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ABSTRACT

This paper quantifies the macroeconomic effects of capital income tax competition in the European Union using a two-country neoclassical dynamic general equilibrium model. This model incorporates three key externalities of tax competition: the relative price externality, the wealth distribution externality and the fiscal solvency externality. We consider tax strategies limited to the class of time-invariant taxes and allow governments to issue debt to smooth the tax burden. The analysis starts from a pre-tax-competition equilibrium calibrated to represent the United Kingdom and Continental Europe (France, Germany and Italy) using data from the early 1980s, just before the European integration of financial markets. When labor taxes adjust to maintain fiscal solvency, competition does not trigger a "race to the bottom" in capital taxes. The UK makes a large welfare gain and cuts its capital tax. Continental Europe increases both labor and capital taxes and suffers a large welfare loss. These results are consistent with evidence showing that over the last two decades the UK lowered its capital tax, while Continental Europe increased both capital and labor taxes. When consumption taxes adjust to maintain fiscal solvency, there is a "race to the bottom" in capital taxes but both the UK and Continental Europe are better off than in the pre-tax-competition equilibrium. The gains from coordination in all of these experiments are trivial.

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1. Introduction.

The European Union is engaged in a heated debate about international tax competition over capital income taxes. The controversy has its origins in the series of competitive cuts in corporate income taxes that EU countries began to undertake shortly after the implementation of the reforms enhancing financial market integration in the early 1980s. The first move was made by the United Kingdom with a cut of its corporate income tax rate from 52 to 35 percent, and since then other European countries have largely followed suit by lowering corporate tax rates and by adjusting other elements of their tax structure (Ireland, for example, has cut its corporate tax rate down to 12.5 percent and it is now seen as the pace-setter in corporate tax cuts). The 1997 report by the ECOFIN Ministers of the European Community (*The Package to Tackle Harmful Tax Competition*) documents in more detail the recent rounds of competitive corporate income tax cuts throughout Europe.

The opposing views in the European debate on capital income tax competition are nicely summarized in recent statements made by Frits Bolkenstein, EU Commissioner for the Internal Market, and by former French president Valéry Giscard d'Estaing. Mr. Bolkenstein is quoted as saying:

> "The priority is to reduce the tax burden EU wide. And don't even attempt to harmonize national tax systems across the board….the EU is already pledged to eliminate harmful tax competition, but a reasonable degree of tax competition would not be harmful at all: it would lead to a market-driven convergence towards lower tax rates..." (*The Economist*, Feb. 10, 2001, p. 52)

An article in the *Financial Times* (May 2, 2003, p. 2) summarizes the views of Mr. Giscard d'Estaing, which are apparently shared by the large economies of Continental Europe, as follows:

> "Plans to scrap the national veto on tax to eliminate "unfair" tax competition will be proposed by Valéry Giscard d'Estaing...He believes that without reform, the EU's single market will be distorted as countries embark on a damaging race to undercut one another's company tax rates…Britain was a pioneer in the 1980s, cutting corporation taxes from 52% to 35%, but Ireland today is the pace-setter with a rate of just 12.5%…. Both countries believe such competition is healthy…However, France and Germany are pushing for more tax harmonisation…"

In this paper we show that quantitative dynamic macroeconomic analysis can go a long way toward explaining key features of the EU competition in capital income taxes after financial liberalization and in rationalizing the opposing views represented by Frits Bolkenstein, the UK and Ireland vis-à-vis Valéry Giscard d'Estaing and Continental Europe. Our framework for the analysis is a two-country version of the workhorse neoclassical dynamic general equilibrium

model with exogenous, labor-augmenting technological change. We use this model to compare the cooperative and non-cooperative outcomes of one-shot games over capital income taxes played by countries that set taxes on factor incomes and consumption and have access to domestic debt markets in an environment of perfect international capital mobility. We calibrate the model to mimic basic macroeconomic facts of the large economies in the EU and to the tax structures they had at the beginning of the 1980s. The data show that the United Kingdom had at that time a significantly different tax structure compared to France, Germany and Italy (the three large economies of Continental Europe, or C3). In particular, capital income taxes were significantly higher in the U.K. than in the C3 and the opposite was true for labor income taxes (see Mendoza, Razin and Tesar (1994)).

The model we use in our quantitative analysis incorporates the three main international externalities of tax competition emphasized in the theoretical literature on the subject (see Persson and Tabellini (1995), Frenkel, Razin and Sadka (1991) and Turnovsky (1997)). The first externality is a variant of the traditional market-power or beggar-thy-neighbor effect on relative prices: countries engaged in tax competition use tax policy so as to influence the terms of trade or the world real interest rate in their favor. The second externality operates via a wealth-redistribution effect. Strategic cuts in capital income taxes are used to attract physical capital to locate in the tax-cutting country. Mendoza and Tesar (1998) and Mendoza (2002) show that this wealth-redistribution externality is large and can have significant welfare effects. The third externality is the fiscal solvency externality triggered by the adverse effect of tax competition on tax revenue. If tax competition triggers a "race to the bottom" in capital taxes, tax revenues are most likely to fall because (a) revenues from taxes on capital decline on account of lower tax rates (assuming these tax rates are in the upward-slopping region of their Laffer curves), (b) the flow of mobile factors of production from a high-tax country to a low-tax country directly reduces the tax base in the high tax country, and (c), in general equilibrium, the relocation of mobile factors can lower factor payments to immobile factors and overall factor income in the high tax country, thus further eroding its tax base. As tax revenue falls, governments are forced either to reduce expenditures or to raise other taxes. If government outlays have utility or production benefits, or if the alternative taxes are distorting, this fiscal solvency externality reduces welfare.

In our model, countries tax a mobile factor of production (physical capital), an immobile factor (labor) and consumption by setting time-invariant tax rates. They also trade one-period bonds under perfect international mobility of *financial* capital. This allows physical capital to relocate across countries even though ownership shares of each country's capital stock are not

traded. The international mobility of *physical* capital is less than perfect, however, because capital-adjustment costs limit the pace at which capital migrates across countries. The model also features domestic public debt so that the fiscal authorities do not need to balance the primary deficit each period, but instead equate the present value of tax revenue with the present value of a pre-determined, time-invariant amount of government outlays (i.e., current government purchases plus transfer payments). Thus, the fiscal solvency externality imposes endogenous tax adjustments but with the flexibility to use public debt as a means to smooth the tax burden.

