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FDI DETERMINATION AND CORPORATE TAX COMPETITION IN A VOLATILE WORLD

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FDI Determination and Corporate Tax Competition in a Volatile World*

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Abstract

This paper investigates the role of economic and political volatility in the process of corporate tax rate determination. Based on a theoretical framework that allows for the ability of multinational firms to choose the optimal timing of foreign investment and to shift profits by transfer pricing, the paper provides an empirical analysis on a large panel data set of countries over the 1983-2003 period. First, a reduced-form dynamic equation of corporate tax rate determination is estimated by generalized method of moments (GMM), where a country's top statutory corporate tax rate depends on a number of measures of economic and political volatility. Our results support the hypothesis that economic volatility is associated with lower top statutory corporate tax rates, while our measures of political volatility have no significant impact on corporate taxation policy. In order to identify the channels through which volatility works, we estimate a structural model allowing for simultaneous determination of the corporate tax rate and the inflow of FDIs to a country, and we are able to show that economic volatility affects the corporate tax setting process through its impact on FDI inflows.

Keywords: corporate tax rates; tax competition; profit shifting.
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1 Introduction

The liberalization of foreign exchange laws that occurred in most OECD countries in the mid and late 1980s virtually implied free mobility of capital and generated a sharp rise in FDI and multinational activity in recent years, thereby creating the conditions for international tax competition for mobile capital.[1] The pressure from international tax competition has consequently been deemed responsible for the decline in the statutory corporate tax rates that has been observed since the mid 1980s, spurring empirical research addressing the issue of the desirability and feasibility of corporate income taxation in a context of globalization and perfect capital mobility.[2] In particular, Rodrik [47] and Devereux et al. [19] show that the relaxation of capital controls stimulates tax competition and thus reduces both statutory and effective tax rates. Slemrod [48] comes to a similar conclusion by providing consistent evidence of international competitive pressure, with the degree of capital market openness being negatively associated with statutory corporate tax rates, although not with average corporate tax rates. Based on panel data on samples of OECD countries, Garretsen and Peeters [23] find that increased international capital mobility - proxied by the volume of FDI flows - generates a downward pressure on effective average tax rates, and Bretschger and Hettich [7], Haufler et al. [26] and Winner [50] find that various measures of capital mobility exert a negative impact on (mobile) capital tax burden and a positive one on (immobile) labour tax burden.

By explicitly recognizing that the ability to tax corporate income heavily depends on a country's economic and political environment, this paper

[1] Such phenomenon is documented, among the others, by Markusen [35], according to whom FDI flows grew at the impressive annual rate of over 30% in the latter half of the the 1990s.

[2] For instance, Lee and Gordon [33], Devereux et al. [20] and Slemrod [48] report that in the 1980s the average top corporate tax rate was about 40%. In the late 1990s, it fell to slightly more than 30%. Moreover, while the statutory tax rate on corporate profits exceeded by 50% the average labour tax wedge in 1980, the two were roughly the same twenty years later (Haufler et al. [26]).

focuses on the role of the degree of economic and political volatility and explores its effects on the taxation of corporate profits. In doing so, it develops a theoretical framework - based on Panteghini and Schjelderup [43] - that allows for investment irreversibility and for the ability of multinational companies (MNCs) to choose the optimal timing of foreign investment and to shift profits by transfer pricing. The model suggests that higher volatility - interpreted either as the probability of receiving bad news or as the seriousness of the bad news (Bernanke [4]) - should induce governments to reduce their tax rates on corporate profits. The reason is that volatility reduces the overall number of foreign firms involved in foreign direct investment (FDI). Consequently, the optimal policy response to the reduction in a country's tax base consists in lowering the corporate tax rate in order to counteract the negative impact of increased volatility.

These predictions are tested on a panel data set of a large number of countries over the 1983-2003 period. First, a reduced-form dynamic equation of corporate tax rate determination is estimated by the generalized method of moments (GMM), where the top statutory corporate tax rate is allowed to depend on a number of measures of economic and political volatility, along with a set of variables reflecting the size, underlying economic structure and degree of capital market openness of a country. Our results confirm the hypothesis that economic volatility is associated with lower top statutory corporate tax rates, while our indexes of political volatility - measured by the frequency of changes in government and by an index of the protection of property rights - do not appear to have any significant impact on corporate taxation policy.

In order to identify the channels through which volatility works, we also estimate a structural model that allows for simultaneous determination of the corporate tax rate and the FDI flow into a country. The results show that our measures of economic volatility significantly and negatively affect the corporate tax rate through their impact on the inflow of FDIs to a country.

Moreover, it turns out that capital market openness has a negative independent effect on the level of the statutory corporate tax rate and a positive one on the size of FDI inflows, with the two effects tending to cancel each other out in a reduced form tax equation.

The rest of the paper is organized as follows. Section **2** presents the theoretical framework used to analyze the impact of volatility on FDI flows and corporate tax rate setting strategies. Section **3** turns to the empirical implementation of the model by estimating a reduced-form dynamic equation of corporate tax rate determination, while section **4** tackles the structural model for simultaneous determination of the corporate tax rate and the flow of FDI into a country. Finally, section **5** summarises our findings.

2 Theoretical framework

A common feature of the standard theoretical tax competition literature is that capital investment is fully reversible or, alternatively, that capital investment is irreversible, although it is characterized by exogenous investment timing. Moreover, most of the theoretical contributions on tax competition disregard risk.[3]

As shown in Dixit and Pindyck [21], volatility has a negative impact on investment timing. This discouraging impact is due to the so-called Bad News Principle (BNP),[4] according to which investment depends on the seriousness of bad news and its probability, but is independent of good news. Indeed, an increase in volatility means that good news gets better and bad news gets worse: since good news does not matter, increased volatility raises the threshold profit rate above which FDI is undertaken. Therefore, an increase in volatility delays FDI timing. This finding is in line with empirical evidence, which shows a negative relationship between uncertainty and FDI. For instance, Chen and So [11] showed that the 1997 Asian financial crisis

[3] Exceptions are Gordon and Varian [24] and Lee [32].
[4] See Bernanke [4].

(which caused an increase in exchange rate variability) discouraged FDI by US MNCs.[5]

In this section we present a real-option model, mainly based on Panteghini and Schjelderup [43], where firms can optimally time their FDI decision and shift profit from one country to another. Given their investment strategies, two governments are assumed to compete in order to attract tax base from abroad.

2.1 A firm's FDI decision

In order to study FDI decisions, let us first focus on a representative firm that is initially located only in country A. The firm earns a constant after-tax profit equal to $(1-\tau_A)\,\Psi_A$, where τ_A is the statutory tax rate and Ψ_A is gross profit. By assumption, this firm has an opportunity to invest in country B, if it incurs a sunk investment cost I.[6] After investing abroad, the firm earns an additional gross profit, denoted as Π_B, that is taxed at the rate τ_B.

We assume that the representative firm can shift profit to save tax payments: we denote the percentage of profits shifted by $\gamma \lesseqgtr 0$. Since the profit shifting benefit depends on the fact that the firm has invested abroad, we normalize tax savings with respect to foreign profit Π_B.

In line with most of the literature on transfer pricing, we make the realistic assumption that it is costly to shift profits for tax saving purposes. For simplicity we assume that the concealment (transaction) cost function,

[5] Further evidence is provided by Aizenman and Marion [2], who focused on the foreign operations of US MCNs since 1989. They showed that uncertainty affects both vertical and horizontal FDI. In particular, they showed that greater supply uncertainty reduces the expected income from vertical FDI but increases the expected income from horizontal FDI. Greater demand uncertainty adversely affects the expected income under both production modes. Moreover, volatility and sovereign risk have a greater adverse impact on vertical FDI than on horizontal FDI. For further evidence see Markusen [35].

