and domestic government bonds  $d_{t+1}$ . The price of capital and the price of consumer goods differ because investment incurs quadratic capital-adjustment costs as a function of the ratio of net investment ( $x_t$ ) to existing capital ( $k_t$ ). The coefficient  $\eta$  determines the speed of adjustment of the capital stock, while  $z$  is set equal to the long-run investment-capital ratio to ensure that at steady state the capital adjustment cost is zero. Net investment is defined as  $x_t \equiv (1+\gamma)k_{t+1} - (1-\delta)k_t$ , where  $\delta$  is the rate of depreciation of the capital stock.<sup>9</sup> For simplicity, international and government bonds are represented as discounted bonds. The price of private bonds is  $q_t$ , the price of public bonds is  $q_t^g$ , and their gross real rates of return are  $R_t \equiv (1/q_t)$  and  $R_t^g \equiv (1/q_t^g)$  respectively.

The right-hand-side of (2) measures after-tax household income, which is made of factor and non-factor incomes. Factor income is derived from supplying capital and labor ( $L_t$ ) to firms at pre-tax factor prices  $w_t$  and  $r_t$ . Labor and capital income are taxed at ad-valorem tax rates  $\tau_L$  and  $\tau_K$  respectively. The capital income tax is based on the residence principle and the tax code provides for a depreciation allowance. Non-factor interest income is derived from the liquidation of holdings of discounted public and private bonds. This income is assumed to be tax-free, but Mendoza and Tesar (1998) examined the implications of relaxing this assumption and found that it can have important effects on the quantitative predictions of the model. Non-

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<sup>9</sup>Investment costs, or similar frictions like gestation lags, differentiate physical from financial assets so as to prevent the instantaneous adjustment of the domestic marginal product of capital to the world interest rate. Without these costs, the model would predict unrealistically large swings in investment and current account balances.

factor income also includes lump-sum transfers from government that represent entitlement payments, these are denoted by  $e_t$ .

Equation (2) embodies an implicit assumption of “extreme home bias” in that domestic capital and public debt are owned only by domestic households. This assumption allows the model to support competitive equilibria in which free international trade in private bonds and residence-based taxation co-exist, yet there can be different country-specific tax rates on domestic capital income owned by the residents of each country. As argued later, this is not possible if shares on physical capital and/or government bonds are freely traded across countries (see also Frenkel et al. (1991)). Other forms of financial-market segmentation, such as trading costs or short-selling constraints, could be introduced with the same purpose, but so far they have proven inadequate to solve the “home bias” puzzle observed in the data and they would complicate the model significantly.

Households also face a standard no-Ponzi-game restriction, which together with (2) implies that the present value of household income must equal that of expenditures plus any initial asset holdings. In addition, households face a standard normalized time constraint in choosing labor supply and leisure allocations:

$$\ell_t + L_t = 1 \tag{3}$$

Firms play a simple role in this model because they face a static optimization problem (since investment decisions are being made by households, who are assumed to own the firms). In particular, firms maximize profits subject to constant-returns-to-scale production technologies taking as given pre-tax factor prices. The detrended production function is Cobb-Douglas:

$$F(k_t, L_t) = k_t^{1-\alpha} L_t^\alpha, \quad 0 < \alpha < 1. \tag{4}$$

where  $\alpha$  is the labor income share. Without loss of generality, all corporate taxes are viewed as included in the capital income tax levied on households. Thus, at equilibrium firms demand factors of production according to standard marginal productivity rules and earn zero profits.

Fiscal policy is made of three elements. First, predetermined sequences of unproductive government expenditures and lump-sum transfer or entitlement payments,  $(g_t + e_t)$  for  $t=0, \dots, \infty$ . Second, a set of time-invariant tax rates  $(\tau_C, \tau_L, \tau_K)$ . Third, a sequence of public bond issues,  $d_t$ , for  $t=1, \dots, \infty$ . The government budget constraint is given by:

$$(g_t + e_t) + d_t = \tau_C c_t + \tau_L w_t L_t + \tau_K (r_t - \delta) k_t + (1 + \gamma) q_t^s d_{t+1} \quad (5)$$

The left-hand-side of this equation measures total government outlays (i.e. goods purchases and entitlement payments) plus debt payments. The right-hand-side measures tax revenue and proceedings from sales of newly-issued bonds. Government purchases, entitlements, and tax rates are viewed as the exogenous instruments of fiscal policy. Thus, any deficit or surplus in the fiscal balance (i.e., in the gap between goods purchases, entitlement payments and tax revenue) is offset by an endogenous change in public debt net of interest and principal on existing debt. Since the government also faces a no-Ponzi-game constraint, the present value of government expenditures plus entitlement payments must equal the present value of tax revenue net of payments on initial public debt.<sup>10</sup> Hence, given its tax and expenditure policies and its initial bond position, the government must choose a time path of public bond issues that satisfies its intertemporal budget constraint.

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<sup>10</sup> Note that (2), (5), and the no-Ponzi-game constraints on households and government imply that the present value of the trade balance equals  $b_0$ .

Public debt is "Ricardian" in the sense that, given  $d_0$  and the policy choices on government purchases, entitlement payments, and tax rates, the competitive equilibrium can be represented either with the path of public bonds dictated by (5) or with a sequence of lump-sum taxes (subsidies),  $T_t$ , set to an amount equal to the fiscal deficit (surplus) each period (see Mendoza and Tesar (1998) for details):

$$T_t = \tau_C c_t + \tau_L w_t L_t + \tau_K (r_t - \delta) k_t - (g_t + e_t) \quad (6)$$

Since the object of interest for determining the competitive equilibrium of the economy and the financing needs of the government is the time path of the fiscal balance, not the path of the stock of public bonds (which at any rate depends on the exogenous initial condition  $d_0$ ), the analysis is conducted using this "Ricardian" representation of the government budget constraint. This change implies also that the relevant budget constraint for households becomes:

$$(1 + \tau_C) c_t + (1 + \gamma)(k_{t+1} + q_t b_{t+1}) + \left( \frac{\eta}{2} \left( \frac{x_t}{k_t} - z \right)^2 - 1 \right) k_t = \quad (7)$$

$$(1 - \tau_L) w_t L_t + (1 - \tau_K)(r_t - \delta) k_t + b_t + e_t + T_t$$

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

$$k_t^{1-\alpha} L_t^\alpha + (k_t^*)^{1-\alpha^*} (L_t^*)^{\alpha^*} = \quad (8)$$

$$c_t + c_t^* + x_t + \frac{\eta}{2} \left( \frac{x_t}{k_t} - z \right)^2 k_t + x_t^* + \frac{\eta^*}{2} \left( \frac{x_t^*}{k_t^*} - z^* \right)^2 k_t^* + g_t + g_t^*,$$

$$b_t + b_t^* = 0 \quad (9)$$

The competitive equilibrium of this two-country world is given by sequences of pre-tax prices  $[r_p, r_t^*, q_p, w_p, w_t^*]$  and allocations  $[k_{t+1}, k_{t+1}^*, b_{t+1}, b_{t+1}^*, x_p, x_t^*, L_p, L_t^*, \ell_p, \ell_t^*, c_p, c_t^*, T_p, T_t^*]$ , for  $t=0, \dots, \infty$ , such that: (a) households in each country maximize utility subject to their corresponding budget constraints, time constraints and no-Ponzi-game constraints, taking as given pre-tax prices, the values of all fiscal policy variables, and date-0 holdings of capital and foreign bonds, (b) firms maximize profits subject to the Cobb-Douglas technologies taking as given pre-tax factor prices, (c) the government budget constraints hold for given tax rates and exogenous sequences of government purchases and entitlements, and (d) the global markets of goods and bonds clear.

## 2.2 *Stationary Equilibrium, Calibration and Design of Tax Policy Experiments*

Changes in tax policy are represented by changes in some or all of the elements of the domestic and/or foreign triples of time-invariant tax rates  $(\tau_C, \tau_L, \tau_K)$  and  $(\tau_C^*, \tau_L^*, \tau_K^*)$ . The analysis is not aimed at solving a Ramsey optimal taxation problem but at studying the effects of once-and-for-all changes in time-invariant tax structures. This is more in line with the Harberger-Feldstein “nth-best economics” approach of assessing the magnitude of the distortions associated with existing policies and identifying simple, welfare-improving policy changes (see Harberger (1964)). Moreover, results for efficiency gains of tax reforms from closed economy studies by Lucas (1990) and Cooley and Hansen (1992) show that the large welfare effects of changes in time-invariant tax rates may dwarf the small effects added by time-varying taxes.<sup>11</sup>

There are two important steps to follow in the process of turning the model proposed here

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<sup>11</sup>This does not alter the fact that both Ramsey optimal taxes and changes in time-invariant taxes are both time-inconsistent in standard dynamic equilibrium models like the one studied here. This problem, however, also plagues other conventional models used to assess the effects of tax changes in policy institutions.

into a quantitative framework suitable for evaluating the macroeconomic effects of tax policies. First, the model must be initialized with parameter values for the functional forms that represent preferences, technology and government policies such that the model can mimic key features of the data of the actual economies that are to be the subject of tax policy assessments. Second, the quantitative solutions of the model must be obtained using an algorithm that can solve accurately for competitive equilibria in the steady-state balanced-growth paths of alternative tax policy regimes and for the transitional dynamics between these long-run equilibria. Assessments of the welfare implications of changes in tax policy depend crucially on the latter, since tax policies that may seem welfare-improving on the basis of comparisons across long-run equilibria can be welfare-reducing once the effects of transitional dynamics are factored in (see Lucas (1990) and Mendoza and Tesar (1998)).

The calibration and simulation steps referred to above are familiar from the quantitative tax policy experiments conducted using closed-economy dynamic macroeconomic models as in Cooley and Hansen (1992) and Chari, Christiano and Kehoe (1994). However, a particular complication arises in an open-economy context because international spillovers of tax policies imply changes in long-run net foreign asset positions and these positions are dependent on initial conditions. This differs sharply from the standard result in closed-economy models in which the steady-state capital stock is independent of initial conditions.