The analysis we undertake here is mainly intended to contribute to the policy debate on tax competition in the EU, but it also contributes to the literature on international tax competition by filling two important gaps. First, this literature typically treats the three international externalities of tax policy separately, studying them in simplified dynamic environments under partial equilibrium and with governments running balanced budgets in every period. Second, most of the literature is theoretical in nature and there have been few attempts to study the quantitative implications of the theory (particularly the outcomes of tax competition and the magnitude of the gains from tax coordination). One important exception is the study by Klein, Quadrini and Rios-Rull (2001), which examines optimal, time-consistent tax policies in a setting with dynamic strategic interaction to explain why the tax on capital income is higher in the United States than in Europe. Recent papers by Sorensen (1999, 2003) and Eggert (1998) quantify the gains from tax coordination using static models that focus mainly on the relative price externality.

We examine two types of tax competition games. In the first case, the fiscal solvency externality forces endogenous adjustments in labor income tax rates so as to ensure that the present value of tax revenue in each country matches the present value of their unchanged government outlays. The second case preserves fiscal solvency by requiring instead adjustments in consumption tax rates. Examining these two alternative scenarios is important because the welfare loss of increasing consumption taxes is typically much lower than that of increasing labor taxes in dynamic neoclassical models like the one we use. Moreover, examining the capital-for-labor tax competition game is important because the harmonization of indirect taxes in the EU left little room for European countries to respond to the fiscal solvency externality by adjusting indirect taxes.

Based on these experiments we find that tax competition is immiserizing for Continental Europe and welfare-improving for the UK when labor taxes are used to maintain fiscal solvency. The UK starts the game with a lower labor income tax rate and a higher capital income tax rate. The model is consistent with the data in predicting that tax competition would *not* result in a race

to the bottom in capital tax rates. Instead, the model and the data show that the UK lowered its capital income tax, while the C3 increased *both* capital and labor income taxes to maintain fiscal solvency. These dynamics produce a non-trivial relocation of capital from the C3 to the UK. The gains from coordination are small for both the UK and the C3, and do not allow the C3 to recoup its losses from tax competition.

In the tax competition game with adjustment in the consumption tax, we do observe a race to the bottom in capital income taxes. However, as Frits Bolkenstein suggested, both countries *gain* from tax competition (relative to the status quo) as the more distorting capital income tax is replaced by higher consumption taxes. Coordination continues to yield only trivial welfare gains over the Nash competition outcome, which may explain why further tax policy coordination has proven to be an elusive goal.

The paper proceeds as follows. Section 2 describes the model and defines the tax competition environment. Section 3 calibrates the model to European data and reports the results of the tax competition experiments. Section 4 concludes.

2. The Model Economy & The Tax Competition Environment

We study international tax competition using a standard two-country, neoclassical model with exogenous long-run growth driven by labor-augmenting technological change. The model is a deterministic version of the typical two-country real-business-cycle model to which we introduce fiscal policy following the setup developed by Mendoza and Tesar (1998).[2] Each country is inhabited by identical, infinitely-lived individuals. Both countries produce a single tradable commodity using capital and labor as inputs, and trade this good and real one-period bonds issued by the private sector. All markets are perfectly competitive. To help isolate the effects of the international externalities of tax policy and their impact on tax competition, we assume that countries are fully symmetric in technology and preferences.

The rate of labor-augmenting technological change is defined as γ. All variables, except leisure and labor input, are detrended by dividing through by γ and the resulting stationary variables are written in lower case. Since long-run growth is exogenous, we can focus on the competitive equilibrium of the detrended model without loss of generality.

Households

The representative household in the home country maximizes lifetime utility over consumption, c_t, and leisure, ℓ_t:

[2] A more detailed discussion of the model and an analysis of a broader set of tax policy experiments can be found in Mendoza and Tesar (2003).

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

In this expression, β is the household's 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 σ. Note that the stationary transformation of the model implies an effective discount factor given by $\beta(1+\gamma)^{1-\sigma}$ instead of β.

The household maximizes (1) subject to the sequence of period budget constraints:

$$(1+\tau_C)c_t + (1+\gamma)\left(k_{t+1} + q_t b_{t+1} + q_t^g d_{t+1}\right) + \left(\frac{\eta}{2}\left(\frac{x_t}{k_t} - z\right)^2 - 1\right)k_t = (1-\tau_L)w_t L_t + (1-\tau_K)(r_t-\delta)k_t + b_t + d_t + e_t \tag{2}$$

for $t = 0,\ldots,\infty$, given the initial conditions $k_0>0$, b_0, and d_0. The household takes as given tax rates on consumption, labor income and capital income, denoted τ_C, τ_L, and τ_K, respectively, and lump-sum government transfer or entitlement payments, denoted by e_t. The household also takes as given the factor payment rates to labor, w_t and capital, r_t, and the prices of government bonds and foreign bonds, q_t^g and q_t (the gross real rates of return on these bonds are $R_t/(1/q_t)$ and $R_t^g/(1/q_t^g)$ respectively).

The left-hand-side of (2) measures household expenditures. These include purchases of consumption goods inclusive of the indirect tax, new capital goods, k_{t+1}, private international bonds, b_{t+1}, and domestic government bonds d_{t+1}. Investment incurs quadratic capital-adjustment costs as a function of the ratio of net investment (x_t) to existing capital (k_t). Net investment adjusted for exogenous technological progress is defined as $x_t / (1+\gamma)k_{t+1}-(1-\delta)k_t$, where δ is the rate of depreciation of the capital stock.

The right-hand side of (2) shows the household's after-tax income. We assume that the capital income tax is based on the residence principle and the tax code provides for a depreciation allowance. Also implicit in (2) is the assumption that international bond payments are tax-free (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).

We also assume that domestic physical capital and public debt are owned entirely by domestic households; i.e. complete "home bias" in the holdings of these assets. This assumption is required for the model to support competitive equilibria in which international trade in private bonds and residence-based taxation co-exist with different country-specific tax rates on domestic capital income. As we show in Mendoza and Tesar (1998), this is not possible if shares on

physical capital and/or government bonds are freely traded across countries (see also Frenkel et al. (1991)). The assumptions of extreme home bias and residence-based taxation could be replaced with source-based taxation and this would result in saving and investment optimality conditions similar to the ones obtained with those assumptions, which would support competitive equilibria with different capital income tax rates across countries. However, actual tax systems are a mixture of residence- and source-based systems. Frenkel et al. (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.