[6] In principle repatriated profit is taxed in the residence country. However, due to deferral possibilities and limited credit rules, the source principle is *de facto* applied (see. e.g. Keen, [30]).

denoted by $\nu(\gamma)$,[7] is quadratic, i.e.,

$$\nu\left(\gamma_A\right) = \frac{n}{2}\gamma_A^2,$$

where $n \geq 0$ is a parameter that indicates how costly it is for the firm to shift profit. Given these assumptions, the optimal percentage of profit shifted from one country to another is equal to $\gamma_A^* = \frac{\tau_A - \tau_B}{n}$. Therefore, the optimal per-unit tax savings arising from profit shifting is:

$$\begin{aligned} \phi\left(\gamma_A^*\right) &= \left[\left(\tau_A - \tau_B\right)\gamma_A^* - \nu\left(\gamma_A^*\right)\right] = \\ &= \frac{\left(\tau_A - \tau_B\right)^2}{2n}. \end{aligned} \tag{1}$$

Using (1), we can calculate the overall after-tax net operating profit of the firm (if it invests in B):

$$\Pi_A^N = \left(1 - \tau_A\right)\Psi_A + \left[\left(1 - \tau_B\right) + \phi\left(\gamma_A^*\right)\right]\Pi_B. \tag{2}$$

According to the relevant literature, investing abroad is inherently risky. For this reason we assume that the EBIT (Earning Before Interest and Taxes) of the foreign subsidiary follows a geometric Brownian motion, i.e.,

$$\frac{d\Pi_B}{\Pi_B} = \sigma dz_B, \text{ with } \Pi_B\left(0\right) \geq 0, \tag{3}$$

where σ is the instantaneous standard deviation of $\frac{d\Pi_B}{\Pi_B}$, and dz_B is the increment of a Wiener process.[8]

Using (2) and (3) we can calculate the firm's net present value (see Appendix A):

[7] The cost element may be interpreted as the hiring of lawyers or consultants to conceal the illegality of the transaction. These costs may or may not be tax deductible. Neither assumption has an impact on the qualitative results, but tax deductibility lowers the cost of profit shifting. See Haufler and Schjelderup [25] for a more detailed discussion.

[8] The general form of the geometric Brownian motion is $d\Pi_B = \mu\Pi_B dt + \sigma\Pi_B dz_B$ where μ is the expected rate of growth. Without any effect on the quality of results, in (3) we set $\mu = 0$.

$$V_A(\Pi_B) = \begin{cases} \frac{(1-\tau_A)\Psi_A}{r} + A_1 \Pi_B^{\beta_1}, & if \quad \Pi_B < \Pi_B^*, \\ \frac{(1-\tau_A)\Psi_A + \left[(1-\tau_B)+\phi\left(\gamma_A^*\right)\right]\Pi_B}{r}, & if \quad \Pi_B \geq \Pi_B^*, \end{cases} \tag{4}$$

where r is the risk-free interest rate, A_1 is an unknown parameter to be determined, and $\beta_1 > 1$. As we can see in (4), before investment (i.e., for $\Pi_B < \Pi_B^*$), the firm's value is equal to a perpetual rent, accounting for domestic after-tax profit (i.e., $\frac{(1-\tau_A)\Psi_A}{r}$), plus term $A_1\Pi_B^{\beta_1}$, that measures the firm's option to expand its business activity abroad. By undertaking FDI, the domestic firm exercises its option and can exploit profit shifting opportunities. After investment (i.e., after Π_B has reached the threshold point Π_B^*), therefore, the firm's value is a perpetual rent that accounts for both domestic and foreign profit, including the profit shifting savings.

Using (4) we can calculate the firm's threshold point above which FDI is profitable (see Appendix B):

$$\Pi_B^* = \frac{\beta_1}{\beta_1 - 1} \frac{rI}{\left[(1-\tau_B) + \frac{(\tau_A - \tau_B)^2}{2n}\right]}. \tag{5}$$

Eq. (5) tells us that it is optimal for the firm to invest abroad whenever Π_B reaches Π_B^*. Moreover, we can see that the higher the benefit from tax avoidance, the lower the trigger point, i.e., the earlier a firm invests abroad.[9]

2.2 Tax competition

Let us next model tax competition between two small open countries, called A and B. We assume that in each country there exists a continuum of firms that can invest abroad. We therefore introduce a set of firms located in country A, and owing an option to invest in country B, and a second set of firms located in country B that can invest in country A. All these firms face the same income shifting cost $\nu(\gamma_i)$ with $i = A, B$.

[9] For further discussion on this strategy see, e.g., Panteghini [42] and Panteghini and Schjelderup [43].

By assumption, each firm is characterized by its own starting profit (Π_i for $i = A, B$) arising from investing abroad. For simplicity, the firm-specific profit is distributed according to a linear density function $f(\Pi_i)$ with $\Pi_i \in \left(0, \overline{\Pi}_i\right]$.

In equation (5) we calculated the threshold point of each firm located in country A. Using the same notation for firms located in country B, we define Ψ_B as the firm's operating profit earned in country B, and Π_A as the stochastic EBIT faced by the foreign subsidiary. The firm's EBIT is driven by the geometric Brownian motion $\frac{d\Pi_A}{\Pi_A} = \sigma dz_A$, with $\Pi_A \geq 0$. Given these assumptions, the trigger point for firms located in country B is:

$$\Pi_A^* = \frac{\beta_1}{\beta_1 - 1} \frac{rI}{\left[(1 - \tau_A) + \frac{(\tau_B - \tau_A)^2}{2n}\right]}. \tag{6}$$

According to (6), therefore, firms initially located in country B invest in A whenever gross profit reaches Π_A^*.

Let us next focus on governments' strategies. Since we are interested in tax base shifting from one country to another, we assume that each government aims at maximizing tax revenues from foreign subsidiaries.[10] In doing so, governments account not only for existing but also for new subsidiaries, investing in the future.

For simplicity, we also assume that no tax deductions due to investment costs are allowed. We can thus show that the effective tax rate levied on foreign subsidiary investing in country i is equal to $\tau_i \left(1 + \gamma_j^*\right) = \tau_i \left(1 + \frac{\tau_j - \tau_i}{n}\right)$, with $i = A, B$, $j = A, B$, and $i \neq j$. Therefore, the objective function of gov-

[10] Tax revenue maximization is a simplifying assumption. However, we will show that the results obtained under this assumption are qualitatively similar to those proven by Panteghini and Schjelderup [43], who use an objective function that is given by the sum of profits generated by FDI and tax revenue from foreign firms' FDI in the home country.

ernment A is (see Appendix C):

$$W_A = \tau_A (1+\gamma_B^*) \int_{\Pi_A^*}^{\overline{\Pi}_A} \frac{\Pi_A}{r} f(\Pi_A)\, d\Pi_A + \tau_A (1+\gamma_B^*) \int_0^{\Pi_A^*} \left(\frac{\Pi_A}{\Pi_A^*}\right)^{\beta_1} \frac{\Pi_A^*}{r} f(\Pi_A)\, d\Pi_A \qquad (7)$$

$$= \frac{\tau_A (1+\gamma_B^*)}{2r\overline{\Pi}_A} \left[\overline{\Pi}_A^2 - \left(\frac{\beta_1 - 1}{\beta_1 + 1}\right) \Pi_A^{*^2}\right],$$

where term $\tau_A (1+\gamma_B^*) \int_{\Pi_A^*}^{\overline{\Pi}_A} \frac{\Pi_A}{r} f(\Pi_A)\, d\Pi_A$ is a perpetual rent that measures the expected overall tax burden on subsidiaries already settled up, and $\tau_A (1+\gamma_B^*) \int_0^{\Pi_A^*} \left(\frac{\Pi_A}{\Pi_A^*}\right)^{\beta_1} \frac{\Pi_A^*}{r} f(\Pi_A)\, d\Pi_A$ measures the expected overall tax burden on subsidiaries that will invest in the future.[11] Using the same procedure we can calculate government B's objective function.[12]

It is worth noting that each government faces a trade-off. On the one hand, it will be stimulated to raise the tax rate levied on the existing subsidiaries: this is in line with the so-called 'capital levy problem' (see e.g. Panteghini [42]). On the other hand, each government is aware that a tax rate increase will not only delay the entry of new subsidiaries, but also encourage profit shifting by taxpayers.

