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International Tax Spillovers and Tangible Investment, with Implications for the Global Minimum Tax

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Abstract

This paper articulates and, using newly-assembled data, explores how international taxation affects aggregate tangible cross-border investment. Spillovers from statutory tax rates abroad seem: As sizable as effects from the host's rate; larger than previous consensus values (attributed to a systematic bias from FDI data); and consistent with 'implicit' profit shifting through real investment (rather than 'paper' profit shifting). Contrary to much policy discussion, the results also imply that: Host countries' marginal effective tax rates have at best a weak effect on real investment; those elsewhere have none; and, applied to the prospective global minimum tax, inward tangible investment in most sample countries will increase.

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International tax spillovers and tangible investment, with implications for the global minimum tax

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1 Introduction

International spillovers in corporate taxation have become a prominent policy concern in recent years, reflecting increased recognition of the impact that each country's tax policies may have on both activity and tax revenues in others, and of the potential this creates for potentially damaging tax competition. These concerns prompted the G20/OECD-led project on Base Erosion and Profit Shifting (BEPS) which has now culminated in the genuinely historic agreement among nearly 140 countries, in October 2021, on fundamental reform of the international tax architecture.[1] A key and unprecedented element of this is agreement on a global minimum effective rate of corporate tax of 15 percent, due to take effect in 2024. One might have expected these policy debates to have been informed by, and generate, close analyses of the effects of international tax reform on cross-border investment. After all, attracting inward investment, including through tax system design, is evidently a major concern in many countries, seeing this as a route to both employment and growth-enhancing knowledge spillovers.[2] And there is indeed a large literature on the topic: large enough to have begun generating meta-studies many years ago (De Mooij and Ederveen (2003), Feld and Heckemeyer (2011)). Over the last few years, however, there has been a shift of interest, both academic and in the OECD/G20 discussions, towards analyzing the anatomy and, in particular, the tax revenue consequences of 'profit shifting' (meaning artificial transactions intended simply to reduce total tax liability).[3] Empirical understanding of tax effects on real cross-border investment, however, has not progressed as rapidly.

The recent preoccupation with the revenue consequences of profit shifting, also stressed by Suárez Serrato (2019), is indeed likely one reason for this. But there is perhaps a more

[1]OECD (2020*a*,*b*).

[2]There is ample evidence on the positive spillover effects from foreign direct investment on the accumulation of know-how (see for instance Baldwin, Braconier and Forslid (2005) and Keller (2010)), economic growth for capital-importing countries (Bosworth and Collins (1999), Javorcik (2004), and Alfaro et al. (2004)), and domestic capital formation in capital-exporting countries (Desai, Foley and Jr. (2005)).

[3]Recent reviews are in Beer, De Mooij and Liu (2020) and Dharmapala (2019). The exact magnitude of profit shifting remains contentious, but has been estimated as dissipating 5-10 percent of total corporate income tax revenue in advanced and emerging economies (OECD (2015) and Tørsløv, Wier and Zucman (2018)), a third or more of all U.S corporate tax revenue (Clausing (2020)), and up to 1.3 percent of GDP in developing countries (Crivelli, De Mooij and Keen (2016)).

fundamental explanation than shifting interests. This is that a great deal of the literature has used Foreign Direct Investment (FDI) data, enthusiasm for which has been dimmed by the increasing recognition of a point first made long ago: "FDI does not correspond directly to any measure of real investment [...] It is more accurately thought of as a measure of financial flows..."[4] Measured FDI includes, importantly, flows that for tax reasons (routing intra-group payments so as to take advantage of reduced withholding tax rates and other tax or treaty provisions), and perhaps for other reasons too, pass through some 'conduit' jurisdiction while generating real investment somewhere else. This means that the same underlying investment can be recorded multiple times as it passes through conduits, giving rise to a form of double counting. And such conduit flows cannot be unravelled from the FDI data, which typically report the location of affiliates' immediate parents, not that of the ultimate parent company. The importance of these points jumps out from the data, in the existence of 'investment hubs' with inward investment clearly far in excess of levels that are plausible for domestic investment, given the size of the domestic economy.[5] Such investments, with no real links to the local economy, may account for around 40 percent of global FDI.[6] Relying on FDI data to infer tax effects on cross-border real investment is thus, at best, highly problematic.