Households also face a standard no-Ponzi-game restriction. This restriction, together with (2) implies that the present value of household income must equal that of expenditures plus any initial asset holdings.

Households allocate their time between labor and leisure subject to the time constraint:

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

where we normalize the total number of hours to unity. Labor is immobile across countries.

Firms

Firms employ labor and capital so as to maximize profits, taking factor prices as given. The production function is Cobb-Douglas:

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

where α is the labor income share. We assume that firms operate under perfect competition, and therefore earn zero profits in equilibrium and factor demands are given by standard marginal productivity conditions. Without loss of generality, all corporate taxes are viewed as included in the capital income tax levied on households.

The Public Sector

Fiscal policy in each country has three components: first, a predetermined sequence of government outlays made up of unproductive expenditures and entitlement payments, (g_t+e_t) for $t=0,...,\infty$; second, a set of time-invariant tax rates $\tau = (\tau_C, \tau_L, \tau_K)$; and third, a sequence of public bond issues, d_t, for $t=0,...,\infty$. The period government budget constraint is given by:

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

The left-hand-side of equation (5) measures uses of government income (i.e. goods purchases, entitlement payments, and debt payments). The right-hand-side measures sources of government income: tax revenue and the proceedings from sales of newly-issued bonds (adjusted to conform with the stationary transformation of the model). Government purchases, entitlement

payments, and tax rates are the instruments of fiscal policy. Thus, a primary fiscal deficit or surplus at date t (i.e., a 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). However, since the government also faces a no-Ponzi-game constraint, the intertemporal government budget constraint requires that the present value of government expenditures plus entitlement payments must equal the present value of tax revenue net of payments on initial public debt.[3]

Competitive Equilibrium

A *competitive equilibrium* is defined by sequences of prices $[r_t,\ r_t^*,\ q_t,\ w_t,\ w_t^*]$ and allocations $[k_{t+1},\ k_{t+1}^*,\ b_{t+1},\ b_{t+1}^*, x_t,\ x_t^*, L_t,\ L_t^*, \ell_t,\ \ell_t^*,\ c_t,\ c_t^*, T_t,\ T_t^*]$ for $t=0,\ldots,\infty$ 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 and factor rental rates, 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 following market-clearing conditions for the global markets of goods and bonds hold:

$$k_t^{1-\alpha} L_t^{\alpha} + \left(k_t^*\right)^{1-\alpha^*} \left(L_t^*\right)^{\alpha^*} = c_t + c_t^* + x_t + \frac{\eta}{2}\left(\frac{x_t}{k_t} - z\right)^2 k_t + x_t^* + \frac{\eta^*}{2}\left(\frac{x_t^*}{k_t^*} - z^*\right)^2 k_t^* + g_t + g_t^*, \tag{6}$$

$$b_t + b_t^* = 0 \tag{7}$$

The Three International Externalies of National Tax Policy

The international externalities of tax policy operating in the model can be understood by studying the implications of the tax distortions on saving, investment and labor supply. This issue is covered in detail in Mendoza and Tesar (1998). We provide here a condensed description.

One of the main driving forces of international tax policy externalities in the model is the arbitrage of after-tax real returns to physical capital that is obtained via international bond trading. Bond trading ensures that the intertemporal marginal rate of substitution in consumption in each country equals the common real rate of return on bonds. In turn, households set optimal

[3] 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.

investment in their country's physical capital so that the after-tax net return on capital equals the return on international bonds. Thus, after-tax returns on capital are equalized across countries.

To see how the externalities come into play, it is useful to consider a unilateral cut in the home capital income tax rate. As a result of the tax cut, there is an increase in the home country after-tax return on capital relative to the foreign country. Home agents borrow from abroad to spread the resulting increase in wealth across consumption in all periods and to offset the short-run burden of increased investment as the economy evolves toward a higher capital stock. The home country accumulates debt in the short-run, which then must be serviced in the new long-run equilibrium.

The increased borrowing by the domestic economy causes a temporary increase in the world interest rate. In the long run, however, the interest rate is determined by the model's balanced growth restrictions, independently of the tax structure. In particular, the gross long-run real interest rate is given by $R=\beta^{-1}-\gamma\sigma$. However, we show in Mendoza and Tesar (1998) that even though the interest rate hike is only temporary and quantitatively small, it can trigger large reallocations of capital across countries and large adjustments in consumption (which in turn can have sizable welfare effects).

In this example of a unilateral home capital income tax cut, the international externality operating via the intertemporal relative price of consumption is reflected in the transitory interest rate hike discussed above. There are also price externalities working through changes in wages and the rental rate of capital in each country. The wealth redistribution effect results from changes in the present value of factor income induced by the reallocation of capital across countries and the changes in the dynamics of capital and labor allocated to production.

The adjustments in prices, factor incomes and the distribution of wealth in turn have an impact on the tax base in the two countries. Government outlays are constant, so the decline in the foreign country's present value of tax revenue means that the foreign labor income and/or consumption taxes must increase to bring the present value of tax revenue back into balance with the present value of unchanged government outlays. These changes in consumption or labor taxes abroad are distorting because they drive the traditional wedge between the marginal rate of substitution in consumption and leisure and the pre-tax real wage. Labor and consumption taxes have symmetric distorting effects on account of this wedge, but they are not equivalent because labor is not the sole source of factor income and capital and labor income are not taxed at the same rates.[4] Moreover, around the calibrated values of the tax rates we work with later, labor and

[4] See Frenkel et al. (1991) for details on direct versus indirect taxation equivalences. The equivalence in our model would also require an inelastic capital stock because otherwise the common labor-capital tax that

consumption taxes have very different effects on tax revenue, welfare and household income. As we show below, the increase in the labor tax needed to replace the loss in the present value of tax revenue due to a reduction in the capital income tax involves greater distortions than those caused by the consumption tax.