At time 0, each government maximizes its objective function, i.e.,

$$\max_{\tau_i} W_i \qquad i = A, B. \qquad (8)$$

The maximization of (8) is part of a sequential game, where at stage 1 each government sets its tax rate (τ_i); at stage 2, the firms in country A and B decide whether and when to invest. Solving (8), we can prove that:

[11] The term $\left(\frac{\Pi_A}{\Pi_A^*}\right)^{\beta_1}$ is the present value of 1 Euro contingent on future investment and measures the expected discount factor.

[12] Government B's objective function is thus equal to

$$W_B = \frac{\tau_B (1+\gamma_A^*)}{2r\overline{\Pi}_B} \left[\overline{\Pi}_B^2 - \left(\frac{\beta_1 - 1}{\beta_1 + 1}\right) \Pi_B^{*^2}\right].$$

Proposition 1 If n is high enough, there exists a unique symmetric Nash equilibrium tax rate $\tau^* \in (0, 1)$.

Proof See Appendix D.

Proposition 1 proves the existence of a symmetric Nash equilibrium tax rate, which equates at the margin the social cost of taxation to its social benefit. This result holds if n is high enough, namely if the cost of profit shifting is high enough. Otherwise, the equilibrium tax rate would collapse to zero.

Let us next focus on the effects of market openness in this tax competitive setting. It is worth noting that market openness is negatively affected by the minimum size of the sunk costs needed to undertake FDI and is positively affected by the average profitability of investing firms. A fall in sunk costs may be related to globalization, as long as tighter economic integration causes a reduction in entry barriers. A rise in average profitability may also be due to the decrease in transportation costs as well as the formidable rise in skill-biased technology and information systems. It is thus reasonable to expect that such factors have a positive effect on profit income. Along this line of reasoning we can prove that:

Proposition 2 A decrease in size of the sunk cost needed to undertake FDI and/or an increase in profitability raises the equilibrium tax rate.

Proof See Appendix E.

The reasoning behind Proposition 2 is straightforward: a decrease in size of the sunk cost and/or an increase in profitability encourages FDI activities. This allows the two competing countries to set a higher tax without deterring FDI. Moreover, an improvement in business profitability raises the number of MNCs and thus widens the overall tax base. Hence, higher tax rates combined with wider tax bases in both countries give larger tax revenue. This result apparently differs from that found by Devereux et al. [19], who estimate a positive relationship between the extent of tax competition and the openness of countries. As will be shown in section **4**, however, market openness has a twofold effect. On the one hand, according to Proposition 2, it has a positive effect on the inflow of FDI, and thus it causes a tax rate increase via FDI. On the other hand, in line with Devereux et al. [19], it has a direct negative effect on tax rates.

As we have pointed out, empirical evidence shows that FDI and multinational firms are a significant part of economic output and investment in many countries. For this reason, the transmission of country-specific shocks by means of MNCs' activities is a phenomenon that deserves particular attention. We can show that:

Proposition 3 Increased volatility lowers the equilibrium tax rates.

Proof See Appendix F.

The reasoning behind Proposition 3 is as follows. According to the BNP, an increase in volatility discourages FDI. This induces firms with an intermediate profitability to delay their investment decision. Thus the number of firms that immediately undertake FDI is less. Subsequently, however, only a fraction of the firms who delayed will receive good news and then invest. The remaining part of firms will decide to further delay investment. This means that, at any time, an increase in volatility reduces the overall number of firms involved in FDI. According to Proposition 3, the governments' policy response is therefore to lower the tax rate in order to partially offset the negative impact of increased volatility.

3 Empirical implementation

The empirical predictions of the theoretical model in section **2** are tested on a large panel data set of countries in the time span 1983-2003. We start by estimating a standard reduced-form equation to determine the corporate tax rate and turn in the next section to estimate a structural model where the tax rate and the inflow of FDI are determined simultaneously.

3.1 Reduced form corporate tax rate equation

First, in order to explore the impact of capital market openness and various measures of volatility on the corporate tax rate setting process, we estimate a dynamic reduced form equation such as (9) below:

$$\tau_{it} = \rho\tau_{it-1} + x'_{it}\beta + v'_{it}\gamma + f_i + h_t + \varepsilon_{it}, \tag{9}$$

where the corporate tax setting policy of country i in period t is represented by τ_{it}. Since the relevant tax rate in explaining the profit shifting-motivated decisions of MNCs is the statutory rate, we use here a country's top statutory corporate income tax rate as the dependent variable.

By estimating the corporate tax setting equation (9), we aim at finding whether, after controlling for a number of structural determinants of corporate tax setting policy (vector x_{it}), various measures of economic and political volatility (vector v_{it}) have an impact on the corporate tax rate. Indeed, countries in which economic, social and political fundamentals are highly volatile should have an increase in the outflow of domestic firms and a decrease in the inflow of FDI. Volatility should therefore act, by means of tax base adjustments, on the level of the corporate tax rate.

Equation (9) includes among the regressors a one-period lag of the corporate tax rate (τ_{it-1}) in order to take into account the high degree of persistency in the corporate tax rate that is typically observed in the data. The model also includes time effects (h_t) in order to capture the influence of time-specific common shocks, and country specific fixed effects (f_i) to account for country characteristics that are constant over time (such as geographic location).

Following recent empirical literature in this area (Slemrod [48], Winner [50], Haufler et al. [26], Garretsen and Peeters [23]), the set of control variables x_{it} in the corporate tax setting equation (9) includes country size, an index of capital mobility, government spending, the rate of employment, the demographic structure of the population and the level of the personal income tax.

First, we measure country size by its GDP, and expect a positive effect of GDP on the corporate tax rate.[13] However, since GDP might also be a proxy for the size of the corporate income tax base, we allow for potential endogeneity of the GDP variable with respect to corporate taxation policy when estimating equation (9).

Secondly, the degree of capital mobility might be a relevant factor to explain FDI decisions by MNCs. Now, an often invoked reason for the apparent decline of tax rates on profits is that firms can choose the location of their plants in order to reduce their tax liabilities. Governments that impose restrictions on capital flows should face an inelastic tax base and should consequently be able to set higher tax rates than open countries. Measuring the actual degree of capital openness of a country, though, is a rather difficult task (Winner [50]). Slemrod [48] employs the discrete Sachs-Warner index of trade openness, that, however, is only an imperfect proxy for the actual degree of capital mobility. Other indicators - such as the stock of foreign FDI in a country - are not suitable measures either, because, by changing sluggishly over time, they tend to capture other time-invariant aspects of a country that make it an attractive destination for foreign investors (such as its size and human capital stock). In the empirical work, we use a similar strategy as Garretsen and Peeters [23], and use the Chinn and Ito [12] index of capital market openness that is based on the legal restrictions imposed on the international mobility of capital and firms.[14]

Equation (9) also includes a measure of government expenditure: since

[13] See Bucovetsky [9], Wilson [49] and Haufler and Wooton [28].