There are of course analyses that do not use aggregate FDI data, with much attention coming to be focused on firm-level data (as for example in Liu (2020) and Millot et al. (2020)). While this has evident importance and appeal, results from aggregate FDI-based studies continue to shape views on tax-responsiveness; and untangling what FDI data do or do not say about tax effects has its own importance from the wider macroeconomic perspective of understanding and managing cross-border capital flows. Moreover—even leaving aside the problems with FDI data—much of the literature focuses only on the impact on inward FDI of host country taxation, and so simply does not speak to the key issue of cross-country

[4]Slemrod (1990), p.83.

[5]See for instance International Monetary Fund (2014), Blanchard and Acalin (2021), Damgaard, Elkjaer and Johannesen (2019) and Coppola et al. (2021).

[6]Aykut, Sanghi and Kosmidou (2017), Damgaard, Elkjaer and Johannesen (2019).

spillovers from one country's tax system to real investment elsewhere.[7]

Against that backdrop, the core purpose of this paper is to make further progress on what thus remains, somewhat surprisingly, one of the least-understood aspects of international tax arrangements: the impact on real investment. The results then enable us to address a key but somewhat neglected aspect of the prospective impact of the global minimum tax: its effects on real investment, both by country and in aggregate.

The fundamental problems associated with the use of FDI data are overcome here by using a newly-constructed dataset on Foreign Affiliate Investment (FAI). These data explicitly record the acquisition of tangible assets (new and old) by foreign affiliates in each host country,[8] and see through conduit flows to identify the country of the ultimate parent. Consequently, neither of the main shortcomings of FDI data applies. Estimation can explore the effects on host-parent bilateral FAI flows of tax systems in the host country, parent country and other potential host countries. Our dataset covers inward investment from 187 parent countries into affiliates in 32 (advanced) host countries from 2003-2016, along with detail on a range of activity variables. The rich information in this dataset helps disentangle the effect of taxes from unobserved, confounding factors on inward foreign investment. The limitation of these data to tangible assets is a significant one, given the increasing importance of intangibles in multinational activity; but there can be little doubt as to the importance and salience of tangible investment for the formation of tax and other policies.

Armed with these data, the conceptual challenge is then to elucidate the precise channels by which taxation might affect inward FAI. Candidates explored in previous work, sometimes somewhat haphazardly, include statutory tax rates, average effective tax rates (along the lines of Devereux and Griffith (2003)) and marginal effective tax rates of the kind developed in closed economy contexts (classically, as in King and Fullerton (1984))[9] . The precise routes by

[7]The semi-elasticity on which the meta-analyses of De Mooij and Ederveen (2003) and Feld and Heckemeyer (2011) focus is that with respect to the host country rate. Some studies do construct simple tax differentials: Bénassy-Quéré, Fontagné and Lahrèche-Révil (2005), for example, examine the effect of tax differentials on bilateral FDI, though the differential is in this case simply that between host and parent statutory rates.

[8]They thus put to rest the lament with which the quotation from Slemrod (1990) continues: "Unfortunately, no data exist on real investment made by foreign branches and subsidiaries."

[9]The King-Fullerton marginal effective tax rate is the wedge between the pre- and post-tax returns on an

which these effects are expected to operate are often not clearly spelt out, either in analytical work or public debate. The reduced marginal effective rates associated with the 2017 Tax Cuts and Jobs Act in the United States, for example, prompted concerns in Canada with the impact on investment there. But how exactly the marginal effective rate in one country, constructed with a closed economy in mind, should impact investment in another is by no means obvious. Similar doubts apply more generally to the helpfulness of the much-noted cross-country 'league tables' of marginal effective tax rates[10] in understanding cross-border investment decisions.