Tax Competition Environment

The strategic interaction between the two countries takes place starting from a pre-tax-competition stationary equilibrium with zero net foreign asset positions that represents the status quo before financial market integration. This pre-tax-competition equilibrium is determined by assigning values to the model's preference, technology and fiscal policy parameters and solving for steady-state allocations along the long-run balanced-growth path. With regard to fiscal policy, this calibration exercise specifies a pair of initial tax structures $\tau = [\tau_c, \tau_L, \tau_k]$ and $\tau^* = [\tau_c^*, \tau_L^*, \tau_k^*]$, and time-invariant levels of transfer payments and government purchases in each country [g,e] and [g*,e*]. The solution to the stationary equilibrium yields a solution for the primary fiscal balances T and T*, which represent the debt service of the steady-state stocks of public debt in each country.

Once the prices and allocations of the pre-tax competition equilibrium are determined, we calculate the payoff that each country receives under a particular choice of capital tax strategies played by each country's fiscal authority. These payoffs correspond to the welfare gain or loss that each country stands to make at the competitive equilibrium supported by the chosen capital tax rates and the endogenous labor or consumption taxes needed to satisfy the intertemporal government budget constraints. Welfare gains or payoffs are computed as percent variations in consumption at all dates that render households indifferent between the pre-tax-competition levels of lifetime utility and the lifetime utility derived under the competitive equilibrium of the new tax rates.

The welfare calculations take into account the transitional dynamics that the two countries follow in moving from the pre-tax-competition equilibrium to the new long-run equilibrium implied by the new set of tax rates.[5] Both the transitional dynamics and the new long-run equilibrium need to be solved simultaneously because models of the class we study here display dependency on initial conditions in the long-run allocations of foreign bonds, and because of the endogenous adjustment in either the labor or the consumption tax needed to preserve fiscal

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could yield a leisure-consumption distortion identical to that of a given consumption tax would imply a different distortion on the investment margin.

solvency. We employ the solution method proposed in Mendoza and Tesar (1998), which takes care of these two issues by ensuring that the tax rates in each country and the dynamics of foreign assets satisfy the present-value constraints of private agents and the government in both countries.

In principle, for given capital income taxes (τ_K,τ_K^*) and their associated fiscal solvency externalities, each country could adjust a combination of its labor and consumption taxes to maintain fiscal solvency by adjusting these taxes so as to equalize the present value of total tax revenues with the present value of the unchanged government outlays. For tractability, we narrow the analysis to tax competition experiments that adopt one of these two rules to maintain fiscal solvency: adjust consumption taxes only (keeping labor tax rates constant) or adjust labor taxes only (keeping consumption taxes constant). These rules are known to both governments and both governments are assumed to be credibly committed to follow them.

The government of each country chooses its capital income tax rate so as to maximize the payoff to that country's residents taking as given the other country's capital income tax and subject to the constraints that: (a) the implied allocations and prices for a global tax structure (τ,τ^*) are a competitive equilibrium, and (b) labor or consumption taxes in both countries adjust so that the intertemporal government budget constraints of the two countries hold.

A *Nash equilibrium* for the capital-income-tax competition game is defined by a pair of capital income tax rates (τ_K^N,τ_K^{*N}) and the associated payoffs for each country such that: (a) τ_K^N maximizes the home country payoff given τ_K^{*N}, (b) τ_K^{*N} maximizes the foreign country payoff given τ_K^N, (c) the payoffs are supported by the prices and allocations corresponding to the competitive equilibrium for (τ_K^N,τ_K^{*N}), and (d) the fiscal solvency rules of both countries (setting either (τ_C,τ_C^*) or (τ_L,τ_L^*)) are satisfied. Thus, the Nash equilibrium is at the intersection of the reaction curves in the strategy space of time-invariant capital income tax rates.

A *cooperative equilibrium* is defined as a pair (τ_K^C,τ_K^{*C}) that maximizes the weighted sum of country payoffs for any home country weight $\lambda \in [0,1]$ and foreign weight λ-1 subject to the constraint that each country is at least as well off as in the Nash equilibrium. Thus, there can be several cooperative equilibria supported by different λ*'s* and the set of all cooperative equilibria determines the core of the players' contract curve. Cooperative equilibria are still tax-distorted competitive equilibria because cooperation undoes the effects of the international tax externalities but not those of domestic tax distortions.

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[5] We consider a strategy space where countries can only choose from the class of time-invariant tax rate. In the closed-economy context, Lucas (1990) and Cooley and Hansen (1992) show that the welfare gains from tax reform with time-invariant tax rates dwarf the additional gains from allowing time-variation in tax rates.

3. Pre-Tax Competition Calibration & Outcomes of Tax Competition in the EU

We construct the pre-tax competition calibration so that the steady-state, balanced-growth equilibrium of the model matches key features of macroeconomic and fiscal policy data for France, Italy, Germany and the United Kingdom. Since our goal is to characterize the outcome of tax competition under perfect international capital mobility, we calibrate the model using data for the beginning of the 1980s just before the barriers to capital mobility across Europe were dismantled.[6] Hence, we view the pre-tax-competition status quo under restricted capital mobility as setting the initial conditions for tax competition under perfect capital mobility. As such, we do not consider the pre-tax-competition status quo as a situation that should be obtained as the equilibrium of the strategic interaction of financially-integrated economies that we modeled in the last section. The calibrated values of technology and preference parameters, tax rates and government expenditure shares used in the pre-tax-competition calibration are listed in Table 1. The values of preference and technology parameters listed at the top of the Table are taken from Mendoza and Tesar (1998).

Figures 1 through 3 plot the time series of capital, labor and consumption taxes in the C3 and the UK over the 1979-96 period. These tax rates are updated estimates of the effective tax rates proposed by Mendoza, Razin and Tesar (1994). Figure 1 shows that the UK capital income tax has fallen sharply since 1981, those of France and Germany have remained fairly constant, hovering around 25-30 percent, and the one for Italy has increased significantly. On average, the capital tax rates of France, Germany and Italy have remained consistently below the capital income taxes in the UK. Labor income taxes in the C3 (see Figure 2) have steadily risen over time and are significantly higher than labor income tax rates in the UK. Consumption taxes used to differ significantly across all European countries, but the treaties for indirect tax harmonization have resulted in significant convergence in effective consumption taxes over the course of the 1990s. For the purposes of the pre-tax competition calibration, we use the 1979 taxes of the UK (τ_K=0.53, τ_L=0.25, τ_C=0.14) and for the C3 we take the average of each tax rate across France, Germany and Italy in 1980 (τ_K=0.265, τ_L=0.374 τ_C = 0.166).[7]

Government expenditure shares have remained fairly steady since 1980. The 1980-1999 sample averages for France, Germany, Italy and the UK range between 17 and 24 percent. We use a value of g/y =0.18 for the calibration.