[14] In particular, Garretsen and Peeters [23] use the so-called Golub index as a measure for the (legal) restrictions placed on international capital mobility. Similarly, the Chinn and Ito [12] capital openness indicator that we use here is based on data taken from the IMF Annual Report on Exchange Arrangements and Exchange Restrictions. While similar to the widely employed Quinn [45] index of capital mobility, we use the Chinn and Ito index because it is more up-to-date (it covers the period 1970-2004, while the Quinn index is available only up to 1999 for some countries and 1997 for others) and for a larger subset of countries (181 against the 90 of the Quinn Index). See also Chinn and Ito [13].

tax revenues are used to finance public expenditure, the degree of public consumption could be an important element to explain the corporate tax rate of a country. There is some evidence, though, that the statutory corporate tax rate is not significantly correlated with the fiscal needs of the government (Slemrod [48]). Some authors (Haufler et al. [26]) even found that the amount of public expenditure influences negatively the corporate income tax rate. Therefore, the sign of the coefficient on public spending is a priori ambiguous. We use the ratio of government expenditure to GDP as a measure of public sector intervention.

In addition, equation (9) includes the employment rate (total employment over total population) as a measure of the size of the labour tax base, and the proportion of young (below age 14) and elderly (above age 65) population to account for potential demographic pressures on tax revenue requirements.

Finally, equation (9) includes the (top) personal income tax rate: according to the so-called "backstop hypothesis" (Slemrod [48]), one of the key reasons for taxing corporate income is to prevent citizens from avoiding personal taxation by incorporating their income. As a result, the statutory corporate tax rate should be higher in countries where the top personal income tax rate is high.

3.2 Measures of volatility

In addition, equation (9) includes a number of economic and political volatility indicators among the regressors.

3.2.1 Economic volatility

As far as economic volatility is concerned, the usual strategy is to calculate the standard deviation of the relevant variables along intervals of 5 or 10 years.[15] In our framework, though, that strategy would be pretty costly in

[15] Notice that this strategy is employed, in particular, in the growth literature that studies the impact of volatility and uncertainty on GDP growth rates. See, e.g., Ramey

terms of data loss. Consequently, in order to fully exploit the information contained in our data set, we calculate the standard deviation of the relevant variable through the five previous years. For example, in order to calculate the volatility of the interest rate in year 2000, we calculate the standard deviation of the interest rates from 1996 to 2000. As a result, this measure amounts to a kind of "moving average" index of volatility. This measure is calculated for three economic variables: GDP growth rate, real interest rate and nominal exchange rate.

Firstly, GDP is a measure of the aggregate income of a country and of the size of the market. The literature on FDI (see e.g. Markusen [35]) reports evidence that the horizontal-type multinational - i.e., multinationals that sell their products to the host country's customers - is the most widespread form of multinational enterprise among OECD countries. It is therefore reasonable to expect that, *coeteris paribus*, MNCs prefer to settle in stable and expanding markets, especially when the investment choice is to some extent irreversible. This finding is in line with Panteghini and Schjelderup [43].

Secondly, interest rate volatility might be important in the light of the role of the tax system in shaping the financial structure of firms. This is due to the fact that interest expenses are usually deductible from corporate taxable income, and offer MNCs a tax shield by making use of both the internal (through the so called "debt shifting" between affiliates) and external credit market.[16] As a result, real interest rate variability could have a number of effects on MNCs' strategies. First, it could require multinational firms that invest in uncertain countries to continuously adjust the optimal debt/asset ratio in response to the changing credit market conditions. Sec-

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and Ramey [46] and Aghion et al. [1].

[16] In particular, external credit market conditions proved to be important determinants of the financial structure of multinationals'affiliates in developed credit markets countries (see Desai et al. [18]) and of partly foreign-owned firms (see Mintz and Weichenrieder [39]). Moreover, as shown in Desai et al. [18], multinational affiliates substitute external and internal debt according to the evolution of credit market conditions.

ond, MNCs that invest in uncertain environments could be forced to change their internal/external debt strategy in response to external credit market conditions of the foreign affiliates. Third, MNCs that use the internal credit market channel can shift profits and tax burden from one country to another by using the debt shifting option. However, an arm's length interest rate is typically used by fiscal authorities in order to calculate the fiscal burden on firms. Uncertainty in interest rates applicable to "between affiliates" debt shifting transactions could then affect the feasibility and profitability of such profit shifting strategies.

Finally, in line with Chen and So [11], we use the exchange rate volatility as a measure of the variability of the relative price of domestic and foreign goods. In fact, as shown by Petroulas [44], exchange rate variability discourages international investment. This means that, fixing the exchange rate - as shown by the EMU evidence in the 1992-2001 period - leads to a substantial increase in FDI.

3.2.2 Political volatility

Vector v_{it} in equation (9) also includes two measures of "political volatility". First, we account for changes in a government's policy by a variable reporting the number of changes of a country's government over the previous five years (see Appendix G for details). Since changes in government composition are often associated with relevant policy changes, this variable should capture the degree of stability of policy orientation of a country's government. Second, we control for private property protection using an indicator (ranging from 0 to 10) that measures the degree of private property protection and consequently the probability of expropriation.[17] Descriptive statistics and data sources of all variables used in the analysis are reported in Appendix G.

[17] Using an index of "social conflict" measuring the degree of social tension in a country (including various symptoms of social unrest, such as strikes, anti-government demonstrations, political assassinations and riots) and the probability of an abrupt change in government's policy and composition gave very similar results.

3.3 Results

Equation (9) is estimated on the unbalanced panel data set described in Appendix G using the GMM estimator developed by Blundell and Bond [6]. The Blundell-Bond estimator uses twice and more lagged values of τ as instruments for the lagged dependent variable under the hypothesis that first-order serial correlation in the residuals of the equation in levels is nil. Moreover, using a GMM approach we can also control for potential endogeneity of other right hand side variables (in particular, government spending, GDP and personal income tax rate). The matrix of instruments includes all of the exogenous variables as well as their lags.

The GMM estimation results of equation (9) are shown in tables 1 and 2. The Arellano and Bond [3] tests for the presence of auto-correlation in the residuals reject the null hypothesis of no first-order autocorrelation and cannot reject the null hypothesis of no second-order autocorrelation. This suggests that twice-lagged values of τ are valid instruments for $\Delta\tau_{it-1}$. Instrument validity is also confirmed by the Hansen test results reported at the bottom of tables 1 and 2. Finally, the standard errors shown in the table are robust to the presence of auto-correlation and heteroschedasticity.

Table 1, column (a), reports the estimation results of a standard specification including no volatility measure; column (b) shows the estimates when the five-year standard deviation of real interest rate (measured by the prime lending rate minus the inflation rate) is included in the equation as a measure of "economic" volatility. Column (c) also adds the two "political" volatility indicators: the index of property rights protection and the number of changes in government over the previous five years.

Similarly to earlier studies, the auto-regressive coefficient on the lagged dependent variable shows a high degree of persistence of the statutory corporate tax rate, with an auto-regressive coefficient of about 0.9. As far as the control variables are concerned, all have the expected sign: larger countries in terms of GDP size - as well as those with higher percentages of young and old population - appear to set higher corporate tax rates, while government spending and employment are estimated imprecisely. Moreover, similarly to the results obtained by Slemrod [48], neither the level of the personal income tax rate nor the index of capital market openness are statistically significant once country fixed effects are included.

As far as our volatility indicators are concerned, the standard deviation of the real interest rate has a significant and negative effect on the corporate tax rate. This result is in line with the theoretical predictions of section **2**, in the sense that, since volatility reduces the overall number of firms involved in FDI activities, a government's optimal policy response consists in lowering the corporate tax rate in order to partially offset the negative impact of increased volatility.[18] On the other hand, the indexes of political volatility, while having the expected negative sign, are not estimated to have a significant impact on corporate taxation policy.