The computation of the initial “status quo” steady-state equilibrium under given current tax policies is straightforward because it is the outcome of a calibration process in which the model is parameterized so as to match basic long-run features of the data -- the same process followed in the calibration exercises performed in closed-economy models. In contrast, the

computation of the steady-state balanced-growth equilibrium under a proposed new tax policy, and the corresponding transitional dynamics, differ markedly from closed-economy studies because the dependency on initial conditions of the net foreign asset positions implies that the new long-run equilibrium and the dynamics by which it is reached must be solved simultaneously. Further details on this issue are provided in the analysis of the model's stationary equilibrium that follows below.

The long-run equilibrium of the home country along a balanced-growth path is summarized by the following system of simultaneous equations:

$$\frac{k}{y} = \frac{\beta(1+\gamma)^{1-\sigma}(1-\alpha)(1-\tau_k)}{(1+\gamma) - \beta(1+\gamma)^{1-\sigma}[1-\delta(1-\tau_k)]} \quad (10)$$

$$\frac{x}{y} = (\gamma + \delta) \frac{k}{y} \quad (11)$$

$$\frac{c}{y} = 1 - \frac{x}{y} - \frac{g}{y} - \frac{nx}{y} \quad (12)$$

$$\frac{nx}{y} = \left[ \beta(1+\gamma)^{1-\sigma} - 1 \right] \frac{b}{y} \quad (13)$$

$$L = \frac{\left( \frac{1-\tau_L}{1+\tau_C} \right) \alpha}{a \frac{c}{y} + \left( \frac{1-\tau_L}{1+\tau_C} \right) \alpha} \quad (14)$$

Equation (10) follows from the steady-state Euler equation for physical capital. It expresses the

capital-output ratio at steady state,  $k/y$ , as a function of preference and technology parameters, and the tax on capital income. Equation (11) is the law of motion for capital accumulation evaluated at steady state, which determines the steady-state investment rate,  $x/y$ . Equation (12) is the resource constraint of the economy, which follows from consolidating the budget constraints of households and government. This equation determines the steady-state consumption-output ratio,  $c/y$ , as a function of the investment rate, the GDP share of government purchases,  $g/y$ , and the net exports-output ratio,  $nx/y$ . Equation (13) is the foreign-asset evolution equation along a balanced-growth path. Since the parameter restrictions set in (1) imply  $\beta(1+\gamma)^{1-\sigma} < 1$ , equation (13) implies that a long-run positive (negative) foreign asset position finances a long-run trade deficit (surplus). Equation (14) represents long-run equilibrium in the labor market as given by the equality between the marginal rate of substitution between consumption and leisure and the post-tax marginal product of labor.<sup>12</sup>

The problem with determining the effect of tax policy changes on the long-run equilibrium of this economy is that equations (10)-(14) form an under-identified simultaneous equation system with six unknowns ( $k/y$ ,  $x/y$ ,  $c/y$ ,  $L$ ,  $nx/y$  and  $b/y$ ) but only five equations. Equations (10)-(11) determine  $k/y$  and  $x/y$  and they are identical to the equations that appear in closed-economy models. However, even given these solutions for  $k/y$  and  $x/y$ , (12)-(14) cannot determine solutions for  $c/y$ ,  $L$ ,  $nx/y$  and  $b/y$ , and hence for the level of all endogenous variables.

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<sup>12</sup>Note that (14) can be used to determine the equilibrium allocation of labor at any date  $t$  along an equilibrium path, not just at steady state, if the corresponding ratio  $c_t/y_t$  is known. Note also the differences in the long-run incidence of the different taxes. The capital income tax affects  $k/y$ ,  $x/y$  and, through the effect of changes in  $x/y$  on  $c/y$ , the equilibrium allocation of labor, while consumption and labor taxes affect equilibrium labor but not the investment rate and the capital output ratio.

The “status quo” initial calibration of the model avoids this problem by taking  $nx/y$  from the data. More precisely, the system (10)-(14) is solved for  $\delta, \beta, a, c/y$  and  $b/y$ , given the values of other preference and technology parameters, tax rates, and long-run averages of  $k/y, x/y, nx/y, g/y$  and  $L$  obtained from macroeconomic time series.

The initial calibration proceeds as follows. The home country is calibrated to the United Kingdom and the foreign country is calibrated to an arithmetic average of the three largest European economies (France, Germany, and Italy). The calibration is set at a quarterly frequency and uses national accounts data from the OECD's *National Accounts* and the updated estimates of effective tax rates for macroeconomic models calculated in Mendoza and Tesar (2001) using the method proposed by Mendoza, Razin and Tesar (1994).<sup>13</sup> A summary of the calibration parameters is reported in Table 1.

The initial tax rates in the calibration were set to the 1996 estimates reported by Mendoza and Tesar (2001). Figure 1-3 plot the time series of each tax rate in the four European economies considered here. As can be observed, harmonization of indirect taxes has produced very similar consumption tax rates across the four countries, while important differences remain with regard to factor income taxes. In particular, the tax on capital income is higher in the United Kingdom than in the other countries, while the opposite is true with respect to labor income taxes. There are also upward trends in the labor income tax rates of France, Germany

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<sup>13</sup>Mendoza et al. (1994) estimated tax rates for the seven largest industrialized countries (G7) over the 1968-90 period by combining tax revenue data with information from the aggregate balance sheets of households, corporations, and government from national accounts. Mendoza, Milesi-Ferretti and Asea (1997) updated these estimates until 1992 and extended them to include several OECD countries. Mendoza and Tesar (2001) updated the G7 estimates through 1996. The data are available at <http://www.econ.duke.edu/~mendozae/pdfs/newtaxdata.pdf>

and Italy. The magnitude of the difference in each tax may be subject of debate, depending on the method used to estimate tax rates, but these estimates do capture the widely-accepted view that the tax on capital income is higher in the United Kingdom than in Continental Europe.

The fiscal sector of the model is also calibrated to match the observed GDP-shares of government purchases in the four countries considered. In this regard there is also a noticeable asymmetry between the United Kingdom and the other three countries. The average GDP share of government expenditures over the 1990-1999 period is 0.19 in the U.K. relative to a mean of 0.21 for the other three countries (the individual country averages are 0.24 for France, 0.2 for Germany and 0.19 for Italy).

Another important aspect of the calibration relates to the initial foreign asset positions, since these together with the initial capital stocks determine the initial wealth of the economy and also determine which country experiences negative or positive income effects on account of changes in the world real interest rate triggered by tax changes. The model treats Europe as a closed economy unit, so that the sum of the bond positions of the United Kingdom and Continental Europe adds to zero. At steady state the foreign asset-GDP ratio is linearly-related to the net exports-GDP ratio as shown in equation (13). Hence, the initial calibration pins down the initial foreign asset-GDP ratios by requiring the model to match the U.K.'s observed net exports-GDP ratio. The U.K. average net exports-GDP ratio for the period 1990-1999 is -0.01.<sup>14</sup>

The rest of the calibration is similar to that adopted by Mendoza and Tesar (1998) and is completed as follows. The per-capita GDP growth rate is set to  $\gamma=1.56$  percent per year (0.39 percent per quarter), the intertemporal elasticity of substitution is set at  $1/2$  ( $\sigma=2$ ), and the annual

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<sup>14</sup>The mean net-exports GDP ratio for Continental Europe over the same period is 0.015.

investment rate is set at the 1990-1999 average for the United Kingdom (0.17). The quarterly capital-output ratio is set to 2.16 (8.62 annually), the labor income share is set at 0.64, and the fraction of time spent at work is set to 20 percent. These three parameter values match estimates for the U.S. economy reported by Cooley and Hansen (1992). These three ratios are likely to differ slightly from those observed in Europe, but the aim of the analysis is to emphasize asymmetries in fiscal policy under an otherwise symmetric two-country model.

Given the above ratios, parameter values, and tax rate estimates, the solution of the system of steady-state equations (10)-(14) implies  $\delta=1.61$ ,  $\beta=0.99$ ,  $a=2.675$ ,  $c/y=0.64$  and  $b/y=1.044$ . Preference and technology parameters are set identical across the United Kingdom and Continental Europe in order to highlight the effects of asymmetries in fiscal policy (in tax rates as well as in government expenditures and entitlements). Given identical preference and technology parameters, the foreign-country version of the system (10)-(14) is solved for  $k^*/y^*$ ,  $x^*/y^*$ ,  $nx^*/y^*$  and  $L^*$  imposing the market clearing condition  $b+b^*=0$ .

The above results imply a value for the long-run real interest rate of 6.1 percent per year. The long-run real interest rate is determined by the standard condition from balanced-growth models:  $r = \rho - \gamma\sigma$ , where  $\rho$  is the rate of time preference (i.e.,  $\rho=\beta^{-1}-1$ ). It is important to note that this long-run real interest rate is invariant to tax policy changes. Hence, international transmission of tax policies via changes in the world's real interest rate can only occur during the transitional dynamics. This is an implication of the assumptions of exogenous long-run balanced growth and residence-based taxation.

Table 1 reports estimates of  $c/y$ ,  $g/y$ ,  $x/y$ , and  $nx/y$ , and the GDP ratios of tax revenue for both economies in the data and in the model, as well as the ratios of capital stock and output

across the U.K. and Continental Europe. The calibration was set to mimic the U.K. ratios  $g/y$ ,  $x/y$ , and  $nx/y$ , but all the other GDP ratios in the Table are endogenous solutions of the long-run equilibrium of the model. The model's ratios are roughly the same as in the data, including the tax revenue-GDP ratios, suggesting that the "status quo" calibration is a reasonable benchmark to conduct tax policy analysis.