[6] We are grateful to Peter Birch Sorensen for suggesting that we place our analysis in this context.
[7] The C3 tax rates are not based on 1979 data because we did not have enough data to construct the estimate of the capital income tax rate in Italy before 1980.

The bottom panel of Table 1 shows that the model's pre-tax competition steady state does well at mimicking the GDP shares of key macroeconomic aggregates observed in European data. The calibration forces the model to reproduce the GDP shares of government expenditures and investment, and the trade balance is set equal to zero by the assumption of restricted capital mobility before the 1980s. However, the consumption, tax revenue and net transfers shares are produced endogenously. The model generates slightly higher consumption-GDP and tax revenue-GDP ratios than is observed in the data (58 v. 57 percent and 38 percent v. 37 percent respectively).[8] The ratio of transfers to output (e/y) is roughly the same as the average of the observed transfers-GDP ratios for France, Italy and Germany in 1985. The 1985 average of net transfers (including subsidies and payments stemming from welfare, healthcare and other entitlement programs) as a share of GDP in the C3 was 24 percent of GDP. Any remainder after the level of transfer payments is subtracted from the primary deficit (i.e., the gap between the levels of tax revenue and current expenditures) represents interest payments on the steady-state level of public debt. We keep the *level* of government expenditures and entitlement payments constant throughout all the tax competition calculations.

Capital Income Tax Competition with Labor Tax Adjustments

The first tax competition game assumes that countries adjust labor tax rates to maintain fiscal solvency. We believe this is an interesting case because the agreements to harmonize indirect taxes in Europe put binding limitations on the countries' ability to deal with the fiscal solvency externality of capital income tax competition by adjusting indirect taxes. Hence, adjustments to maintain fiscal solvency fell largely on labor income.

The top part of Table 2 shows the changes in observed tax rates over time. The lower part of the table, Sections B.1 and B.2, shows the model's predictions for capital and labor taxes and the welfare gains when countries play Nash and when they cooperate. The model is consistent with the observed tax rate estimates in predicting that the UK would lower its capital tax and the C3 would increase both labor and capital taxes. The increase in the C3 capital tax rate in the model is similar to that observed in the data, while the cut in the capital income tax in the UK is larger than in the data and the increase in the labor tax in the C3 is smaller. The model deviates from the observed pattern of the UK labor tax, which hovered around 25 percent instead of increasing to 31.7 percent as the model predicted. However, this is due in part to the fact that we do not correct for cuts in public expenditures and transfers that took place in the United Kingdom

[8] Tax revenue as a share of GDP was fairly stable during the 1985-1999 period in France and the UK but it rose sharply in Germany and Italy, reflecting largely the process of debt reduction undertaken in these countries to reach the Maastricht guidelines. The average for the C3 in 1985 tax was 37 percent.

and would allow a lower labor tax to maintain fiscal solvency in the model. We view these results as suggesting that the adjustments in tax rates observed in Europe after barriers to capital mobility were removed can be rationalized in part as the outcome of capital income tax competition in an environment of perfect capital mobility.

The model predicts that tax competition produced a substantial increase in UK welfare equivalent to an increase of 3.87 percent in consumption in every period, and a large welfare loss for the C3 of 2.17 percent in trend consumption. In the model, the large cut in UK capital income tax from 53 to 20 percent induces a large relocation of capital from the C3 to the UK. As a consequence, the tax base in the C3 erodes, and the tax authorities on the Continent are forced to increase *both* the capital and labor income taxes to balance the budget. With tax coordination, the capital income tax rate is *higher* in both regions relative to the Nash outcome. [9] However, the welfare gains from cooperation over the Nash competition outcome are very small, ranging from 0.01 to 0.24 percent of trend consumption.

It is important to note that even under cooperation, the C3 end up worse off than in the pre-tax-competition equilibrium. The welfare loss (gain) for the C3 (UK) under cooperation is between 1.93 (3.88) and 2.17 (4.16) percent depending on the country weighs in the cooperative payoff function. This suggests that, relative to the pre-tax competition baseline, the C3 were at a disadvantage relative to the UK in the process of financial integration – given the higher initial labor taxes and lower capital taxes in the C3, engaging in cooperative or noncooperative tax competition with the UK under perfect mobility of financial capital was immiserizing for the C3.

Capital Income Tax Competition with Consumption Tax Adjustments

We next turn to the tax competition game when the consumption tax is used to maintain fiscal solvency (see Table 2.B.2). Given the small distortion associated with increasing the consumption tax, Nash competition triggers the familiar "race to the bottom" in capital income taxes. Nash competition leads to a large reduction in the capital income tax in the United Kingdom and in the C3. In fact, in the Nash equilibrium both countries subsidize capital income.[10] To maintain the present value of tax revenue equal to the present value of the unchanged government outlays, the consumption tax rate goes up by 13 percentage points in the UK and by 10 percentage points in the C3. Still, Nash competition is beneficial in the sense that households in both countries obtain a gain in lifetime utility relative to the pre-tax competition

[9] Since the core of the contract curve of the cooperative solution contains a range of cooperative equilibria that are Pareto improvements over the Nash equilibrium, we report in Table 2 the bounds of this range.

[10] Note that tax competition does not drive taxes on capital to zero in this model even if the two countries were symmetric because countries are large enough to affect the world interest rate. At the point of zero

stationary state. UK households obtain a large welfare gain that is equivalent to an increase of 5.3 percent in consumption in every period. The welfare gain for the C3 is much smaller at just 0.35 percent of trend consumption.

The driving force of the "race to the bottom" in capital income taxes is the incentive that each country has to attempt to undercut the capital income tax in the other country, and use the resulting inflow of financial capital to help smooth the cost of increasing the capital stock. There are three limiting factors to this "race to the bottom." One is the trade-off between labor and leisure – as the capital stock increases, work effort must increase and at some point the marginal value of leisure offsets the consumption benefit from higher output. The second limiting factor is the fact that, since strategic interaction leads the two countries to cut capital taxes simultaneously, access to global capital markets cannot help households reduce the welfare cost of having to expand the capital stock by borrowing from abroad, and hence they must sacrifice lower current consumption for higher future consumption (as they would in a closed economy undertaking a tax reform). Although the real interest rate increases to compensate for this sacrifice, the households' private rate of discount places a limit on the extent to which they are willing to forego current consumption. The last limiting factor is the distortion of the consumption tax. In the model, this distortion is generally weaker than the distortions of the capital and labor taxes, but at some point increasingly large subsidies on capital income would need to be traded for increasingly large consumption taxes that would induce large distortions.