Table 2, column (d), shows the results when using the standard deviation of the GDP growth rate as a measure of economic volatility, while columns (e) and (f) use the standard deviation of the nominal exchange rate as a measure of economic volatility. The results show that the nominal exchange rate volatility has a negative and significant impact, while the political uncertainty variables and GDP growth rate volatility are not estimated to have any significant effect on the corporate tax rate.

4 Structural model estimation

While estimation of the corporate tax equation (9) supports the hypothesis that economic volatility plays a role in the corporate tax setting process, it is unable to reveal how volatility works. In fact, the corporate tax determination equation can be thought of as a reduced form of a two-equation structural model. Similarly to the specification in Brett and Pinkse [8], the

[18] Similar results, though slightly less precise, are obtained when employing the nominal interest rate volatility.

structural form specification comprises a first equation that models the FDI inflow as a function of a given set of exogenous variables including our measures of volatility, as well as the corporate tax rate. Secondly, the model includes the tax rate setting equation, where the corporate tax rate is regressed on a set of variables that includes the endogenously determined size of FDI.

In particular, we want to verify whether the volatility measures that proved to be significant determinants of corporate taxation policy exert their effect through the FDI flow into a country, and whether a country's policy-makers react to changes in FDI decisions by manoeuvring the tax rates. Indeed, according to the theoretical model outlined in section **2**, we should expect higher volatility as well as higher corporate tax rates to influence negatively the FDI inflow into a country. On the other hand, the larger the amount of FDI, the higher the tax rate on corporate income should be.

As a result, the structural form we employ is made up of the following two equations, where the corporate tax rate (τ_{it}) and the FDI inflow (b_{it}) are determined simultaneously:

$$\tau_{it} = \rho\tau_{it-1} + \alpha b_{it} + x'_{it}\beta + f_i + h_t + \varepsilon_{it} \tag{10}$$

$$b_{it} = \kappa\tau_{it-1} + v'_{it}\phi + \delta z_{it} + g_i + m_t + \eta_{it}. \tag{11}$$

In equation (10), the top statutory corporate tax rate depends on its own lag (τ_{it-1}), on the logarithm of the FDI inflow (b_{it}) and on a vector of variables (x_{it}) including demographic composition of the population, rate of urbanization, employment rate, personal income tax rate and the logarithm of the size of FDI outflows.[19]

The logarithm of the FDI inflow b_{it} appears as the dependent variable in equation (11), where it depends on our volatility measures (v_{it}) and on the lagged statutory tax rate (τ_{it-1}), based on the assumption that FDI flows

[19] Apart from demographics and rate of urbanization, all other variables are allowed to be endogenous.

adjust to changes in the corporate taxation policy with a lag.[20] Finally, equation (11) includes an index of productivity (GDP per worker, z_{it}) that should capture the attractiveness of a location for FDI, and both equations include GDP, public spending as a share of GDP and the Chinn-Ito index of capital market openness.[21]

The model is estimated by three stage least squares (3SLS), and both equations include time (h_t, m_t) and country (f_i, g_i) fixed effects.[22]

The results obtained when using the standard deviation of the real interest rate as a measure of economic volatility are reported in table 3.[23] In order to allow for the fact that FDI inflow might itself affect the volatility of the real interest rate, we treat it as endogenous by using its own lags as instruments. On the other hand, the two political volatility variables are taken as exogenous.

The results show that the lagged statutory corporate tax rate has a negative and statistically significant effect on the size of FDI flowing into a host country. Moreover, the economic volatility variable is estimated to have a negative and significant impact on FDI: at mean values, the implied elasticity of FDI with respect to the interest rate volatility equals around -0.7. Coher-

[20] This dynamic specification has also been chosen for convenience. Using the contemporaneous statutory tax rate made identification of the parameters more difficult, while - due to the high persistence of the statutory corporate tax rate - it did not lead to substantially different results. Moreover, alternative dynamic hypotheses - such as allowing for immediate FDI adjustment to corporate tax rate changes in equation (11) and letting corporate tax rates respond to FDI inflows with a lag in equation (10) - yielded similar results.

[21] After controlling for country fixed effects, alternative measures of attractiveness of a location for investment - such as the duration of education of people aged 25 and more as an index of human capital endowment, and indexes of infrastructure endowment - did not exhibit any correlation with the flow of FDIs to a country. See de Mooij and Ederveen [14] for a review of the empirical literature on the determinants of FDI.

[22] While there are a number of theoretical reasons (such as third-country effects) why FDI inflows into a country may depend on FDI in proximate countries, Bloningen et al. [5] show that the presence of country dummies makes inclusion of a spatial lag of FDI in equation (11) almost redundant.

[23] Since similar results emerge when using the nominal exchange rate volatility or the nominal interest rate volatility, they are not reported and are available on request.

ently with the reduced form estimates, political volatility indicators, while having the expected negative sign, are not estimated to have a significant role in the FDI determination process.

As far as the other variables are concerned, the measures of human capital, infrastructure endowment and productivity do not appear to influence the FDI inflow. While these results might be explained by the fact that those variables are measured with an error and fail to properly capture a country's attractiveness for foreign investment, they are compatible with the hypothesis that profit shifting is the leading force driving FDI flow. Finally, the backstop hypothesis is not supported by our findings.

Estimation of the tax rate determination equation that explicitly includes FDI on the right hand side shows that the latter variable has the expected positive and significant impact on the corporate tax rate. This confirms the model predictions. Unlike the reduced form specification, the Chinn-Ito measure of capital openness now has the expected negative impact on the corporate tax rate, consistent with the view that opening up an economy enhances the competitive downward pressure on tax rates. It is remarkable, though, that the openness variable is estimated to have a positive effect on the inflow of FDI: this suggests that the insignificance of the capital openness variable when estimating the reduced form tax setting equation might be due to the fact that the two opposite effects of the capital openness measure on FDI and tax rates respectively tend to cancel each other out.

Overall, the evidence from the estimation of the structural model suggests that the degree of volatility as well as the extent of capital market openness affect FDI flows and corporate tax setting. In particular, our results suggest that economic volatility tends to inhibit FDI inflow and, by reducing the available tax base, it exerts a negative effect on the level of the corporate tax rate.

5 Concluding remarks

Based on a theoretical framework that allows for irreversibility in the investment decision of MNCs and for the possibility of profit shifting via transfer pricing, this paper has explored the role of capital market openness and political and economic volatility on FDI flows and corporate tax rate determination. The empirical analysis on a large panel data set of countries over the 1983-2003 period gives the following main results. First, when a reduced-form dynamic equation of corporate tax rate determination is estimated by the generalized method of moments (GMM), the top statutory corporate tax rate is estimated to be negatively and significantly affected by economic volatility. On the other hand, the indicators of political volatility and capital market openness, while having the expected sign, do not have a significant impact on corporate taxation policy. Second, when estimating a structural model that allows for simultaneous determination of the corporate tax rate and the flow of FDIs into a country, it turns out that a country's degree of capital market openness is important to determine FDI inflow and corporate tax rates, and that economic volatility tends to affect the corporate tax rate through its negative impact on FDI inflow.