The parameters of the capital-adjustment-cost function can be set once the long-run investment rate and capital-output ratio are known. These two determine the investment-capital ratio as  $x/k=(x/y)/(k/y)$ . As mentioned earlier,  $z$  is set equal to  $x/k$  so that adjustment costs are zero in the long run. The value of  $\eta$  is set so that the rate of convergence to the long-run, balanced-growth path matches empirical estimates of conditional growth-convergence coefficients (see Mendoza and Tesar (1998)). This implies  $\eta=10$ .<sup>15</sup>

The solution of the transitional dynamics from the initial "status quo" balanced-growth path to the new long-run equilibrium associated with a proposed tax policy change is obtained using the method proposed by Mendoza and Tesar (1998). Their approach ensures that the following two critical properties of the competitive equilibrium are satisfied. First, the long-run foreign asset positions to which countries converge for a proposed tax policy scenario are consistent with foreign asset accumulation dynamics starting from initial conditions that correspond to the foreign asset positions in the "status quo" calibration. Second, the levels of government purchases and entitlement payments that prevailed before the tax policy change are

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<sup>15</sup>This approach can yield values of  $\eta$  larger than speed-of-adjustment estimates suggested by the empirical investment literature. However, the higher values can also be a proxy for multi-sector interactions or other frictions absent from the model that slow down capital accumulation. A variant of the present model with nontraded goods, calibrated with a lower value of  $\eta$ , produces similar results for cuts in the U.S. capital income tax as the present model.

kept constant at all times. Thus, changes in taxes under a proposed tax policy must be “revenue neutral” in present value (if one tax is cut and tax revenue falls as a result, the others need to increase to ensure that the present value of tax revenue matches the present value of the unchanged government outlays). The implicit assumption is that government debt adjusts to fill any gap between tax revenue and total government outlays in any given period.

The dynamic consistency of the bond positions is accomplished by solving the model combining the King-Plosser-Rebelo (KPR) linear approximation algorithm with an iterative "shooting" routine on holdings of foreign bonds. The algorithm starts with an initial guess for the long-run bond positions in the long-run equilibrium under the proposed tax policy (typically the same as the “status quo” bond positions). The long-run equilibrium conditions are then solved using the simultaneous equation system in (10)-(14) and the transitional dynamics are solved by linearizing around these new balanced-growth allocations using KPR. The transitional dynamics are traced for 2500 periods setting as initial conditions the values of  $k$ ,  $k^*$ , and  $b$  in the “status quo” calibration. These simulations yield foreign bond positions that converge to some long-run bond positions. If the latter differ from the initial guess, the new results are adopted as a new guess and the process is repeated.

The intertemporal “revenue neutrality” of the proposed tax changes is ensured with a second iterative routine. Once a consistent solution for foreign asset dynamics is obtained, the algorithm checks whether the present value of the unchanged government outlays (i.e., expenditures plus entitlement payments) equals the present value of tax revenue. If this equality fails, one of the taxes 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. The algorithm

starts again with the shooting routine on foreign bonds using the updated taxes, and the process is repeated until it converges to consistent solutions for both taxes and long-run bond positions.

Once a full solution of a tax policy experiment is obtained (i.e., long-run equilibria before and after the tax change as well as transitional dynamics), the welfare effect of the policy is computed by calculating the “compensated lifetime consumption variations” proposed by Lucas (1987) and (1990). Accordingly, the net welfare effect of a tax policy change is measured by the constant percentage change in consumption in all periods that leaves households indifferent between the lifetime utility obtained by remaining in the “status quo” equilibrium and the lifetime utility obtained by undertaking the tax policy change (inclusive of the stage of transitional dynamics in consumption and leisure).

The solution method proposed here can accommodate alternative assumptions with regard to the structure of the tax adjustments that are considered. Tax policies can be examined as unilateral changes adopted by one country, with the other country adjusting either distortionary or lump-sum taxes to preserve its revenue neutrality in the face of international spillovers of the tax changes made by the first country. Alternatively, tax policy changes can be examined as world-wide changes in some distortionary taxes met by world-wide revenue-neutral changes in other distortionary taxes.

### *2.3 The International Transmission Channels of Tax Policy*

The model features the three main channels by which changes in country-specific tax rates have external effects on foreign countries mentioned in the introduction. First, the price channel: changes in tax policy alter the world’s real interest rate (or the price of internationally-traded bonds) as well as the prices of nontradable factors of production. Second, the wealth

channel: changes in tax policy have efficiency effects that affect the total capital stock of the world economy and the distribution of capital across countries. Third, the tax-revenue-erosion channel: the tax bases of foreign countries are affected by the price and wealth channels, forcing foreign tax authorities to implement undesired changes in their own structure of distortionary taxes in order to maintain intertemporal fiscal balance.<sup>16</sup>

The basic economic intuition behind the operation of these three channels can be derived from studying the optimality conditions that characterize the competitive equilibrium of the model. Consider in particular the optimal saving and investment margins in the home and foreign countries. Because of the assumptions of residence-based taxation, extreme home bias, and tax-free foreign interest income, these optimal margins imply that:

- (a) The intertemporal marginal rates of substitution in consumption are the same across countries and both are equal to the inverse of the price of international bonds (which is the world's gross real interest rate).
- (b) The *post-tax* net marginal products of capital (including the marginal capital-adjustment costs) are equalized across countries, and both are also equal to the world's gross real interest rate.

The second of these conditions implies that the home-country net marginal product of capital differs from that in the foreign-country by a factor equal to  $(1-\tau_k)/(1-\tau_k^*)$ . If the home country cuts its capital income tax, arbitrage of the returns on domestic capital and foreign bonds by home agents leads them to borrow from abroad to take advantage of the increased post-tax

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<sup>16</sup> Alternatively, this revenue-erosion effect can be modeled as forcing changes in government expenditures with production or utility benefits, which would also be distortionary.

return on domestic capital, and thus finance the attractive new investment without a costly consumption sacrifice. Foreign agents are willing to lend but at the right price (since neither country is a small open economy), and this price is reflected in the equality of intertemporal marginal rates of substitution listed in condition (a). A capital outflow from the foreign country into the home country takes place and the world's real interest rate rises. Moreover, as capital flows out of the foreign country, the foreign wage rate and price of capital (which differs in the short-run from the price of consumption and the world interest rate because of the adjustment costs) also change. These interest rate and factor price changes represent the price channel of the international spillovers of tax policies. Note that the interest rate change can only be transitory because, as explained earlier, the long-run real interest rate is independent of tax policy and is set by the exogenous-growth condition:  $r = \rho - \gamma\sigma$ .

The wealth channel works through the process by which the home (foreign) country increases (reduces) its debt and capital stock during the transition, as the efficiency gains of the domestic tax cut materialize. The domestic debt build-up in the early stages of transition reflects not only the borrowing incurred to expand the capital stock but also the debt acquired to distribute evenly over time the consumption benefits of the increased wealth of the economy. The home country runs a trade deficit in the short run but at steady state it services its increased long-run debt with a permanent trade surplus, while the opposite happens in the foreign country. Following Mendoza and Tesar (1998), the short-run debt build-up can be referred to as a *smoothing effect* and the servicing of the increased long-run debt can be labeled an *income-redistribution effect*. The physical wealth of the world economy may increase or fall as a result of the efficiency gains of the tax cut (i.e., the world's capital stock may rise or fall), but the home

country always becomes relatively wealthier than the foreign country. There is also a change in portfolio composition, the home country holds more physical capital and less foreign bonds at the new long-run equilibrium.

The revenue-erosion channel operates via the effects of the price and wealth channels on the labor-income, capital-income, and consumption tax bases of the foreign country. This channel is the net result of the endogenous changes in foreign allocations and prices that determine each tax base in response to the change in home-country taxes. As the present value of foreign tax revenue changes, the foreign tax authority is faced with the choice to either adjust tax rates or cut government outlays. The model forces the latter to remain constant (although the quantitative framework can be easily altered to consider adjustments in these outlays). As a consequence, the foreign government must choose a combination of tax-rate changes that yields a present value of tax revenue equal to the present value of the unchanged government outlays.<sup>17</sup>

The intuition developed above to account for the international transmission channels of tax policy is based on studying the effects of a cut in the domestic capital income tax. However, changes in the domestic labor income tax or the consumption tax induce effects on the foreign economy that operate through similar channels. The price channel is less direct because changes in domestic labor or consumption taxes do not have a direct effect on the price relevant for the investment margin in the foreign country (as is the case with the capital income tax). A cut in domestic labor or consumption taxes raises the domestic post-tax effective real wage and induces the classic income and substitution effects on the domestic supply of labor. The subsequent

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<sup>17</sup>Since government outlays are constant at their pre-tax-harmonization level, the present value of these outlays changes only due to changes in the time path of the world's interest rate.

change in the equilibrium labor allocation has an indirect effect on the domestic marginal product of capital and this sets in motion the arbitrage effects at work in the case of changes in the domestic capital income tax. The wealth channel and the tax-revenue-erosion channel are also present since they reflect the effects of the price channel on the allocations of the world general equilibrium. However, it is reasonable to argue that the less-direct nature of the price channel makes all three channels of international transmission of tax policy weaker when they operate through changes in the consumption or labor taxes than through the capital income tax.<sup>18</sup>

One additional implication of the model's saving and investment optimality conditions is the intuition for the result that the model can support competitive equilibria in which the foreign and domestic capital income tax rates can differ despite residence-based taxation<sup>19</sup>. As argued earlier, this is due to the "extreme home-bias" assumption that there is no international trade in shares of ownership of the capital stock located in each country. If equity trading were allowed, and the tax system is residence-based, the home (foreign) households would pay  $\tau_K$  ( $\tau_K^*$ ) on their holdings of both  $k$  and  $k^*$  ( $k^*$  and  $k$ ). Arbitrage of returns across bonds, domestic capital and foreign capital would then require that both *post tax* and *pre tax* net returns on capital in each country be equalized, and this in turn would require that  $\tau_K = \tau_K^*$  at equilibrium.

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<sup>18</sup>This can be the case even when the efficiency-driven welfare gains from cuts in the labor income tax exceed those resulting from cuts in the capital income tax. Mendoza and Tesar (1998) show an example of a U.S. labor tax cut with a larger welfare gain than a U.S. capital income tax cut even though the three channels of international spillovers are weaker.

<sup>19</sup>The assumptions of extreme home bias and residence-based taxation could be replaced with source-based taxation without altering the saving and investment optimality conditions (a) and (b) described earlier. Actual tax systems are a mixture of residence- and source-based systems. Frenkel, Razin, and Sadka (1991) show that personal income taxes across OECD countries are mainly residence based, while corporate income taxes are source based in principle but supplemented by treaties that allow for credits or deductions so as to approximate residence-based taxation.