In the Nash game, policymakers fail to internalize the impact of the reduction in the capital income tax in each country on the world interest rate. When countries cooperate and the joint effect on the interest rate is internalized, each country prefers a somewhat smaller tax. Because of the shift to more efficient taxation, the welfare gains under tax coordination (relative to the pre-tax-competition equilibrium) are larger than under Nash competition. However, as in the previous game with the labor adjusting to satisfy fiscal solvency, the magnitude of the incremental welfare gains of tax coordination over the Nash competition outcome are negligible. The largest incremental gain from cooperation is 0.29 percent of trend consumption, and it is obtained by the UK in the case in which the labor tax adjusts to maintain fiscal solvency and the weigh of the UK in the cooperative payoff function is set to maximize the payoff to the UK. These findings suggest that if there are small costs involved in coordinating tax policy, these costs would likely eliminate all incentives for cooperation.

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capital income taxes, each country has an incentive to subsidize capital, pushing up the world interest rate and forcing some of the costs of capital accumulation onto the rest of the world.

4. Conclusions.

This paper explored the quantitative effects of international tax competition over capital income taxes in the EU using a two-country version of the workhorse neoclassical balanced-growth model with exogenous, labor-augmenting technological change. We computed the solutions of one-shot games over time-invariant capital income tax rates in a framework that incorporates the three basic externalities of tax policy emphasized in the international tax competition literature (the relative-price, wealth-redistribution, and fiscal solvency externalities). National tax authorities are benevolent and assess the payoff of their capital-income-tax strategies in terms of the welfare gains, net of welfare costs of transitional dynamics, accruing to their countries' residents. These welfare gains are computed as cardinal equivalents of the lifetime utility variations induced by the changes in competitive equilibrium allocations obtained under alternative tax strategies. The tax authorities also have access to domestic debt markets so that they can smooth the effects of the fiscal solvency externality on the tax burden over time.

The quantitative analysis starts from a pre-tax-competition equilibrium calibrated to mimic basic macroeconomic and fiscal policy features of the four large European economies (France, Germany, Italy and the United Kingdom) at the beginning of the 1980s, just before the barriers to financial capital mobility in the EU were dismantled. Tax rates in France, Germany and Italy did not differ nearly as much as they did between them and the UK, so we calibrate one country to represent the UK and the other to represent an average of the three large economies of Continental Europe (the C3). The data show that prior to the 1980s the UK taxed capital more and labor less than the C3 did and that the differences in the tax rates were large.

We consider capital income tax competition between the C3 and the UK under two scenarios, one in which labor taxes are adjusted in response to the fiscal solvency externality and one in which consumption taxes are adjusted instead. In general, we find that the C3 fares poorly under both the Nash and the cooperative outcomes because of the significantly less efficient tax system it starts with at the pre-tax-competition status quo. Remarkably, in the case in which labor taxes adjust (which is the most relevant for the EU given the existence of VAT tax harmonization treaties that prevented adjustments in consumption taxes), the Nash equilibrium yields changes in capital and labor taxes that are qualitatively similar to those observed in Europe since the 1980s. In particular, the model matches the data in predicting that there would be no race to the bottom in capital income taxes and that the countries in Continental Europe would increase both capital and labor taxes. The net gains from moving from the Nash outcome to a cooperative equilibrium by means of tax coordination are small at less than a quarter of a percent of trend consumption. These findings suggest that the factor income tax rates prevailing in Europe could be rationalized

as the outcome of tax competition, and that the lack of progress in further tax policy coordination in the region could reflect the fact that the costs of coordination exceed the small benefits.

In the case in which the fiscal solvency externality triggers adjustments in consumption taxes, Nash competition in capital income taxes produces a staggering "race to the bottom" in capital tax rates. However, contrary to the conventional wisdom that this reduction in capital taxes is harmful to society, we find that both the C3 and the UK benefit from tax competition. The C3 obtain a modest welfare gain of about 0.4 percent in lifetime consumption compared to the pre-tax competition equilibrium while the UK obtain a large gain equivalent to a 5.3 permanent increase in consumption. The race to the bottom is harmful in the formal sense that the cooperative equilibrium dominates the Nash outcome, but from a quantitative standpoint the gains from tax coordination are still negligible.

In Mendoza and Tesar (2003) we explored the robustness of our findings to three important modifications of the initial pre-tax-competition calibration considering the case of two symmetric countries. First, we allowed for countries to differ in that one starts as a net debtor and the other as net creditor in the pre-tax-competition equilibrium. Second, we made labor inelastic, so that the labor tax becomes a non-distorting tax. Third, we lowered capital adjustment costs to speed up significantly the transitional dynamics between the pre- and pos-tax-competition equilibria. The results show that faster transitional dynamics and asymmetries between net creditors and debtors can increase the gains of tax coordination, up to 0.76 percent of trend consumption. Reducing the elasticity of labor supply increases the domestic efficiency gains of reducing capital income taxes and weakens the three international externalities of unilateral capital income tax cuts. As a result, instead of replicating the observed changes in capital and labor taxes in Europe, the capital-for-labor tax game with inelastic labor supply results in a strong "race to the bottom" in capital income taxes reminiscent of the outcome obtained in the capital-for-consumption tax game. The gains from tax policy coordination were once again negligible

The framework used in our quantitative analysis generalizes the standard setup used in many theoretical studies on international tax competition, yet it is subject to several caveats. One important caveat is that we do not address issues of time inconsistency and dynamic strategic interaction because the tax competition games modeled here are one-shot games, in which tax authorities are assumed to meet once and to remain committed to the tax structure obtained as the outcome of the one-shot game. We implicitly assume that there is an institutional arrangement (such as an international tax treaty) that operates as a credible commitment mechanism that prevents countries from deviating in the future from the outcome of the one-shot game. Still, even though the game is played once, the payoffs of the players are dynamic in that they reflect

levels of lifetime utility along intertemporal competitive equilibrium paths, including the transitional dynamics from the pre-tax-competition equilibrium to the new stationary equilibrium under competition. It is interesting to note, however, that Klein, Quadrini and Rios-Rull (2001)) found that when time-inconsistency is taken into account, strategic interaction amongst two national tax authorities in a repeated game results in equilibrium strategies that feature large adjustments in capital income taxes in the first period followed by nearly time-invariant taxes.