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Table 1 Reduced-form corporate tax rate determination equation (I)

	τ_{it}		
	(a)	(b)	(c)
τ_{it-1}	0.911 (0.034)***	0.898 (0.047)***	0.906 (0.043)***
openness	-0.062 (0.074)	-0.063 (0.117)	-0.052 (0.095)
GDP	1.606 (0.661)**	0.940 (0.508)*	0.931 (0.467)**
public spending	-0.013 (0.015)	-0.016 (0.013)	-0.007 (0.013)
personal income tax	0.004 (0.015)	-0.003 (0.021)	-0.012 (0.014)
employment	-1.761 (1.878)	-2.206 (2.855)	-1.294 (2.170)
% old	0.119 (0.045)***	0.099 (0.040)**	0.100 (0.033)***
% young	0.056 (0.021)***	0.056 (0.030)*	0.051 (0.019)***
VOLATILITY			
real interest rate		-0.105 (0.043)**	-0.112 (0.037)***
property rights			-0.090 (0.081)
political			-0.062 (0.128)
observations	1646	1153	1133
countries	114	89	87
time effects	yes	yes	yes
fixed effects	yes	yes	yes
Hansen test	$\varkappa^2_{57}$=59.17	$\varkappa^2_{55}$=51.14	$\varkappa^2_{55}$=45.90
(p value)	(0.396)	(0.623)	(0.776)
AR(1) test	$z = -4.92$	$z = -4.13$	$z = -4.14$
(p value)	(0.000)	(0.000)	(0.000)
AR(2) test	$z = 0.48$	$z = 0.41$	$z = 0.37$
(p value)	(0.628)	(0.682)	(0.714)

Notes

1) dependent variable: top statutory corporate income tax rate;

2) standard errors in parentheses;

3) *, **, ***: significant at 10%, 5%, 1%;

4) the Arellano-Bond test for an AR(1)/AR(2) error process in the equation in first differences is distributed as a standard normal $z(0,1)$;

5) the Hansen test of overidentifying restrictions (k) is distributed as ${\varkappa^2}_k$.

Table 2 Reduced-form corporate tax rate determination equation (II)

		τ_{it}	
	(d)	(e)	(f)
τ_{it-1}	0.916 (0.043)***	0.910 (0.038)***	0.904 (0.043)***
openness	-0.065 (0.089)	-0.079 (0.076)	-0.062 (0.091)
GDP	1.402 (0.553)**	2.931 (1.213)**	3.423 (1.144)***
public spending	-0.013 (0.012)	-0.016 (0.016)	-0.019 (0.010)*
personal income tax	-0.003 (0.016)	-0.001 (0.014)	-0.005 (0.017)
employment	-2.072 (2.184)	-2.511 (2.644)	-2.692 (2.712)
% old	0.154 (0.061)**	0.130 (0.047)***	0.130 (0.041)***
% young	0.064 (0.027)**	0.055 (0.018)***	0.058 (0.020)***
VOLATILITY			
nominal exchange rate		-0.967 (0.288)***	-1.067 (0.302)***
GDP growth rate	-0.005 (0.040)		
property rights	-0.032 (0.081)		0.017 (0.065)
political	-0.661 (0.685)		-0.128 (0.137)
observations	1496	1611	1504
countries	99	113	99
time effects	yes	yes	yes
fixed effects	yes	yes	yes
Hansen test	$\varkappa^2_{59}$=58.42	$\varkappa^2_{60}$=56.34	$\varkappa^2_{59}$=54.49
(p value)	(0.497)	(0.610)	(0.642)
AR(1) test	$z = -4.69$	$z = -4.94$	$z = -4.83$
(p value)	(0.000)	(0.000)	(0.000)
AR(2) test	$z = -0.37$	$z = 0.08$	$z = -0.00$
(p value)	(0.714)	(0.936)	(0.998)

Notes

1) dependent variable: top statutory corporate income tax rate;

2) standard errors in parentheses;

3) *, **, ***: significant at 10%, 5%, 1%;

4) the Arellano-Bond test for an AR(1)/AR(2) error process in the equation in first differences is distributed as a standard normal $z(0, 1)$;

5) the Hansen test of overidentifying restrictions (k) is distributed as $\varkappa^2{}_k$.

Table 3 Structural-form model: FDI and corporate tax rate

	τ_{it}	b_{it}
τ_{it-1}	0.811 (0.182)***	-0.119 (0.043)***
b_{it}	2.922 (0.888)***	
productivity		-0.315 (1.113)
GDP	-0.008 (0.113)	0.010 (0.024)
openness	-1.461 (0.509)***	0.213 (0.103)**
public spending	-0.355 (0.401)	0.050 (0.095)
% old	-0.899 (1.479)	
% young	-0.713 0.986)	
urbanization	0.049 (0.542)	
employment	-0.138 (1.094)	
personal income tax	0.205 (0.157)	
FDI outflow	-1.164 (0.772)	
VOLATILITY		
real interest rate		-0.177 (0.055)***
property rights		-0.146 (0.121)
political		-0.059 (0.094)
observations	481	
countries	51	
Hansen-Sargan test (p value)	0.98	
time effects	yes	yes
fixed effects	yes	yes

Notes

1) dependent variables: τ_{it} = top statutory corporate income tax rate; b_{it} = log(FDI inflow);

2) standard errors in parentheses;

3) the Hansen-Sargan test of overidentifying restrictions is distributed as $\chi^2_{(43)}$;

4) *, **, ***: significant at 10%, 5%, 1%.

A Derivation of (4)

Using dynamic programming, we can write the firm's value as

$$V_A(\Pi_B) = \begin{cases} (1-\tau_A)\,\Psi_A dt + e^{-rdt}\xi\left[V_A(\Pi_B + d\Pi_B)\right] & \text{before investment,} \\ \\ \Pi_A^N dt + e^{-rdt}\xi\left[V_A(\Pi_B + d\Pi_B)\right] & \text{after investment,} \end{cases} \tag{12}$$

where $\xi\,[.]$ is the expectation operator. Rearranging function (12) and applying Itô's Lemma gives

$$rV_A(\Pi_B) = L + \frac{\sigma^2}{2}\Pi_B^2 V_{A_{\Pi_B\Pi_B}}(\Pi_B), \tag{13}$$

where $L = (1-\tau_A)\,\Psi_A, \Pi_A^N$, and $V_{A_{\Pi_B\Pi_B}}(\Pi_B) = \frac{\partial^2 V_A(\Pi_B)}{\partial \Pi_B^2}$. The general closed-form solution of function (13) is

$$V_A(\Pi_B) = \begin{cases} \frac{(1-\tau_A)\Psi_A}{r} + \sum_{i=1}^2 A_i \Pi_B^{\beta_i} & \Pi_B < \Pi_B^*, \\ \\ \frac{(1-\tau_A)\Psi_A + \left[(1-\tau_B)+\phi\left(\gamma_A^*\right)\right]\Pi_B}{r} + \sum_{i=1}^2 D_i \Pi_B^{\beta_i} & \Pi_B \geq \Pi_B^*, \end{cases} \tag{14}$$

where β_1 and β_2 are the positive and negative roots of the characteristic equation $\frac{\sigma^2}{2}\beta(\beta-1) - r = 0$, respectively.[24]

To calculate A_i and D_i for $i = 1, 2$, we introduce three boundary conditions. First of all we assume that whenever Π_B goes to zero, condition $V_A(0) = 0$ holds. This implies that $A_2 = D_2 = 0$. Secondly, we assume that financial bubbles do not exist. This means that $D_1 = 0$.[25] Given these results we obtain (4).

---

[24] These roots are $\beta_1 = \frac{1}{2} + \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} > 1$, and $\beta_2 = \frac{1}{2} - \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} < 0$.

[25] For further details see e.g. Dixit and Pindyck [21].

B The threshold point (5)

To calculate (5) we apply the Value Matching Condition (VMC) and the Smooth Pasting Condition (SPC).[26] The VMC requires the equality between the present value of the project, after investment, and the firm's value before investment. The SPC requires equality between the slopes of these terms at point $\Pi = \Pi_B^*$. Substituting (4) into the VMC and SPC we thus have

$$\frac{(1-\tau_A)\,\Psi_A}{r} + A_1 \Pi_B^{*\beta_1} = \frac{(1-\tau_A)\,\Psi_A + [(1-\tau_B)+\phi(\gamma_A)]\,\Pi_B^*}{r} - I, \quad (15)$$

$$\beta_1 A \Pi_B^{*\beta_1 - 1} = \frac{[(1-\tau_B)+\phi(\gamma_A)]}{r}. \quad (16)$$

Solving the two-equation system (15)-(16) gives the threshold point (5) and the value of A_1.