### **3. The Case Against European Tax Harmonization**

This section uses the quantitative framework proposed in Section 2 to analyze the macroeconomic effects of harmonizing capital income taxes in Europe. The experiment shares the basic features of the ones conducted by Frenkel, Razin and Symansky (1990) and (1991) and Frenkel, Razin, and Sadka (1991) for the case of the harmonization of the value-added tax (VAT). They followed the spirit of the European VAT harmonization agreements and modeled VAT harmonization as a policy by which a high-VAT, low-income-tax country and a low-VAT, high-income-tax country agree to set a common VAT rate in between their existing high and low rates, adjusting income tax rates as necessary to maintain tax-revenue neutrality period by period.<sup>20</sup> One important difference in the analysis conducted here, however, is in that tax-revenue neutrality is not maintained period by period but in terms of the present value of tax revenue matching the present value of unchanged government outlays. Thus, the experiments below relax the assumption implicit in the VAT harmonization studies that governments cannot engage in optimal borrowing to smooth taxation.

In the capital-income tax harmonization experiments conducted here, the U.K. starts as a high-capital, low-labor tax country while Continental Europe starts as a low-capital, high-labor tax country. The two economies agree to harmonize the capital income tax rate at a common level in between their initial tax rates. The high degree of consumption-tax harmonization already attained in Europe is preserved by assuming that the consumption tax rate is left

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<sup>20</sup>VAT harmonization in Europe was achieved gradually through various agreements since 1967. Convergence of VAT rates was achieved by implementing agreements on bands for allowable general VAT rates (with a narrowing width that eventually converged to a minimum rate) and lists of products eligible for reduced and zero rates.

unchanged in all countries. The initial levels of government expenditures and entitlement payments are kept constant in each period throughout the experiment, so that the assessment of the effects of tax changes is not blurred by endogenous changes in government outlays. This implies that each country must adjust its labor income tax rate so as to ensure that the present-value of its total tax revenue matches the present value of its unchanged government outlays.

One important caveat is that the significance of each of the international transmission channels of tax policy is difficult to isolate in the results of the tax harmonization experiments because they reflect the combined effect of the three transmission channels resulting from changes in capital and labor tax rates in both countries in the model. To address this issue, the tax harmonization analysis is preceded by an analysis of a unilateral cut in the capital income tax by the United Kingdom that provides a clearer picture of the operation of the international spillover effects driven by relative prices, wealth distribution, and tax-revenue erosion.

### *3.1 Unilateral Cuts in the Capital Income Tax of the United Kingdom*

The unilateral tax cut in the United Kingdom is modeled as a cut of 5 percentage points in its capital income tax from 47.2 percent to 42.2 percent. Results are reported for two scenarios. First, an ideal scenario in which Continental Europe is assumed to have access to lump-sum taxation in order to deal with the revenue-erosion effect and maintain intertemporal fiscal balance. Second, a scenario fully consistent with the assumptions of the model in which Continental Europe must use the labor tax to offset any adverse tax-revenue effects.

The first experiment is useful for gauging the magnitude of the erosion of foreign tax revenue directly induced by the U.K. tax cut free from the indirect effects of endogenous adjustments in distortionary tax rates in Continental Europe. The experiment also yields the best

outcome for Continental Europe in terms of welfare because the use of lump-sum taxes to offset the tax-revenue-erosion effect neutralizes the distortions associated with endogenous changes in the labor or capital taxes needed to maintain intertemporal fiscal balance.<sup>21</sup>

Figures 4-6 plot the transitional dynamics of the variables that reflect the three channels of transmission of tax policy in this first experiment. The dynamics are plotted as percent deviations from the initial “status quo,” as calibrated in Section 2, for 300 quarters after the cut in the U.K. capital tax. Figure 4 plots the effects on prices. The world real interest rate increases by about 5 tenths of a percentage point (in the plot the interest rate data are scaled by a factor of 100) and then declines gradually to return to its initial state, which is invariant to any tax policy changes because of the exogenous balanced-growth considerations discussed earlier. This interest rate change may seem small, but the changes in equilibrium allocations and welfare that it leads to are very large (as shown below).

With regard to pre-tax factor prices, in the United Kingdom the wage rate rises on impact by about 0.5 percent and then rises gradually to settle at a level nearly 3 percent higher than in the pre-tax-cut equilibrium. The rental rate on domestic capital falls on impact by about 1 percent and continues to fall gradually until it reaches a level nearly 5.5 percent lower than at the initial equilibrium. Pre-tax factor prices also change in Continental Europe but the changes are transitory. On impact, the rental rate on foreign capital increases by 1 percent while the wage

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<sup>21</sup>In as much as the Ricardian representation of public debt as transfers holds, one can say that when time-invariant consumption, labor or capital taxes are used the foreign government still has some access to lump-sum taxation. There is a clear difference, though, in that changing these tax rates is distortionary even if Ricardian transfers are used to compensate for temporary fiscal deficits or surpluses, while there are no extra distortions when the tax-revenue-erosion effect is offset with lump-sum taxes.

rate falls by about 0.5 percent. Both return gradually to their pre-tax-cut levels following a monotonic convergent path.

Figure 5 illustrates the significance of the wealth redistribution effect with respect to holdings of physical capital. The capital stock of the United Kingdom increases following a concave, monotonous convergent sequence to a level 9 percent higher than before the tax cut. The capital stock in Continental Europe declines down to a minimum of 1.4 percent below the pre-tax-cut level and then recovers somewhat to converge to a long-run equilibrium 0.9 percent below the initial level. Clearly, the world's capital stock increases as a result of the tax cut in the United Kingdom but the share of it owned by Continental Europe is smaller.

Figure 6 illustrates the tax-revenue-erosion effect. European tax revenue raises on impact by about  $3/4$  of a percentage point but it quickly falls below the initial level and converges to a long-run level  $3/4$  of a percentage point lower than before the U.K. tax cut. In this case Continental Europe uses lump-sum taxes or transfers to offset any resulting difference in distortionary tax revenue relative to government outlays. Figure 6 shows how these lump sum taxes (i.e., the fiscal deficit as a share of GDP) need to be allocated over time so as to maintain time-invariant levels of government purchases and entitlements. The plot also shows the dynamics of tax revenue and transfers in the United Kingdom, where the labor tax is increased to restore intertemporal fiscal balance (the labor tax increases only by 1.2 percentage points). Given the dynamics of factor prices, consumption, capital and labor, there is an initial decline of almost 2 percent in U.K. tax revenue followed by a recovery to a level that permanently exceeds the initial level of tax revenue by  $3/4$  of a percentage point. The plot of the U.K. fiscal deficit reflects only adjustments in public debt (i.e., *Ricardian* lump-sum transfers) used to meet

temporary tax revenue shortfalls so that the present value of distortionary tax revenue matches that of government outlays.

The U.K. tax cut sets in motion the price channel and the smoothing and income-redistribution effects of the wealth channel that lead to changes in the dynamics of macroeconomic aggregates in Continental Europe through standard income and substitution effects. In theory, some of these effects have ambiguous signs even for the functional forms used in the model. In the numerical simulation, however, Figure 7 shows that output and the supply of labor increase in Continental Europe on impact and then fall to permanently lower levels. Consumption does the opposite. It falls on impact and then rises gradually to a slightly higher permanent level. The trade balance-GDP ratio increases by 2 percentage points on impact, reflecting the transfer of resources going into building up the U.K.'s higher capital stock and consumption driven by the smoothing effect. In the long run, the trade balance-GDP ratio actually falls and is about 3/4 of a percentage point lower than in the initial equilibrium, reflecting the servicing of the debt that the U.K. accumulated in the process of convergence to its new steady-state equilibrium (i.e., the income-redistribution effect).

The welfare effects (i.e., the changes in lifetime utility) of this unilateral tax cut, including the transitional dynamics, are equivalent to an increase in trend consumption of 0.8 percent for the United Kingdom and a decline of 0.2 percent for Continental Europe. Given the modest unilateral tax cut that was considered, the large effects on prices, wealth distribution, and tax revenue, and the corresponding large changes in equilibrium allocations and welfare, indicate that the international transmission channels of tax policy are very strong. This is the case even in this best-case scenario in which the fall in the present value of tax revenue relative to that of

government outlays in Continental Europe is made up by lump sum taxation.

Consider next the same 5-percentage-point cut in the U.K. capital income tax, but discard the assumption that Continental Europe uses lump-sum taxation to maintain fiscal balance. Continental Europe has to raise its labor tax by 3.8 percentage points, from 47.4 to 51.2 percent – an unintended tax hike triggered by the unilateral tax cut in the United Kingdom. The transmission channels also result in an increase in the U.K.'s labor income tax, but one that is nearly 1/4 of a percentage point smaller than in the lump-sum tax case.

The price channel differs in that the short-lived interest rate hike is smaller, and, more importantly, factor prices in Continental Europe experience larger changes and in opposite directions compared to the lump-sum tax case. The rental rate of capital falls by 1.5 percent on impact and the wage rate rises by 1 percent. They still converge gradually following a monotonic path back to their initial levels. Pre-tax factor prices in the United Kingdom display fairly similar dynamics as before. The wealth channel is more powerful. The capital stock in the U.K. converges to a level 10 percent higher than in the pre-tax-cut equilibrium, while that of Continental Europe falls to a level 6 percent lower. The erosion of the present value of tax revenue has been prevented in both countries by the upward adjustments in labor taxes. As a result, the initial increase in tax revenue in Continental Europe is nearly 4 times larger (3 percent instead of 0.75 percent). Interestingly, the change in Continental Europe's public deficit as a share of GDP implied by the changes in public debt consistent with keeping time-invariant government outlays is still significant. On impact, the fiscal balance improves by 1.2 percentage points of GDP.

Relative to the lump-sum tax case, the net effect of the above price, wealth and tax-

erosion channels is a larger welfare gain for the United Kingdom (1.06 percent instead of 0.83) and a much larger welfare loss for Continental Europe (3.7 percent instead of 0.21). The difference between these welfare estimates across the lump-sum and labor-tax scenarios is a measure of the welfare implications of the tax-revenue-erosion channel, taking into account how the increase in the distortionary labor tax required in Continental Europe to offset the budgetary impact of the U.K. tax cut feeds back into the price and wealth transmission channels. Note that capturing these feedback effects accurately requires the model to keep track of how pre-tax factor prices, factor allocations and consumption react in equilibrium to the tax changes. In this regard, simplifying assumptions restricting the response of these variables, such as linear production technologies, exogenous capital accumulation, or unitary intertemporal elasticity of substitution in consumption, are not innocuous.