The approach taken here is to ground the empirics in a simple but reasonably general model of the investment decisions of a multinational that potentially operate in several countries. This generates a sufficient statistic which summarizes the impact of the international and domestic tax system on inward investment, encapsulating effects through statutory tax rates, in both the host country and alternative locations abroad, and King-Fullerton-type marginal effective tax rates. In doing so, it highlights one form of spillover that has been largely neglected in the international tax literature: the direct effect that investment in one affiliate within a multinational may have on the profitability of others. It might be, for example, that investing in one, and expanding its sales, reduces the price at which others can sell; or expanding one may require using scarce expertise within the group and so reduce the profitability of others. We refer to this, for want of a better term, as 'implicit' profit shifting, and distinguish it from 'paper' profit shifting of the kind that, as mentioned above, has become the primary focus of attention. In the empirics, we allow for, and attempt to differentiate between, these two forms of profit shifting and the tax effects that operate through them.

The paper is structured as follows. Section 2 sets out the broad framework that articulates potential channels for tax spillovers on real investment and guides the empirical work. Section 3 elaborates on the fundamental differences between FAI and FDI data and Section 4 then develops an estimation strategy. Section 5 sets out baseline results, explores their robustness

underlying investment which just yields the investor their required post-tax return (conventionally expressed as a proportion of the former).

[10]As, notably, Mintz (2018) and Bazel and Mintz (2020).

and some extensions, and explores directly the empirical consequences of using FAI rather than FDI data. Section 6 applies the results to assess the implications for real inward investment of the prospective global corporate minimum tax rate. Section 7 concludes.

2 Channels of Tax Spillover

To fix ideas, consider a multinational potentially investing through controlled affiliates in N countries. Suppose too, for now, that profit shifting through artificial transactions between them is not possible: relaxing this will be one of the later extensions. Denoting by $K_j \geq 0$ the tangible capital that the multinational invests in its affiliate in jurisdiction j, and by $F_j(K_j)$ some output associated with that capital, we suppose taxable receipts of the affiliate in the typical host jurisdiction h to be of the form $R_h[F_1(K_1), .., F_h(K_h), .., F_N(K_N)]$.[11] The key feature this allows for is the possibility that receipts of an affiliate located in any country h may depend on the production of related affiliates in other countries. This serves to capture a range of possible patterns of multinational activity.

The simplest such possibility is that each affiliate serves its own local and competitive market, selling its product at price P_h, so that $R_h = P_h.F_h(K_h)$; this is in effect the familiar closed economy case, with no cross effects across the distinct affiliates. But there are many other possibilities captured by this structure. One, a case of particular interest in analyzing the consequences of closer economic integration, is that the affiliates sell a homogeneous product into a single integrated market within which the multinational has some degree of market power, so that $R_h = P(\sum_{i=1}^{N} F_i)F_h$, where $P(.)$ denotes inverse demand, with $P' < 0$.[12] In this case, each cross effect $\partial R_j/\partial F_h - P'F_j$ is strictly negative: increased output in h reduces the price at which all affiliates sell, and so reduces revenue in all countries other than h itself. Another possibility is that expanding output in affiliate h diverts scarce managerial resources away from other affiliates, again implying a negative cross-effect. There may also be circumstances, however, in which cross effects are positive, reflecting some

[11]The $F_j(K_j)$ are assumed increasing and strictly concave; intermediate goods supplied by third parties is taken to be subsumed in the revenue functions.

[12]Derivatives are indicated by a prime for a function of one variable.

form of cross-border complementariness across host countries. (The idea of cross-country complementarities has attracted significant attention in the literature, but with a focus quite different from that here: there it is on the relationship between domestic investment and investment abroad;[13] here it is on the relationships between inward investment into alternative locations.) In the analysis that follows, while the possibility is left open that cross effects may indeed be positive between h and some affiliates in the group, it is assumed, for definiteness, that the aggregate cross effect over affiliates is strictly negative, so that $\sum_{j\neq h}^{N} \partial R_j / \partial F_h < 0$.