C The government's objective function (7)

Let us focus on foreign subsidiaries already settled up (i.e., with $\Pi_i \in \left(\Pi_i^*, \overline{\Pi}_i\right]$). The expected present value of each subsidiary is $\frac{\Pi_i}{r}$. Given the density function $f(\Pi_i)$, we can thus calculate the overall expected tax base of subsidiaries already operating in country i, i.e.,

$$\int_{\Pi_i^*}^{\overline{\Pi}_i} \frac{\Pi_i}{r} f(\Pi_i)\, d\Pi_i. \quad (17)$$

Let us next focus on the subset of subsidiaries that will invest in the future, i.e., with $\Pi_i \in (0, \Pi_i^*)$. We denote t_i^* as the optimal time of investment in country $i = A, B$. Following Harrison [27] it is easy to ascertain that[27]

$$\xi\left[e^{-rt_i^*}\right] = \left(\frac{\Pi_i}{\Pi_i^*}\right)^{\beta_1} \text{ for } \Pi_i < \Pi_i^*. \quad (18)$$

---

[26] For a discussion of these conditions see Dixit and Pindyck [21].

[27] For further details see Panteghini [40].

Using (18) we can thus calculate the expected tax base of subsidiaries investing in the future:

$$\int_0^{\Pi_i^*} \left(\frac{\Pi_i}{\Pi_i^*}\right)^{\beta_1} \frac{\Pi_i^*}{r} f\left(\Pi_i\right) d\Pi_i. \tag{19}$$

Summing (17) and (19), and multiplying by the effective tax rate $\tau_i\left(1+\gamma_j^*\right)$, with $i \neq j$, we obtain (7).

D Proof of Proposition 1

Let us focus on country A, and solve (8). The f.o.c. is equal to:

$$\begin{aligned} \frac{\partial W_A}{\partial \tau_A} &= \frac{1}{2r\overline{\Pi}_A}\left\{\frac{\partial\left[\tau_A\left(1+\gamma_B^*\right)\right]}{\partial \tau_A}\cdot\left[\overline{\Pi}_A^2-\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^{*2}\right]+\left[\tau_A\left(1+\gamma_B^*\right)\right]\frac{\partial\left[\overline{\Pi}_A^2-\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^{*2}\right]}{\partial \tau_A}\right\} \\ &= \frac{1}{2r\overline{\Pi}_A}\left\{\left(1+\frac{\tau_B-2\tau_A}{n}\right)\left[\overline{\Pi}_A^2-\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^{*2}\right]-2\left[\tau_A\left(1+\gamma_B^*\right)\right]\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^*\frac{\partial \Pi_A^*}{\partial \tau_A}\right\}=0. \end{aligned} \tag{20}$$

Under symmetry (20) reduces to:

$$\begin{aligned} \left.\frac{\partial W_A}{\partial \tau_A}\right|_{\tau_A=\tau_B=\tau} = \frac{1}{2r\overline{\Pi}_A}\left\{\left(1-\frac{\tau}{n}\right)\left[\overline{\Pi}_A^2-\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^{*2}\right]\right. &= 0, \\ \left. -2\tau\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^*\frac{\partial \Pi_A^*}{\partial \tau_A}\right\} &= 0 \end{aligned} \tag{21}$$

with $\tau_A=\tau_B=\tau$, $\Pi_A^*|_{\tau_A=\tau_B=\tau} = \Pi_B^*|_{\tau_A=\tau_B=\tau} = \frac{\beta_1}{\beta_1-1}\frac{rI}{(1-\tau)}$ and $\left.\frac{\partial \Pi_A^*}{\partial \tau_A}\right|_{\tau_A=\tau_B=\tau} = \left.\frac{\partial \Pi_B^*}{\partial \tau_B}\right|_{\tau_A=\tau_B=\tau} = \frac{\beta_1}{\beta_1-1}\frac{rI}{(1-\tau)^2}$.

Following the same procedure we can find government B's f.o.c.

Rearranging we can write (21) as follows:

$$\left(\frac{\overline{\Pi}}{rI}\right)^2 = \frac{\beta_1^2}{\beta_1^2-1}\left[1+\frac{2\tau}{(1-\tau)\left(1-\frac{\tau}{n}\right)}\right]\frac{1}{(1-\tau)^2}, \tag{22}$$

with $\overline{\Pi}_A=\overline{\Pi}_B=\overline{\Pi}$. It is easy to show that (22) holds if $\left(1-\frac{\tau}{n}\right)>0$, i.e., if $n>\tau$ (i.e., if n is high enough). Moreover, we can show that the second order condition under symmetry is

$$
\begin{aligned}
&\frac{\partial^2 W_A}{\partial \tau_A^2} = \\
&= \frac{1}{2r\overline{\Pi}_A}\left\{-\frac{2}{n}\left[\overline{\Pi}_A^2 - \left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^{*2}\right] - 2\left(1+\frac{\tau_B-2\tau_A}{n}\right)\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^*\frac{\partial \Pi_A^*}{\partial \tau_A}\right. \\
&-2\left(1+\frac{\tau_B-2\tau_A}{n}\right)\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^*\frac{\partial \Pi_A^*}{\partial \tau_A} - 2\left[\tau_A\left(1+\gamma_B^*\right)\right]\left(\frac{\beta_1-1}{\beta_1+1}\right)\left(\frac{\partial \Pi_A^*}{\partial \tau_A}\right)^2 \\
&\left.-2\left[\tau_A\left(1+\gamma_B^*\right)\right]\left(\frac{\beta_1-1}{\beta_1+1}\right)\Pi_A^*\frac{\partial^2 \Pi_A^*}{\partial \tau_A^2}\right\}.
\end{aligned}
$$

It is easy to ascertain that, under symmetry, we have $\left.\frac{\partial^2 W_A}{\partial \tau_A^2}\right|_{\tau_A=\tau_B=\tau} < 0$ if n is high enough. Proposition 1 is thus proven.■

E Proof of Proposition 2

Rewrite (22) as

$$
\left(\frac{\overline{\Pi}_A}{rI}\right)^2 = \frac{\beta_1^2}{\beta_1^2-1} g(\tau), \tag{23}
$$

where $g(\tau) \equiv \left[1+\frac{2\tau}{(1-\tau)\left(1-\frac{\tau}{n}\right)}\right]\frac{1}{(1-\tau)^2}$. Differentiating (23) gives

$$
2d\left(\frac{\overline{\Pi}_A}{rI}\right) = \frac{\beta_1^2}{\beta_1^2-1}\frac{\partial g(\tau)}{\partial \tau}d\tau \tag{24}
$$

with $\frac{\partial g(\tau)}{\partial \tau} > 0$. Rearranging (24) thus gives

$$
\frac{d\tau}{d\left(\frac{\overline{\Pi}_A}{rI}\right)} = \left(\frac{\beta_1^2-1}{\beta_1^2}\right)\frac{2}{\frac{\partial g(\tau)}{\partial \tau}} > 0.
$$