### 3.2 *European Tax Harmonization*

The analysis now turns to the harmonization of the capital income tax across Continental Europe and the United Kingdom. The harmonized tax rate is set as the weighted average of the initial rates,  $\lambda 47.2 + (1-\lambda)27.9$ , for any  $\lambda \in [0,1]$ . Government outlays are kept constant in each period in both countries and labor taxes are adjusted as necessary to keep the present value of tax revenue in each country equal to the present value of the unchanged government outlays.

Table 2 summarizes the results of the tax harmonization experiments for  $\lambda = 1, 0.75, 0.5$ . For each case, the table reports the new factor income tax rates, welfare changes, and the impact and long run effects relevant for each of the three transmission channels of tax policy. The harmonized capital income tax rates are set at 47.2, 42.4 and 37.6 percent for values of  $\lambda$  equal to 1, 0.75 and 0.5 respectively. Given the initial labor income tax rates of  $\tau_L = 24.4$  percent and

$\tau_L^*=47.4$  percent, the adjustments in labor taxes shown in Table 2 indicate that for high values of  $\lambda$  (i.e., when the harmonized capital income tax rate is closer to the existing U.K. tax) both countries cut labor income tax rates. For  $\lambda=1$  the U.K. labor tax falls to 23.3 percent and the labor tax in Continental Europe falls to 41.7 percent, while lower values of  $\lambda$  result in one or both countries increasing the labor tax. At  $\lambda=0.5$  the U.K. labor tax rises by almost two percentage points and the labor tax in Continental Europe increases by 0.5 percentage points.

From the perspective of welfare effects, tax harmonization does not make much sense. Welfare changes are positive for both countries the higher the value of  $\lambda$ , but even when the capital income tax rate is harmonized at the current U.K. rate the welfare gain for Continental Europe is very small. Lowering  $\lambda$  to 0.75 or 0.5 enlarges the U.K. welfare gain but it turns the gain in Continental Europe into a significant welfare loss. If the harmonized tax rate is set at the average of current tax rates welfare in the U.K. increases by 2.1 percent but the loss in Continental Europe is nearly 2.7 percent.

These results are driven by the large effects of the international transmission channels of tax policy. The transmission channels reflect in turn the fact that the options presented by tax harmonization imply a significant efficiency gain for the U.K. *relative* to Continental Europe because the capital income tax always falls in the former relative to the latter, while labor income taxes tend to move in the same direction in both countries. The logic that harmonization of capital income taxes allows the country with the initial low capital tax and high labor tax (i.e., Continental Europe) to switch to a higher capital tax and a lower labor tax, while the country in the opposite situation (i.e., the United Kingdom) switches to a lower capital tax but a lower labor tax, fails. In the best-case scenario for Continental Europe (with  $\lambda=1$ ), in which the harmonized

tax rate is set at the level of the initial U.K. tax, both countries preserve fiscal solvency by lowering labor taxes. As  $\lambda$  falls, the United Kingdom lowers its capital tax and the increase in the capital tax in Continental Europe is therefore smaller. The U.K. has to increase its labor tax to preserve intertemporal fiscal balance, but this is also the case in Continental Europe despite the rise in its capital tax rate because of the adverse tax revenue implications of the price and wealth channels.

The previous argument is similar to that of a dynamic Laffer curve. Continental Europe's tax rate on capital rises but the present value of tax revenue falls relative to the present value of government outlays, requiring a higher labor income tax to make up for the difference. The effects at work to produce this Laffer-curve effect operate through the general-equilibrium dynamics of pre-tax factor prices, the interest rate, factor allocations and consumption, which are the determinants of the time path of the tax base and the discount rate of the tax revenue stream.

The price channel data listed in Table 2 shows that the interest rate falls on impact, but the decline is small and it becomes even smaller as  $\lambda$  falls. The interest rate then rises gradually to return to its invariant steady-state determined by the balanced-growth condition. The impact effects on U.K. pre-tax factor prices are similar regardless of the value of  $\lambda$ , but the long run effects differ sharply. If  $\lambda=1$ , the harmonized tax rate equals the current U.K. tax rate and the steady-state conditions of the model imply that the long-run U.K. investment rate, rental rate of capital, and wage rate must be the same as before tax harmonization. As the capital income tax rate drops (with  $\lambda=0.75$  or  $0.5$ ), the long-run rental rate (wage rate) falls (rises) below (above) the pre-tax-harmonization level by as much as 9.5 (5.8) percent for  $\lambda=0.5$ . The effects on pre-tax factor prices in Continental Europe are generally larger than in the U.K.. The capital rental rate

increases on impact and in the long run, while the wage rate falls, and these effects are larger the higher the value of  $\lambda$ . These changes in factor prices, coupled with the tax rate adjustments, could help Continental Europe to raise tax revenue but the large, gradual fall in its capital stock more than offsets the movements in factor prices and yields long-run levels of tax revenue 2.5 to 3 percentage points lower than before tax harmonization.

The large wealth redistribution reflected in the wealth channel is the main result of the increase in relative efficiency in the United Kingdom. Harmonization of the capital income tax always results in the United Kingdom owning a larger share of the world's capital. The world-wide capital stock falls for high values of  $\lambda$  but increases for low values of  $\lambda$ . Interestingly, the best welfare outcome for Continental Europe (i.e., the one with the highest  $\lambda$ ) is obtained when its capital stock suffers the largest drop. The reason is that this is also the case in which the size of the redistribution of wealth in favor of the U.K. (as proxied by the sum of the absolute values of the changes in capital stocks) is the smallest, and this entails dynamics for pre-tax factor prices and consumption and labor allocations that allow the largest cut in the labor tax of Continental Europe. The resulting smaller distortion on the labor supply-consumption margin and the smaller redistribution of capital yield consumption and labor dynamics that support higher lifetime utility.

The model fails to produce solutions for cases in which  $\lambda < 0.46$ . The reason is that in this case there is no adjustment of the labor tax in Continental Europe that is consistent with maintaining a present value of tax revenue equal to the present value of government outlays. Lower  $\lambda$ 's imply lower hikes in the capital tax in Continental Europe and larger cuts in the capital tax of the United Kingdom, which imply in turn larger efficiency losses in Continental

Europe relative to the United Kingdom. Making up for the resulting larger revenue-erosion effects requires Continental Europe to increase its labor tax. However, since this tax obeys a sequence of Laffer-curve relationships each period, and since the Cobb-Douglas technology implies that these Laffer curves shift downward as Continental Europe's capital stock declines, it is possible that the present value of the sequence of tax revenue produced by the maxima of the Laffer curves falls short of what is needed to keep the present value of total tax revenue equal to that of government outlays.

#### **4. Concluding Remarks: If Harmonization is Undesirable, What Then?**

This paper examined the quantitative significance of three key international transmission channels of tax policy: the price channel, the wealth channel, and the tax-revenue-erosion channel. The theoretical foundations of these transmission channels in dynamic optimizing models of the open economy have been widely studied since the 1980s, but efforts to develop quantitative applications of the theory than can be incorporated into a policymaking framework have progressed slowly due to limitations of numerical methods. This paper borrowed numerical solution techniques developed by Mendoza and Tesar (1998) to study the features of the transmission channels of tax policy in a two-country dynamic, general-equilibrium model based on the workhorse model of exogenous growth driven by labor-augmenting technological change. The model is calibrated to key features of the fourth largest European economies and solved with an algorithm that yields accurate solutions of short- and long-run changes in net foreign asset positions and endogenous adjustments in tax rates necessary to ensure intertemporal fiscal solvency. These have been the two main hurdles encountered in developing quantitative applications of open-economy intertemporal equilibrium models of tax policy.

The findings of this paper suggest that the macroeconomic effects reflecting the dynamic, general-equilibrium implications of the three international transmission channels of tax policy are very large. When these transmission channels are taken into account, the harmonization of capital income tax rates in Europe (as proxied by the convergence of capital tax rates to an ad-hoc weighted average of existing capital income taxes) does not seem desirable – in the sense that it generally fails to yield a Pareto efficient outcome. Pareto efficiency is crucial because if one of the tax-harmonizing countries is made worse off the sustainability of the policy is called into question, and prospects for successful negotiations to implement it are poor to begin with.

What are the alternatives to capital income tax harmonization? One alternative is to explore tax harmonization in a less stringent environment, which can be viewed as an effort to undertake an Europe-wide tax reform. For instance, the harmonized indirect tax rates can be kept constant and government outlays can also be kept unchanged as before, but the tax authorities can jointly search for a Pareto-improving mix of capital and labor income tax rates that yields the same welfare gain to each country. Interestingly, this outcome is obtained with an agreement in which the U.K. keeps its tax on capital income unchanged and Continental Europe *increases* its capital income tax by 14.5 percentage points to 43.5 percent. This tax increase allows both countries to cut labor taxes and still maintain time-invariant levels of government expenditures and entitlements set at their pre-tax-harmonization levels. The labor tax falls by 0.5 and 4.9 percentage points in the U.K. and Continental Europe respectively. The welfare gain in both the U.K. and Continental Europe is equivalent to a 0.8 percent increase in trend consumption.

A second, more ambitious alternative is to obtain a quantitative assessment of the actual

outcome that Nash or Stackelberg competition among national tax authorities can be expected to yield, and compare it with the outcome of a concerted effort for tax coordination (in the sense of adopting a tax structure fully consistent with a cooperative solution of the same tax-competition game). This is the line pursued in Mendoza and Tesar (2001). There, we use the quantitative framework used in this paper as the backbone of a more complex algorithm that solves for the reaction curves of national tax authorities taking into account the full general-equilibrium dynamics that capture the global transmission channels of tax policy. These reaction curves are then used to construct numerical solutions of Nash and Stackelberg international tax competition, the outcomes of which can be contrasted with those of cooperative equilibria. This quantitative analysis can be a useful tool for exploring the analytical results on international tax competition from studies like those by Razin and Sadka (1989) and (1990). Preliminary results suggest that, in line with recent observations in the financial media and views of some Commissioners in the European Union (see *The Economist*, Feb. 10, 2001, p. 52), a good dose of tax competition might actually be welfare-improving relative to the existing tax structure, and that relative to this improvement the gains from coordinating to move to a cooperative equilibrium may be small.