A second caveat is that even though our model captures three of the most widely studied externalities of international tax competition, it still leaves out some potentially important externalities that can operate via other elements of the tax system. In particular, our analysis does not consider the possibility of labor migration in response to labor tax changes, cross-border shopping in response to consumption tax changes, imperfect information regarding the origins and amounts of foreign-earned income of residents, international cross-ownership of firms, and taxation of internationally traded assets. Theory suggests that tax coordination can be desirable when these issues are considered (see, for example, Huizinga and Nielsen (1997) and (2002)), but whether the resulting magnitudes of the welfare gains from coordination in models with these features could be larger than the small gains from coordination reported here remains an open question.

Two other potentially important caveats are that we ignore production and utility benefits of government expenditures as well as the effects of tax competition on long-run growth. However, the effects of productive government expenditures are approximated by assuming that the fiscal solvency externality forces upward adjustments in distortionary tax rates, and the assumption abstracting from long-run-growth effects of taxation seems to be supported by existing empirical evidence (see Mendoza, Milesi-Ferretti and Asea (1997)).

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TABLE 1: Parameter Values and Pre-tax Competition, Steady-State Allocations for Calibration to Europe

Parameter values

Technology and preferences

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

C3 tax policy parameters (in percent)

τ_K	26.5
τ_L	37.44
τ_C	16.62

Pre-tax competition, balanced-growth allocations (GDP ratios for the C3)

	Data	Model
c/y	0.57 [a]	0.58
x/y	0.24 [a]	0.24
g/y	0.18 [b]	0.18
tb/y	-0.02 [a]	0
tax revenue/y	0.37 [c]	0.38
net transfers/y	0.24 [c]	0.24

Data sources: Tax rates are authors' estimates based on the methodology described in Mendoza, Razin and Tesar (1994). Consumption, investment, trade balance and government expenditure ratios are based on OECD National Income Accounts. Tax revenue and net transfers are from the Revenue Statistics for the OECD countries

a. Average for France, Germany and Italy in 1980.

b. Average of France (1980), Italy (1980) and Germany (1991).

c. Average of France, Italy and Germany in 1985.

Table 2: Nash and Cooperative Equilibria of Capital Income Tax Competition between Europe and the UK

		Tax Rates		
		Pre-tax-competition[a]	1990	1996
A. Observed tax rates				
a. C3	τ_K	0.265	0.271	0.280
	τ_L	0.374	0.439	0.466
	τ_C	0.166	0.172	0.157
b. UK	τ_K^*	0.530	0.570	0.472
	τ_L^*	0.250	0.245	0.244
	τ_C	0.140	0.165	0.152

		Tax Rates			Welfare gain (percent)		cooperation
		Initial	Nash	Cooperative Equilibria[b]	Nash	Cooperative Equilibria[b]	
B. Predictions from Tax Competition Game							
1. Labor tax adjusts to maintain fiscal solvency							
a. C3	τ_K	0.265	0.295	[0.31, 0.37]	-2.17	[-2.17, -1.929]	[0, 0.241]
	τ_L	0.374	0.397	[0.376, 0.390]			
b. UK	τ_K^*	0.530	0.195	0.245	3.87	[3.882, 4.156]	[0.012, 0.286]
	τ_L^*	0.250	0.317	[0.306, 0.309]			
2. Consumption tax adjusts to maintain fiscal solvency							
a. C3	τ_K	0.265	-0.152	[-0.115, -0.10]	0.349	[0.349, 0.365]	[0.001, 0.016]
	τ_C	0.166	0.263	[0.253, 0.255]			
b. UK	τ_K^*	0.530	-0.092	[-0.05, -0.0325]	5.285	[5.288, 5.313]	[0.003, 0.028]
	τ_C^*	0.140	0.272	[0.259, 0.263]			

a. The benchmark year for pre-tax-competition is 1979 for the UK, and 1980 for C3 as complete 1980 data were unavailable for all countries.

b. The table shows data for the range of all Cooperative equilibria that are Pareto improvements over the Nash outcome. The range of tax rates are reported from lowest to the highest tax rate for the set of Cooperative equilibria. Note, however, that the lower the capital tax rate, the higher the labor tax rate must be to satisfy budget balance.

Figure 1

Capital income tax rates in France, Germany, Italy and the United Kingdom: 1979-96