Proposition 2 is thus proven.■

F Proof of Proposition 3

Differentiating (23) gives

$$
\frac{\partial\left(\frac{\beta_1^2}{\beta_1^2-1}\right)}{\partial \sigma^2} g(\tau)\, d\sigma^2 + \frac{\beta_1^2}{\beta_1^2-1}\frac{\partial g(\tau)}{\partial \tau}d\tau = 0,
$$

with $\frac{\partial\left(\frac{\beta_1^2}{\beta_1^2-1}\right)}{\partial\sigma^2} = -\frac{2\beta_1}{\left(\beta_1^2-1\right)^2}\underbrace{\frac{\partial\beta_1}{\partial\sigma^2}}_{<0} > 0$. Therefore we have:

$$\frac{d\tau}{d\sigma^2} = -\frac{\frac{\partial\left(\frac{\beta_1^2}{\beta_1^2-1}\right)}{\partial\sigma^2} g\left(\tau\right)}{\frac{\beta_1^2}{\beta_1^2-1}\frac{\partial g(\tau)}{\partial\tau}} < 0.$$

This proves Proposition 3.■

G The dataset

1. Baseline full sample of countries (114 countries). Longest time period: 1983-2003 (unbalanced panel).

Argentina#, Australia#, Austria, Azerbaijan, Bahamas, Bahrain#, Bangladesh#, Barbados, Belgium#, Belize, Bolivia#, Botswana#, Brazil, Bulgaria, Cambodia, Cameroon, Canada#, Chile#, China, Colombia#, Congo Dem. Rep.Congo (Republic of), Costa Rica#, Cote d'Ivoire, Croatia, Cyprus#, Czech Republic, Denmark#, Dominican Republic, Ecuador#, Egypt#, El Salvador, Estonia, Fiji, Finland#, France#, Gabon, Germany#, Ghana, Greece, Guatemala#, Haiti, Honduras, Hong Kong, Hungary#, Iceland, India#, Indonesia#, Iran, Ireland#, Israel#, Italy#, Jamaica#, Japan#, Kazakhstan, Kenya#, Republic of Korea, Kuwait, Latvia, Liberia, Lithuania, Malawi, Malaysia#, Malta, Mauritius#, Mexico#, Morocco, Mozambique, Namibia, Netherlands#, Netherlands Antilles, New Zealand#, Nicaragua, Nigeria, Norway#, Oman, Pakistan, Panama#, Papua New Guinea#, Paraguay#, Peru#, Philippines#, Poland#, Portugal#, Qatar, Romania, Russia, Saudi Arabia, Senegal, Singapore#, Slovak Republic, Slovenia, Solomon Islands, South Africa#, Spain#, Sri Lanka#, Suriname, Swaziland, Sweden#, Switzerland#, Tanzania, Thailand#, Trinidad & Tobago, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom#, United States#, Uruguay, Uzbekistan, Venezuela#, Vietnam, Zambia, Zimbabwe.

2. Variable name (number of observations; mean; standard deviation; minimum value; maximum value), description and source.

- Capital market openness index (3250; 0.068; 1.548; -1.753; 2.623): Chinn-Ito capital openness measure. This indicator assumes higher values when countries become more open. Chinn and Ito [12]. Dataset downloadable at: www.ssc.wisc.edu.

- Corporate tax rate (2209; 34.32; 10.78; 0; 75): central government top corporate income statutory tax rate. World Tax Database at the Michigan Ross School of Business (www.bus.umich.edu), integrated with data from World Bank (WDI) and from KPMG (Corporate tax rates survey, issues from 1998 to 2003).

- Education (2131; 3.50; 1.71; 0.30; 7.67): average years of schooling of people aged 25 or more. This variable should capture the human capital endowment of a country. Data are provided on a five years basis. Consequently, in years with missing data -since this variable evolves slowly over time-, we have considered it as constant and equal to the most recent data available. Quality of Governance Dataset (www.qog.pol.gu.se). Original Source: Barro-Lee Education Attainment dataset.

- Employment (3176; 0.444; 0.066; 0.241; 0.599): ratio of total employment over total population. This variable should measure the importance of the tax base composed of wages and salaries. Own calculations based on PWT data.

- FDI inflow (2689; 5.109; 3.162; -9.557; 16.403): log of the total inflow of FDI in constant 2000 USA millions of dollars. UNCTAD, FDI indicators, available at http://stats.unctad.org/fdi/. Converted into constant 2000 USA dollar using local currency/USA dollar nominal exchange rate taken from PWT and CPI from IMF, International Financial Statistics.

- FDI outflow (1996; 3.802; 4.265; -15.57; 17.103): log of the total outflow of FDI expressed inconstant 2000 USA dollars. UNCTAD, FDI indicators, available at http://stats.unctad.org/fdi/. Converted into constant 2000 USA dollar using local currency/USA dollar nominal exchange rate taken from PWT and CPI from IMF, International Financial Statistics.

- Infrastructure index (2260; -2.32; 1.93; -6.62; 1.78): ratio of the log of the length of the road and railway line network over the log of the total country area. This variable should measure the infrastructure endowment of the country. Data are provided on a five years basis. Consequently, in years with missing data -since this variable evolves slowly over time-, we have considered it as constant and equal to the most recent data available (see Serven and Calderon [10]).

- Old (3591; 6.232; 4.274; 1.00; 19.33): share of population aged 65 or more. WDI.

- Young (3591; 34.76; 10.27; 14.11; 50.40): share of population aged 14 or less. WDI.

- Personal income tax (1974; 38.28; 18.17; 0; 90): central government top personal income tax rate. World Tax Database at the Michigan Ross School of Business (www.bus.umich.edu) . Integrated with data from the World Bank (WDI) and, for OECD countries, with data from the OECD Tax Database.

- Public spending (3447; 23.663; 10.950; 2.12; 98.27): government expenditure share of GDP. Penn World Tables (PWT).

- Size (3447; 16.807; 2.269; 10.806; 23.112): log of Purchasing Power Parity Gross Domestic Product in thousands of currency units. Penn World Tables (PWT).

- Urbanization (3771; 51.20; 23.70; 4.22; 100): share of urban population. WDI.

- Exchange rate volatility (3393; 25.37; 73.97; 0; 798.8): standard deviation in the rate of growth of the nominal exchange rate with the USA dollar. In the estimates that use this variable, the USA was dropped from the sample. PWT.

- GDP volatility (3313; 5.419; 5.308; 0.258; 60.035): standard deviation of the GDP growth rate in the preceding five years. GDP is in Purchasing Power Parity. Penn World Tables (PWT).

- Interest rate volatility (2308; 5.84; 9.81; 0.17; 346.20): standard deviation of the real interest rate (defined as nominal lending rate minus inflation rate computed as the rate of growth of the GDP deflator) in the preceding five years. WDI.

- Political instability (3801; 0.469; 0.694; 0; 4): total number of changes, recorded in the preceding five years, in the executive composition. Own calculations based on data taken from the Polcon dataset (www-management.wharton.upenn.edu).

- Property rights protection (2417; 5.518; 1.885; 1.022; 9.624): degree of property rights protection. Fraser Institute (www.freetheworld.com). Until 1999, this variable is provided on a five years basis. Consequently, in years with missing data -since this variable evolves slowly over time-, we have considered it as constant and equal to the most recent data available.

Notes:

1. #FDI data available.

2. PWT refers to: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.2, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, September 2006.

3. WDI: World Development Indicators (2006), World Bank.

4. The FDI inflow and outflow variables comprise capital provided (either directly or through other related enterprises) by a foreign direct investor to a FDI enterprise or capital received by a foreign direct investor from a FDI enterprise. FDI includes the three following components: equity capital, reinvested earnings and intra-company loans. Equity capital is the foreign direct investor's purchase of shares of an enterprise in a country other than that of its residence. Reinvested earnings include the direct investor's share (in proportion to direct equity participation) of earnings not distributed as dividends by affiliates or earnings not remitted to the direct investor. Such retained profits by affiliates are reinvested. Intra-company loans or intra-company debt transactions refer to short- or long-term borrowing and lending of funds between direct investors (parent enterprises) and affiliated enterprises.