The tax system in each country j has two components. One captures the marginal effective tax rate in the tradition of King and Fullerton (1984); we refer to this as the KF-$METR$. Familiar from the analysis of investment in closed economies as a sufficient statistic for tax effects on investment, this is modeled as tax of M_j (expressed as a proportion of the required return, which is denoted by ρ and taken to be fixed) applied to the use of real capital in j. The other is a 'source-based' statutory tax rate on the profit earned on investments in j (against which M_j is deductible) at rate T_j. The multinational's aggregate after-tax profit is thus

$$\Pi(K_1, .., K_N) = \sum_{j=1}^{N} (1 - T_j) \left(R_j \left[F_1(K_1), .., F_N(K_N) \right] - \rho(1 + M_j) \right), \tag{1}$$

it being assumed that the required return to capital is deductible where the associated capital is located. All this, it should be noted, relates to a multinational parented in some particular country p; that could be recognized by the clutter of an additional subscript, but the point only becomes material if residence-based taxes apply, and the implications of that are more readily developed when it comes to the later empirics.

From (1), the necessary condition[14] on the multinational's choice of investment in the

[13] See for example Becker and Riedel (2012), using firm level data for EU firms, and Desai, Foley and Hines (2009) for the United States. Note too that, being rooted directly in commercial relations between affiliates, the complementariness in mind here differs from that which can arise indirectly as tax changes act on the cost of capital by affecting the gains from 'paper' profit shifting—that is the mechanism at work in Suárez Serrato (2019), for example, and is addressed in Section 5 below.

[14] It is assumed that Π is concave over non-negative $\boldsymbol{K} \equiv \{K_1, ..., K_h\}$.

typical host country h, K_h, is

$$(1-T_h)\left\{\frac{\partial R_h}{\partial F_h}F_h' - \rho(1+M_h)\right\} + F_h' \sum_{j \neq h}^{N} (1-T_j)\frac{\partial R_j}{\partial F_h} \leq 0 \tag{2}$$

with an internal solution for K_h iff the equality holds. The first term here is familiar from the closed economy setting, being the post-tax marginal revenue product of capital in h net of the tax-inclusive cost of capital. If there were no second term, this would have the familiar implication that the $KF\text{-}METR$ is a sufficient statistic for tax effects on investment in h, with the statutory rate itself having no independent impact. It is the second term which is the novelty introduced by the revenue structure introduced above, capturing the impact on the incentive to invest in h of the consequent cross effect on the net revenues of affiliates elsewhere. If, for example, that aggregate cross-effect (after tax) is negative, then following the closed-economy rule of equating the marginal revenue product of capital to the $KF\text{-}METR$-inclusive costs of capital will lead (given the assumed negativity of the overall cross-effect) to too high a level of investment in h, because doing so ignores the adverse impact of investing there on the profitability of other affiliates in the multinational group.

The key point is that interdependence in the circumstances of the affiliates within the multinational group means that one aspect of investing in h is that may serve as an 'implicit' profit shifting device, in the sense of moving taxable profits across countries. Through this route the attractions of investing in h depend (through the terms multiplying F_h') on statutory tax rates in the host country relative to those h and elsewhere. This has evident similarities with the more traditional idea of what we refer to here as 'paper' profit shifting as a matter of tax avoidance realized through artificial transactions. Here, however, the profit shifting is tied directly to, and implicit in, the real investment decisions that are the multinational's core business.[15]

The way in which taxation consequently affects the levels and allocation of investment

[15] One other aspect of the difference between 'implicit' and 'paper' profit shifting as the terms are used here is worth noting: while both shift profits in the sense of increasing them in some countries while reducing them in others, implicit profit shifting will generally affect the multinational group's consolidated profit, whereas the essence of 'paper' profit shifting is that (apart from any cost associated with the artificial arrangements themselves) it does not.

across the multinational group more generally can be most clearly seen by recasting (2) into the familiar structure of a direct characterization of the equilibrium marginal revenue product of capital in h, the relevant marginal revenue now being that of the group:

Proposition 1 *The multinational's real investment decisions are characterized, for all $h = 1, ...N$, by*

$$\frac{\partial R}{\partial F_h}.F_h'(K_h) \leq \rho(1 + I\text{-}METR_h) \tag{3}$$

where $\boldsymbol{T}$ denotes the N-vector of statutory tax rates,

$$I\text{-}METR_h \equiv \frac{M_h - \Delta_h(\delta, \boldsymbol{T})}{1 + \Delta_h(\delta, \boldsymbol{T})}, \tag{4}$$

in which

$$\Delta_h(\delta, \boldsymbol{T}) \equiv \alpha_h \left(\frac{\sum_{j \neq h} T_j \delta_{hj} - T_h}{1 - T_h} \right), \tag{5}$$

with

$$\alpha_h \equiv - \left(\sum_{j \neq h}^{N} \partial R_j / \partial F_h \right) / (\partial R / \partial F_h) \geq 0 \tag{6}$$

and

$$\delta_{hj} \equiv \frac{\partial R_j / \partial F_h}{\sum_{i \neq h}^{N} \partial R_i / \partial F_h}. \tag{7}$$

Proof: This is the special case of a more general result in Appendix A obtained by setting Ω_h there (defined after (10) below) to zero.

There is a lot to unpack in Proposition 1.[16] Its highest level implication is that, as the notation is intended to suggest, the $I\text{-}METR_h$ combines the N statutory rates and the usual closed economy marginal effective rate in the host country into what can be thought of as a generalization to an international setting of the standard $KF\text{-}METR$. That is, just as $KF\text{-}METR_h$ summarizes all relevant tax effects for an enterprise operating in just one country, so the set of all $I\text{-}METR_h$ is sufficient to characterize tax effects on investment

[16] Matters are evidently more complex, for instance, than the simple view, often heard in policy contexts, that multinationals' location decisions are driven by cross-country comparisons of some kind of average effective tax rate, along the lines of Devereux and Griffith (2003), while the level of investment, conditional on location, then depends on the $KF\text{-}METR$ in the host country. The difficulty with that intuition is that the first part comes from viewing investment as fixed in scale, while the latter presumes it to have variable scale.

in all countries in which the multinational might operate. This is so in terms of both the intensive margin (the level of investment in host country h, conditional on some investment taking place there) and, given the assumed absence—for now—of locational fixed costs, for the extensive margin (whether to invest in h at all).[17] The critical difference between the $I\text{-}METR$ and the familiar $KF\text{-}METR$ is that the former allows for interactions in production and revenues across the affiliates within a multinational group:[18] if there are none, the $I\text{-}METR$ reduces to the standard $KF\text{-}METR$.[19]

More precisely, the structure of $I\text{-}METR_h$ shows that taxation affects the multinational's investment in h through two channels. The first is through the term $\Delta_h(\delta, \boldsymbol{T})$, which we refer to as the '(statutory) rate differential'. This, in turn, serves as a sufficient statistic for the impact of statutory tax rates, in all jurisdictions, on cross-border investment decisions. And, beneath the somewhat heavy notation, it has a straightforward structure.

In the numerator of Δ_h is the excess of a weighted average[20] of the statutory tax rates in countries j other than the host h over that in the host itself, with the weight δ_{hj} attached to the statutory tax rate in j being the proportion of the additional revenue to the rest of the multinational group that is generated by increased investment in h which accrues to the affiliate in j. It is this rate differential term that captures the implicit profit shifting inherent in the cross-country allocation of investment.

Through Δ_h, an increase in the tax rate abroad, in some $j \neq h$, tends[21] to increase investment in the host country h if, and only if, $\partial R_j/\partial F_h < 0$, so that the cross effect is negative: intuitively, an increase in T_j then makes it more attractive to invest in h because doing so reduces the amount of profit in j that has now become more heavily taxed. Comple-

[17]How the latter part of this conclusion is affected by the presence of locational fixed costs is taken up in Section 5.

[18]A further difference, of course, is that while the $KF\text{-}METR$ depends only on tax parameters the $I\text{-}METR$ also depends on the structure of the multinational's operations.

[19]Because then $\alpha_h = 0$.

[20]We use this term for brevity, though it should be noted, however, that since it may that $\partial R_j/\partial F_h > 0$ for some $j \neq h$ (even though, by assumption, this cannot be so in the aggregate), the weights may not all lie between zero and one.