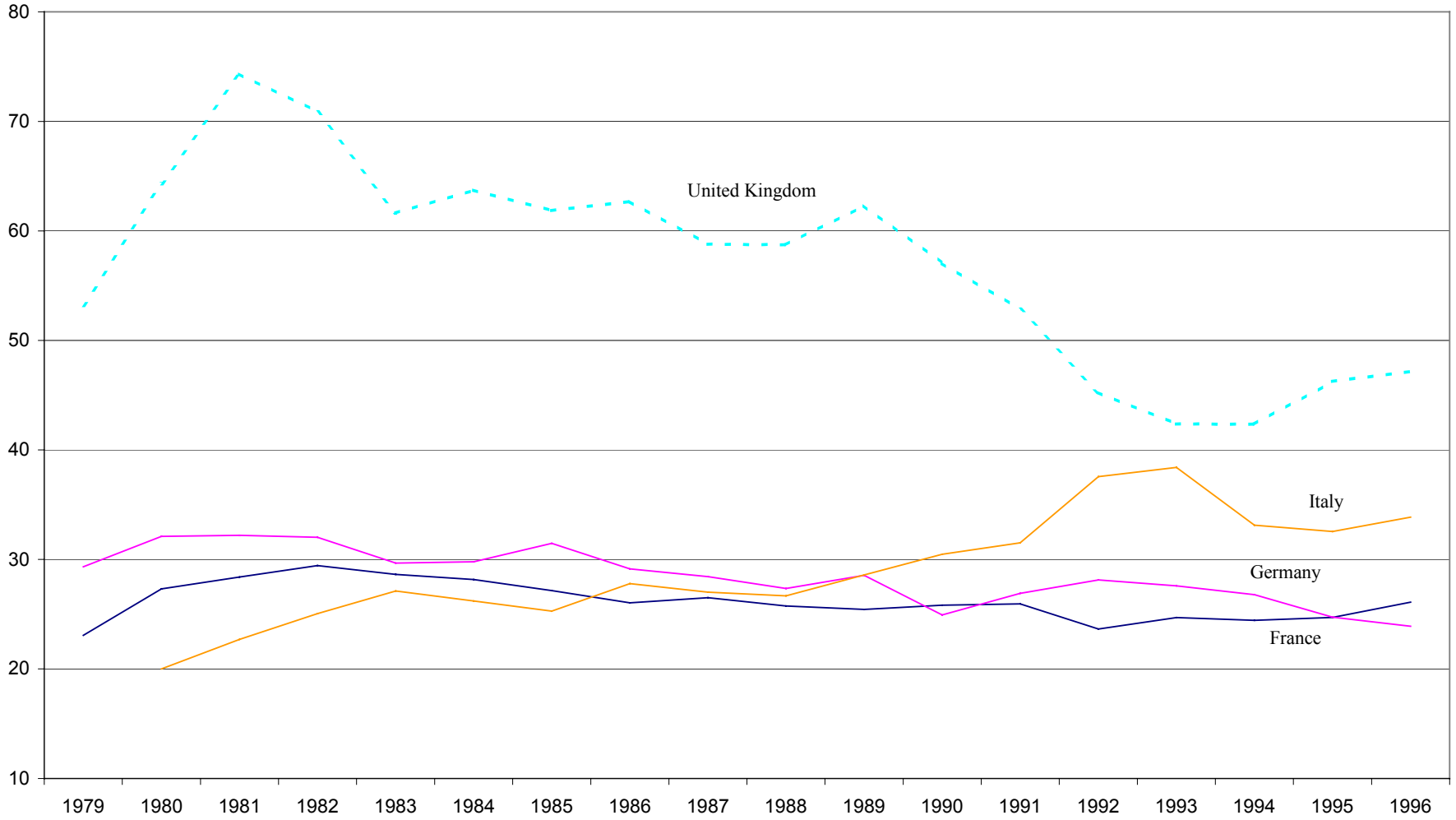

Figure 2

Labor income tax rates in France, Germany, Italy and the United Kingdom: 1979-96

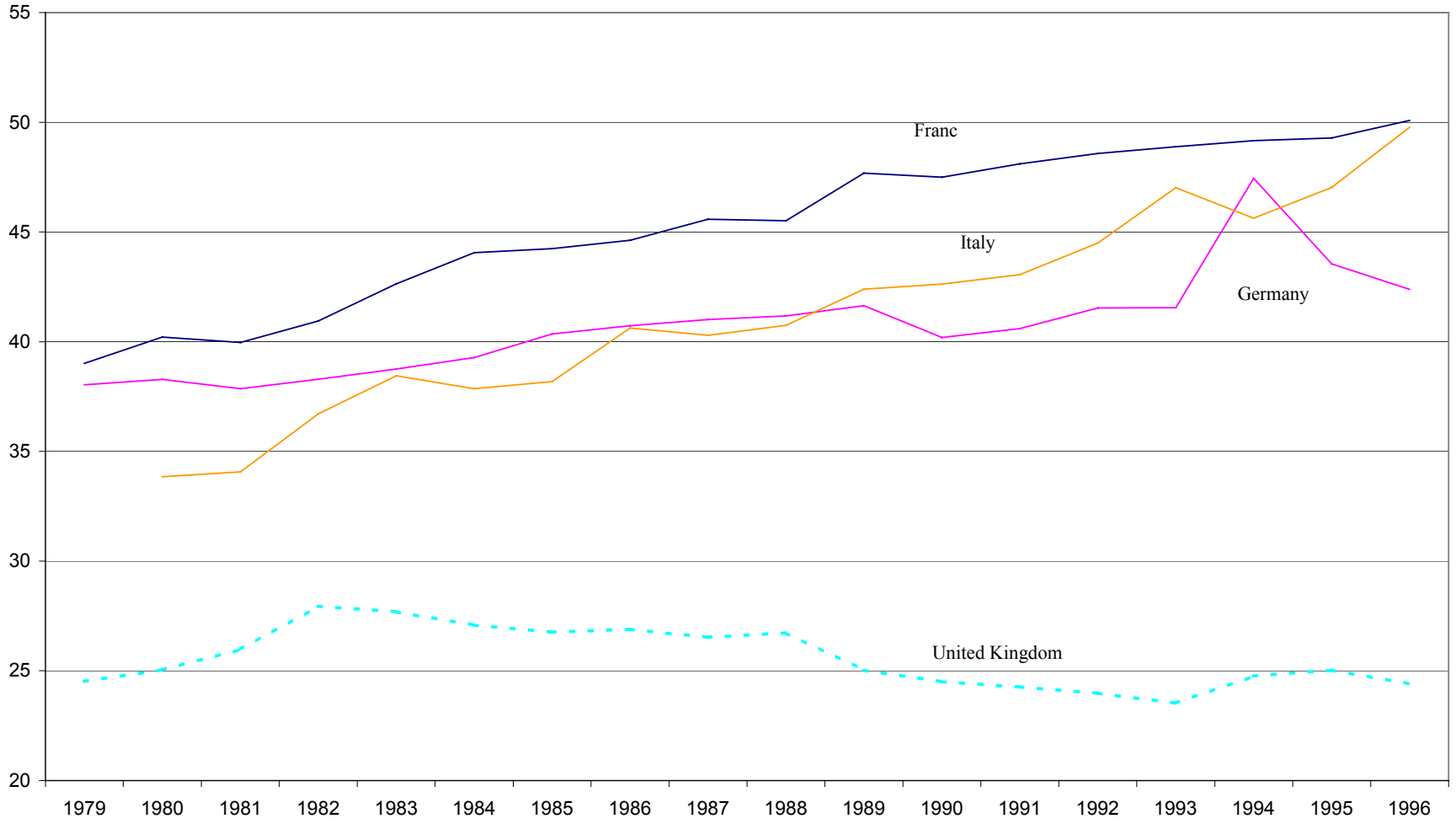

Figure 3:
Consumption tax rates in France, Germany, Italy and the United Kingdom: 1979-96