It is also worth noting that the conclusion that European capital tax harmonization is undesirable is subject to important caveats that reflect some important shortcomings of the analytical model on which it is based:

1. The analysis is based solely on efficiency gains within a representative-agent framework. The model deals with large *international* redistribution effects, but ignores within-country redistribution effects which are very important in the overall assessment of

alternative tax policies at a *national* level.

2. The model assumes that tax changes do not affect the rate of economic growth over the long run. Even though there is evidence that this assumption is quantitatively justifiable for a large class of models of endogenous growth (see Mendoza, Milesi-Ferretti and Asea (1997)), there are growth effects of taxation that have yet to be explored empirically and could turn out to be important (see, for example, Peretto (1999)).
3. Tax policy in the model examined here is inherently time-inconsistent. Benevolent fiscal authorities have the incentive to reconsider previously announced tax policies if given the chance to re-optimize in the future. Economic agents take into account the entire future path of tax rates in formulating their optimal plans and these plans are time-consistent, but a government that chooses to re-optimize at some future date is oblivious to this situation. However, the European record with VAT tax harmonization suggests that the same cross-border institutions and agreements that have served as an effective commitment mechanism to make harmonized VATs sustainable could work to support broader coordinated efforts at reforming national tax systems.
4. The observed differences in tax systems currently in place in Europe (which play a crucial role in yielding the result that harmonization is undesirable) are taken as given, so the model abstracts from explaining why tax systems differ across countries in the first place. Since the economic and political forces that drive these differences are likely to be the same as those driving harmonization efforts, it is important to develop political models that can tackle this issue within a quantitative framework similar to the one examined here.

5. The model assumes that government expenditures are unproductive. While the extent to which government expenditures are beneficial for private-sector production or utility is highly controversial, it is worth acknowledging that revenue-erosion effects can lead to undesirable cuts in government expenditures or entitlement programs. Still, the costly distortions due to increases in labor taxes forced by tax-revenue erosion in the model examined here may approximate similar effects as those that would result if instead productive government expenditures had to be reduced. Hence, it is unclear whether altering the model to incorporate adjustments in productive government purchases would alter the welfare outcomes reported in the paper.
6. The quantitative results can be very sensitive to the values set for some of the model's parameters. Mendoza and Tesar (1998) showed that is particularly the case with the initial net foreign asset positions, the elasticities of labor supply and capital-adjustment costs, and the assumption of whether foreign interest income is taxed or not.

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Table 1. Calibration Parameters and the Pre-Tax-Harmonization Equilibrium

*Preference and Technology Parameters:*

$\delta=1.61$      $\beta=0.99$      $a=2.675$      $\gamma=1.56$      $\sigma=2$      $\alpha=0.64$      $\eta=10$

*Fiscal policy parameters (in percent)*

	United Kingdom	Continental Europe	France	Germany	Italy
$\tau_C$ 1/	15.6	15.6	16.0	16.4	14.7
$\tau_L$	24.4	47.4	50.1	42.4	49.8
$\tau_K$	47.2	28.0	26.1	23.9	33.9
$g/y$	19.4	20.8	23.6	19.5	19.0

*Pre-tax-harmonization balanced-growth allocations (in percent):*

	United Kingdom		Continental Europe	
	Data	Model	Data	Model
$c/y$	64.1	64.4	57.1	57.6
$x/y$	17.2	17.2	20.7	20.6
$nx/y$	-1.0	-1.0	1.5	1.1
Tax revenue	35.3	36.1	41.1	44.7
$L$		20.0		15.9
$k/k^*$		92.9		107.6
$y/y^*$		111.1		90.0

Note: The data column shows averages for the period 1990-1999. Continental Europe is an arithmetic average of data for France, Germany and Italy. The data source is the OECD's National Income Accounts and Revenue Statistics. Tax rates are the 1996 estimates of effective tax rates computed using the method proposed by Mendoza, Razin and Tesar (1994). 1/ The 1996 consumption tax in the United Kingdom is 15.2 percent but the calibration assumes an initial consumption tax that is identical across countries.

Table 2. Macroeconomic Effects of Capital Income Tax Harmonization in Europe

	Weight of current UK capital income tax					
	$\lambda=1$		$\lambda=0.75$		$\lambda=0.5$	
	Impact effect	Long-run effect	Impact effect	Long-run effect	Impact effect	Long-run effect
<i>New tax rates</i>						
$\tau K = \tau K^*$	47.17	47.17	42.37	42.37	37.56	37.56
$\tau L$	23.29	23.29	24.74	24.74	26.16	26.16
$\tau L^*$	41.72	41.72	44.12	44.12	47.85	47.85
<i>Welfare effects (percent compensating variation in trend consumption):</i>						
United Kingdom		1.26		1.68		2.05
Continental Europe		0.13		-0.59		-2.68
<i>Price channel (percent changes relative to pre-harmonization steady state):</i>						
$R$	-0.14	0.00	-0.05	0.00	0.01	0.00
$w$	1.30	0.00	1.34	3.01	1.54	5.75
$r$	-2.26	-0.01	-2.35	-5.13	-2.69	-9.46
$w^*$	-3.14	-9.58	-2.48	-6.87	-1.33	-4.39
$r^*$	5.83	19.61	4.57	13.48	2.41	8.30
<i>Wealth channel (percent changes relative to pre-harmonization steady state):</i>						
$k$	0.00	3.27	0.00	11.30	0.00	19.10
$k^*$	0.00	-22.50	0.00	-18.03	0.00	-15.79
<i>Tax-revenue-erosion channel (percent changes relative to pre-harmonization steady state)</i>						
$tr$	-2.98	0.50	-3.83	1.16	-4.86	1.80
$def/y$ 1/	-1.10	0.18	-1.42	0.40	-1.80	0.60
$tr^*$	7.19	-3.06	6.55	-2.61	6.68	-2.56
$def^*/y^*$ 1/	2.99	-1.41	2.80	-1.26	2.92	-1.26
<i>Allocations (percent changes relative to pre-harmonization steady state):</i>						
$y$	-2.26	3.26	-2.35	5.59	-2.69	7.83
$c$	3.58	0.68	1.93	1.92	0.64	2.81
$x/y$ 1/	2.78	0.00	3.73	0.93	4.86	1.80
$nx/y$ 1/	-6.88	2.23	-6.92	2.34	-7.47	2.61
$L$	-3.52	3.26	-3.64	2.51	1.01	-0.48
$y^*$	5.83	-7.30	4.57	-6.98	2.41	-8.80
$c^*$	6.52	-0.27	2.83	-1.02	-2.44	-4.36
$x^*/y^*$ 1/	-5.97	-3.37	-5.13	-2.44	-4.52	-1.58
$nx^*/y^*$ 1/	6.98	-2.63	7.11	-2.80	7.84	-3.23
$L^*$	9.25	2.52	7.23	-0.12	3.79	-4.62

Note: The initial tax rates are as reported in Table 1. The consumption tax rate remains constant and equal across countries.

1/ Difference relative to the corresponding initial GDP ratio in percentage points