[21]In the informal comparative statics that follow we simplify by treating the various derivatives of the affiliates' revenues as constants.

mentarities in production across the two affiliates, on the other hand, would imply reduced investment in h when T_j increases.

An increase in the tax rate in the host country itself, T_h, on the other hand, unambiguously reduces investment there directly through the numerator of Δ_h. This may though be mitigated by an effect through the denominator, which arises (recalling for instance equation (2)) from the increased value of deducting the financial costs of investing in h. Under the seemingly weak condition that the weighted average of foreign tax rates is less than unity, however, the overall effect is readily seen to be that an increase in the host's tax rate reduces inward investment.

A final implication of Δ_h is that the effects on real investment of the difference between rates in the host country and abroad are greater the larger is α_h: that is, as one might expect, the stronger are the spillover effects of additional investment in h on other affiliates' taxable receipts relative to the impact on the multinational's overall revenue.

The second and more familiar channel of tax effect captured by the $I\text{-}METR$ is through M_h, the $KF\text{-}METR$ in the host country, increases in which lead to lower investment there.[22] If corporate income tax (CIT) rates are the same in all countries, or investment in h has no repercussions for revenues in any other affiliate, this is the only tax consideration at work. More notable, as being in contrast to much public commentary, is that there is no direct cross-border effect on investment in h from the $KF\text{-}METR$ in any other jurisdiction j. One can, however, imagine—and we will later consider— circumstances in which such effects might arise, as for example if the multinational faced a binding limit on the overall amount of capital available to it, $\sum_{j=1}^{N} K_j \leq K$:[23] a lower $KF\text{-}METR$ in the United States might then indeed reduce investment in Canada.

Note too that these two channels of effect interact: the larger is Δ_h, and hence the more favorable to h is the statutory rate differential the smaller is the adverse impact on investment there of an increase in the $KF\text{-}METR$.

[22]It is assumed in what follows that $1 + \Delta_h > 0$; this, it seems, is not theoretically assured, but serves as a stability-type condition without which tax effects may be perverse. It is, in any event, satisfied at all data points in our sample.

[23]Adding such a constraint to the setting above, the direct effect of an increase in M_j for any $j \neq h$ is readily seen to be an increase in K_h.

The empirics that follow below explore the role of the $I-METR$, and its two interacting components, the rate differential term Δ_h and the $KF\text{-}METR_h$, as the key channels through which taxes affect investment. It also considers one further implication of (4) (and reasons why it might fail): for countries in which some investment occurs, there is, in the absence of any capital constraint on the multinational, no spillover effect on investment in h from the $KF\text{-}METR$ in any other country.

3 Foreign Affiliate Investment

This section describes the FAI data used in the empirics, comparing it both conceptually and empirically with the more commonly employed FDI data.

3.1 Understanding Foreign Affiliate Investment (and FDI) data

The two crucial features of FAI data are that they report cross-border investment in physical capital and that in doing so it looks through conduit structures to identify the ultimate parent country. In contrast, as stressed at the outset, much of the empirical work on taxation and cross-border investment has used data not on FAI but on foreign direct investment (FDI),[24] which differ from FAI data in both respects.

First, whereas FAI data capture real investment, FDI data capture funds received by a foreign affiliate that may or may not correspond to tangible investment. These funds comprise both direct net transfers from the immediate parent company (not necessarily the ultimate parent), whether through equity or debt, and earnings retained by the foreign affiliate. And these amounts appear as FDI regardless of their end use. Retentions that are recorded as FDI may, for example, be kept within the foreign affiliate as cash reserves, with

[24] Some studies have used foreign affiliate statistics for other purposes, including Tørsløv, Wier and Zucman (2018) to assess the extent of profit shifting by multinationals (for 2017), and by Fukui and Lakatos (2012) and Ramondo, Rodríguez-Clare and Tintelnot (2015) to study the pattern of multinational production activities. For US-based multinationals, the Bureau of Economic Analysis (BEA) foreign affiliates data has been widely used (one notable instance being Desai, Foley and Hines Jr (2004)), as it will be below. The OECD's Activities of Multinational Enterprises (AMNE) Database has also compiled inward and outward foreign affiliate statistics for 31 OECD countries between 2008 and 2016, as described in Cadestin et al. (2018).

no addition to real investment. Or the funds received may be passed on to another affiliate in the same multinational group. In such cases, inward FDI into a jurisdiction will exceed real investment there. On the other hand, inward FDI will understate foreign affiliates' real investment to the extent that their tangible investment is financed in ways other than by cross-border transfers or retentions (but instead by, instance, local borrowing or local issuance of shares). FAI data does not suffer from either form of misstatement of tangible investment.