Figure 1. European Capital Income Taxes

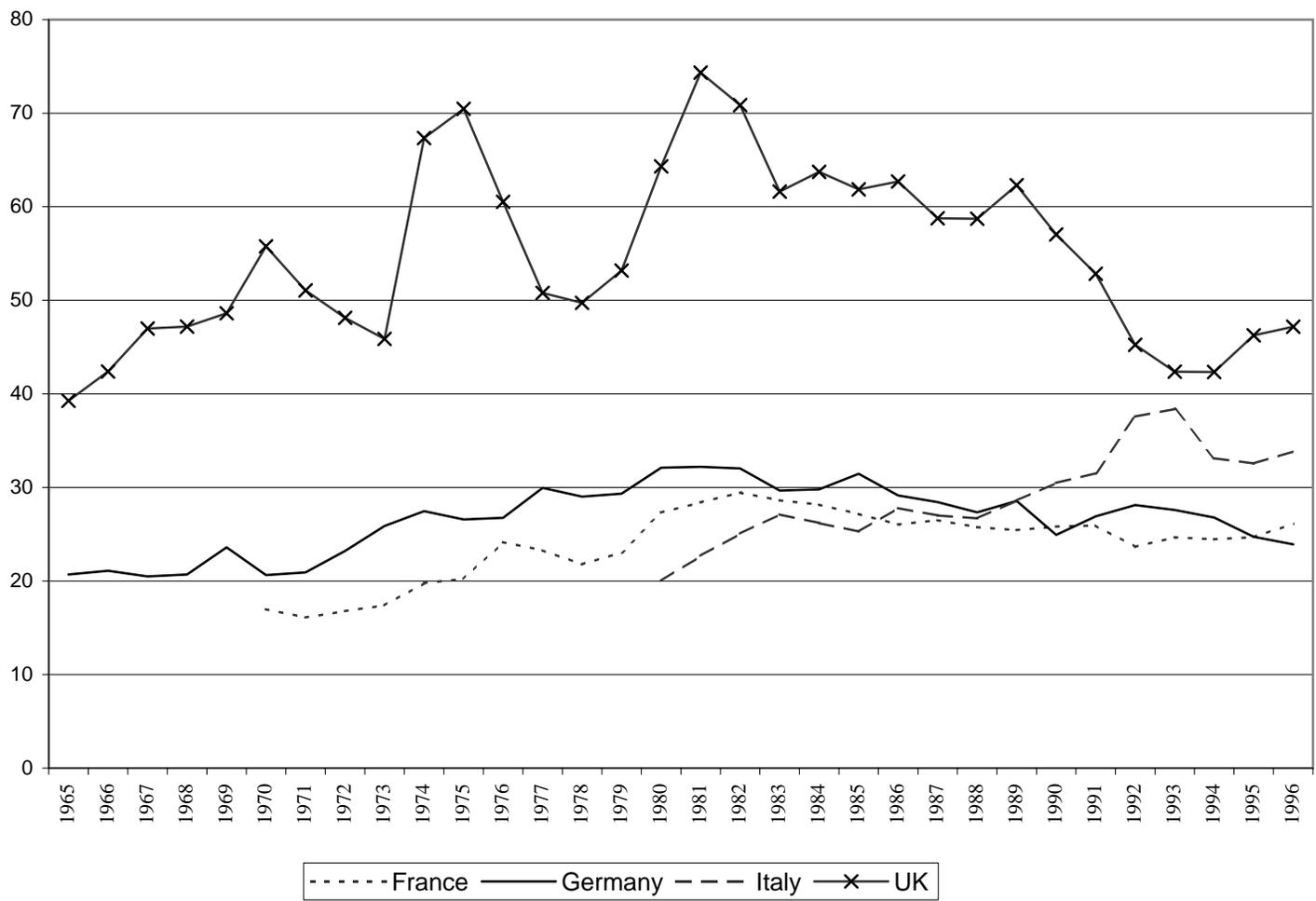


Figure 2. European Labor Income Tax Rates

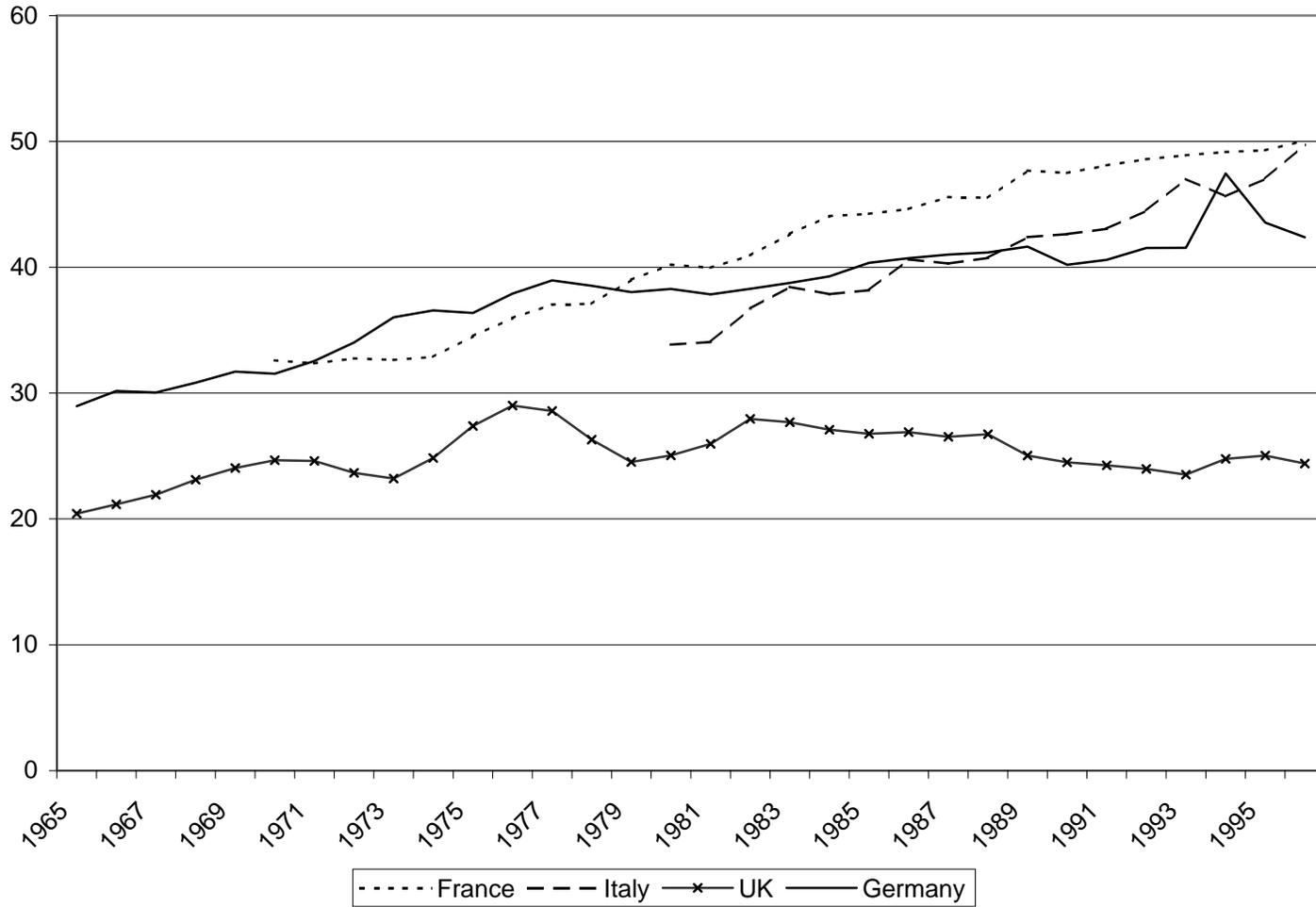


Figure 3. European Consumption Tax Rates

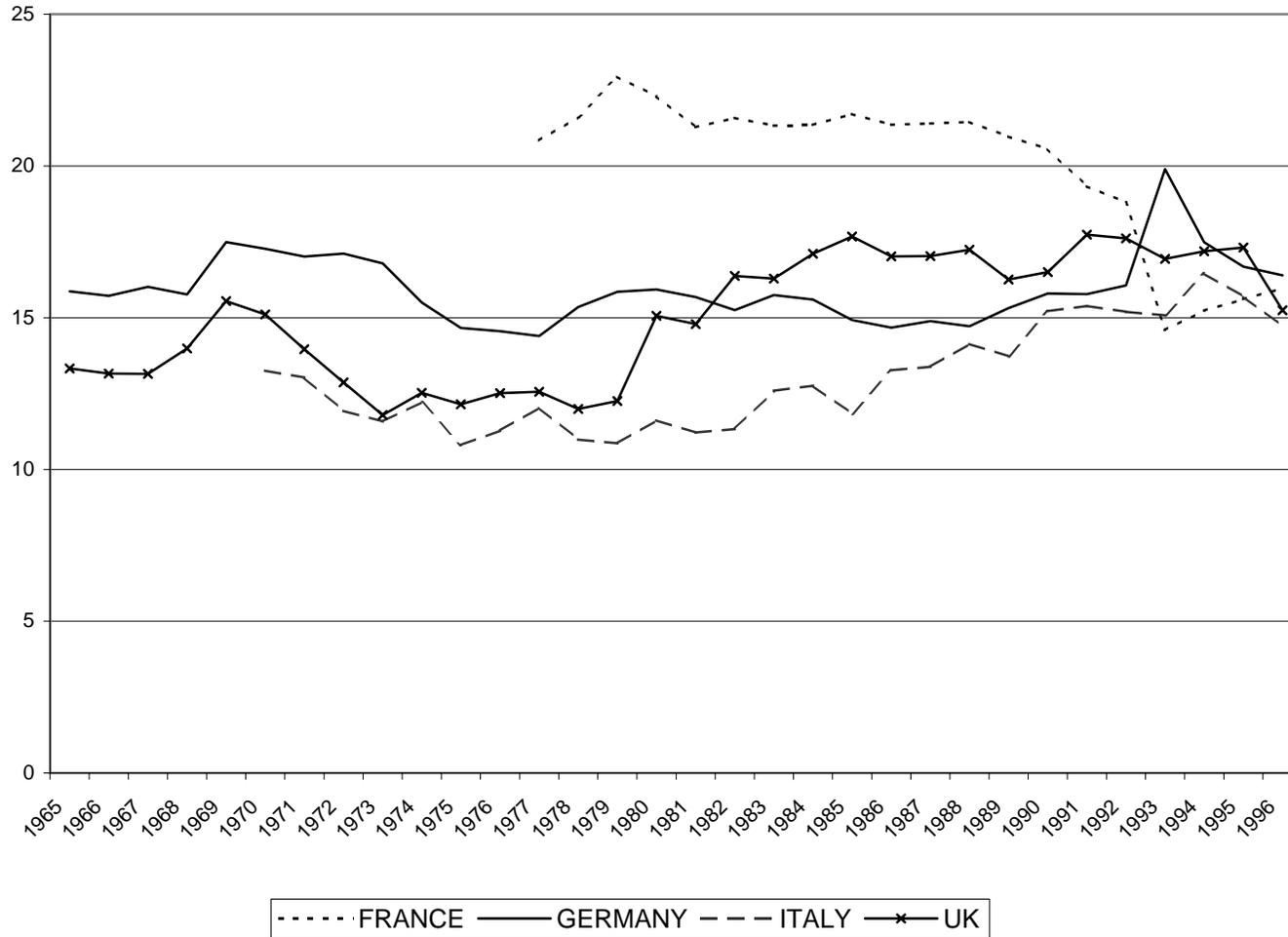
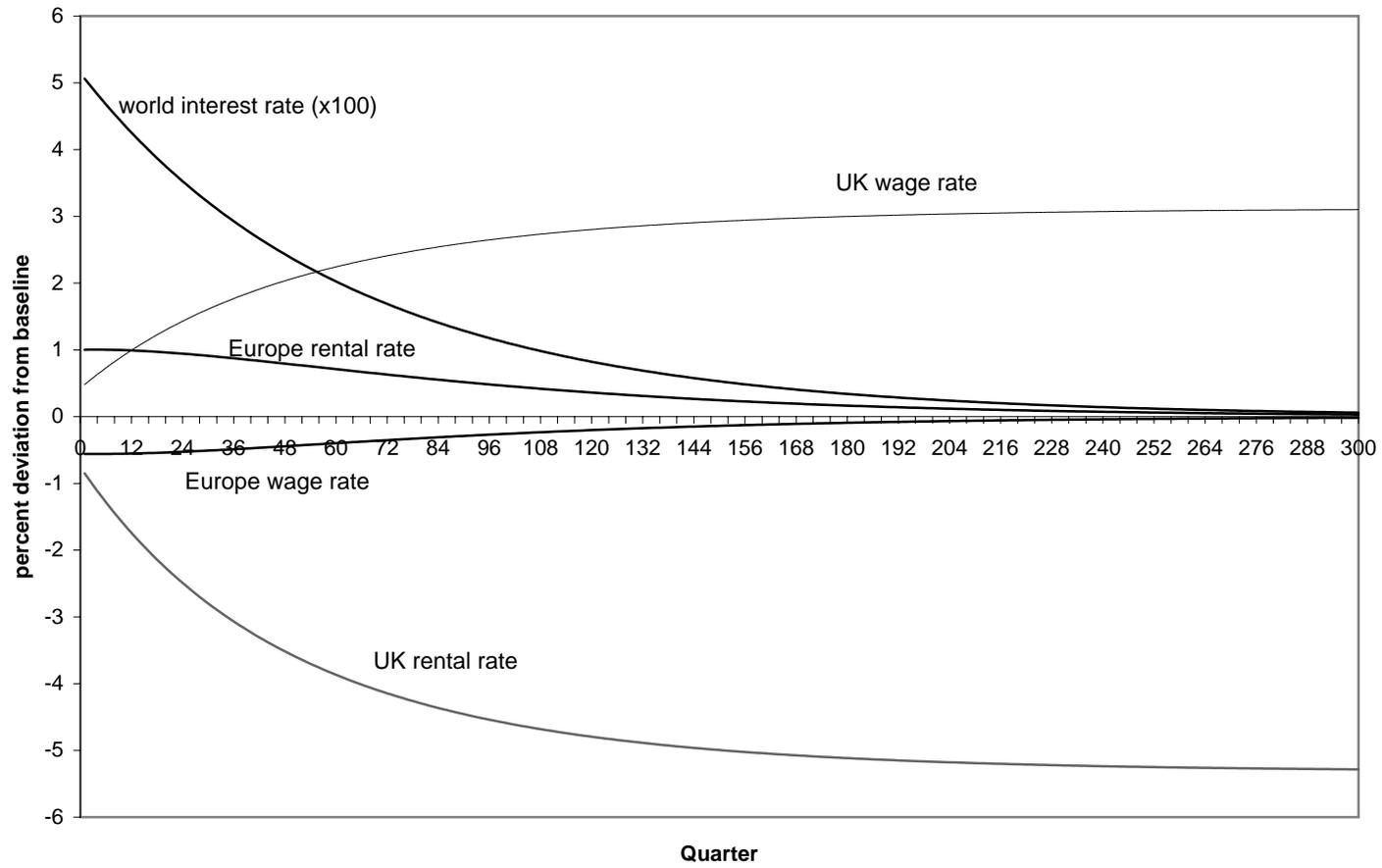
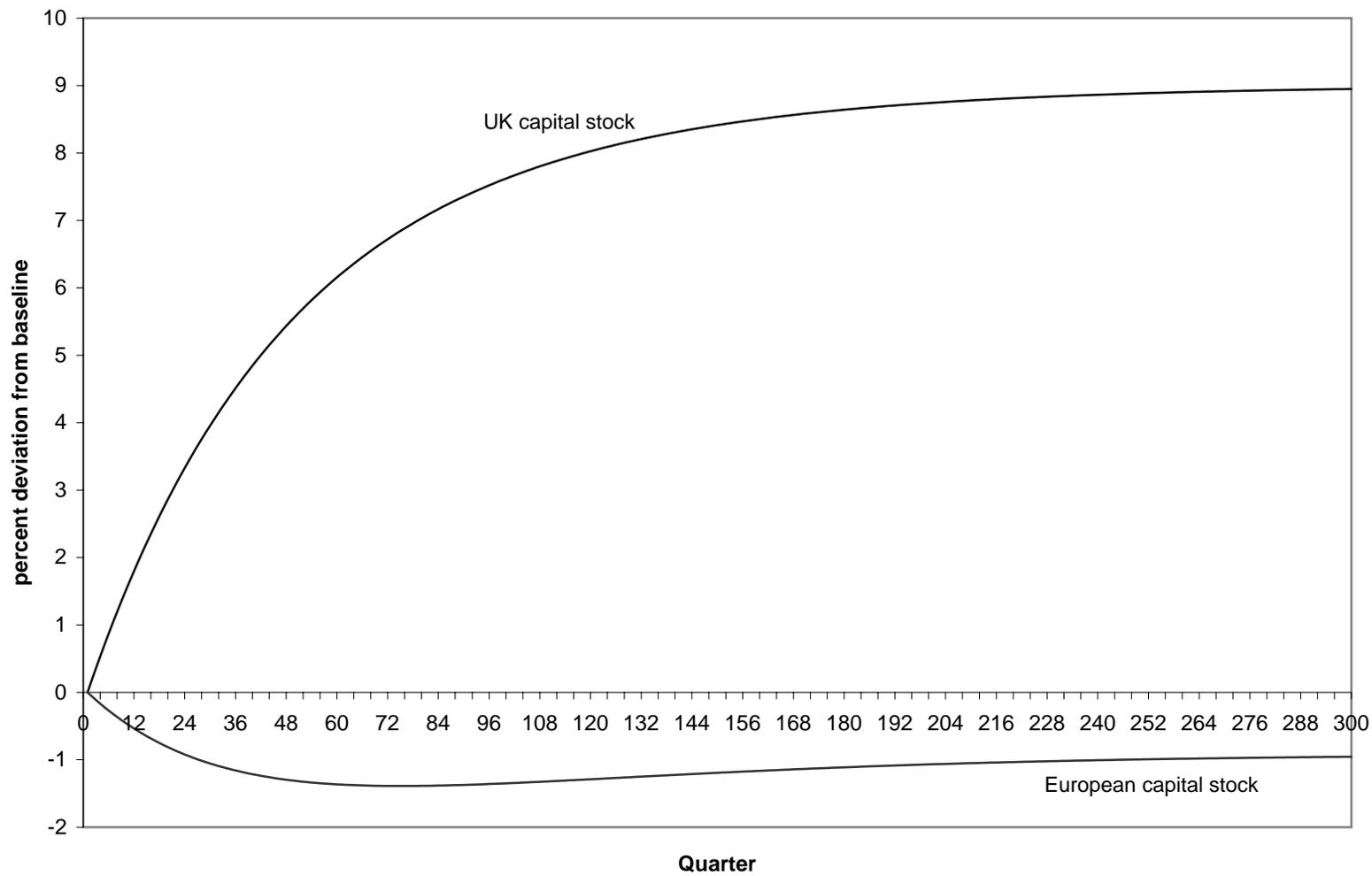


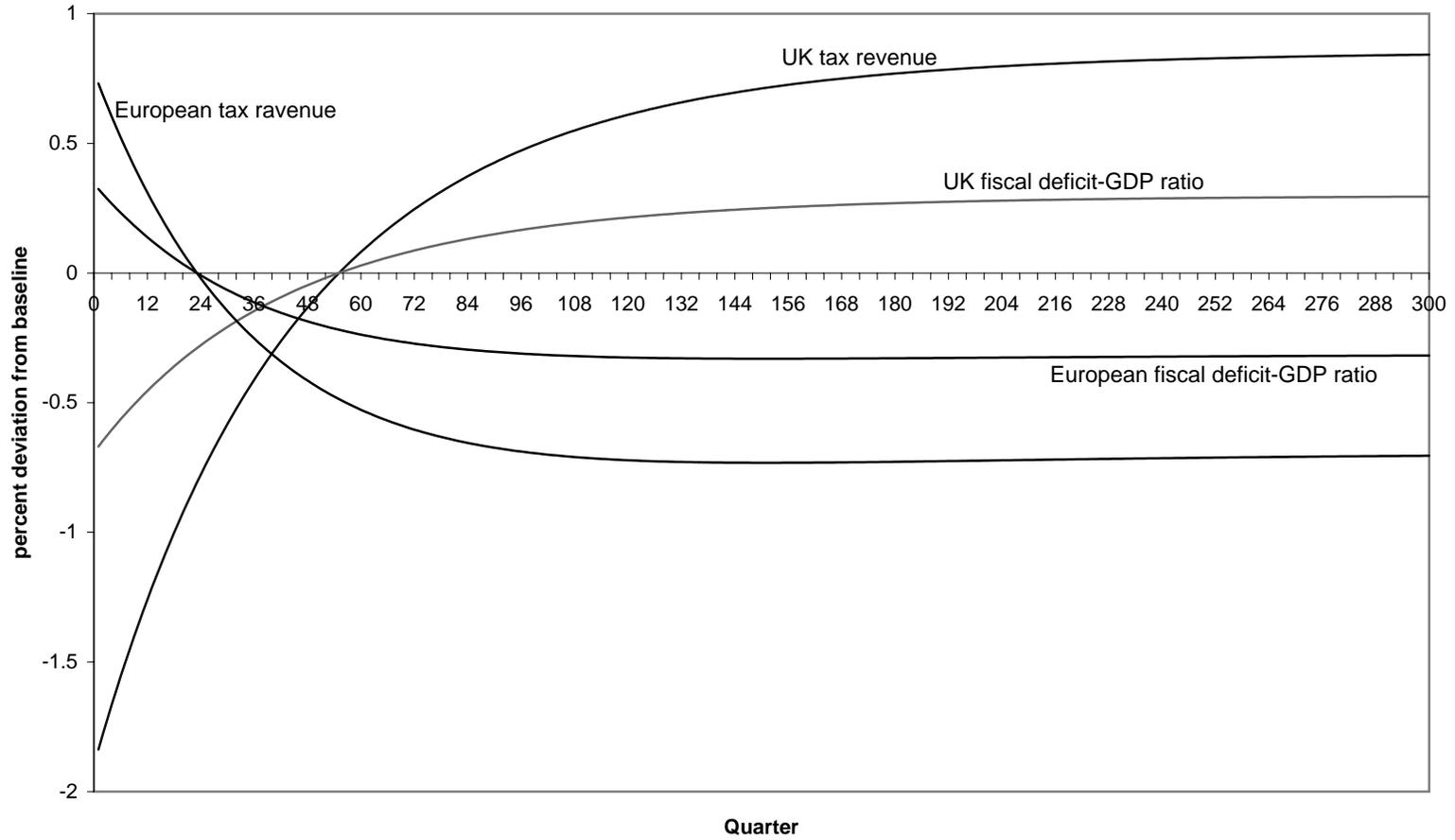
Figure 4. The Price Channel



**Figure 5. The Wealth Channel**



**Figure 6. The Tax-Revenue-Erosion Channel**



**Figure 7. Macroeconomic Dynamics in Continental Europe**