The second and closely related key difference[25] is that FAI data see through to the location of the ultimate parent company, whereas in FDI data the 'parent' country typically refers to the location of the immediate investor.[26] This reporting convention for FDI creates additional and serious issues for the measurement of investment: whenever funds pass through an intermediate country the same underlying funds will be recorded twice in the FDI statistics, with the intermediate country as the destination country for the first observation and as the 'parent' country for the second. FDI data will thus double count (or more) investments whenever conduit transactions arise between the ultimate parent and the final host country. This double counting, which is rooted in the equity method of accounting, also gives rise to double counting of profits for any company with intermediate affiliates at the micro level (Blouin and Robinson, 2019). At the global level, double counting of multinational investments would imply a misleadingly high level of aggregate FDI, inflated by pass-through funds that are recorded multiple times.

An example illustrating these core differences between FAI and FDI data—which will also prove helpful in understanding some later results—is provided in Figure 1, with implications summarized in Table 1. It takes the case of an ultimate parent in country UP which has a controlled affiliate in a country of intermediate ownership IP, that affiliate in turn being the immediate parent of another affiliate in host country H. The ultimate parent injects $2

[25]There is a third difference, which is in the threshold for ownership/control: FDI data comprise all foreign interests with 10 percent or more voting power, while the FAI statistics have a higher threshold of 50 percent.

[26]There are some other data available by ultimate investors, for example the OECD's Inward "FDI by immediate and by ultimate investing country dataset" and from UNCTAD. For the former, however, coverage is limited and the distinct series by ultimate and investing countries are for stocks (not flows); for the latter, bilateral FDI by ultimate owner and host country is not publicly available after 2012 (Casella (2019)).

Table 1. FDI vs. FAI - Stylized Comparison

	UP to H	UP to IP	IP to H	Total
FDI	2	1	1	4
FAI	3	0	0	3

of equity directly into the affiliate in the host country, and $1 of equity into it indirectly through the affiliate in IP, possibly through a loan.

Total inward FDI in country H is then $3, comprising $1 FDI from country IP and $2 FDI from country UP. But there is also another $1 of FDI recorded as a flow into country IP from country UP, even though those funds only pass through to H, without any real activities taking place in IP. Aggregate FDI is thus $4, double counting all the cross-border funds that pass through intermediaries.

In contrast, the total amount of inward FAI in H will be between $0 and $3, depending on how much these funds are invested in physical capital goods—and it is that invested amount which is recorded in the FAI data. All the FAI would be recorded in country H, with FAI in country IP being zero. Supposing, for instance, that all the funds go to real investment, FAI will be recorded as $3 in H and zero elsewhere.

The two sets of statistics diverge further if there is local financing of real investment since, as noted, real investment supported by a local injection of funds is included in FAI but not in FDI. Local borrowing in H to finance real investment of $0.5, for example, increases FAI into H by $3.5 but leaves measured FDI unaffected. On the other hand, any changes in the amount of retained earnings in the host affiliate that is not invested in real assets would change FDI, but not FAI: with uninvested retained earnings in H of 0.8, for instance, FAI in H remains at 3.5, while FDI into H increases to 3.8 and global FDI to 4.8.

3.2 The FAI Dataset

The FAI dataset used here has been constructed by combining information on inward real investment from the *Foreign Affiliate Statistics* (FAS) provided by Statistics Canada, the

Bureau of Economic Analysis (BEA) of the US, and Eurostat.[27] The unit of observation is at the host/ultimate parent/year level, reporting the sum, over all multinationals with ultimate parents in a particular country, of their gross investment into foreign affiliates in each of the host countries covered by these sources (together with their turnover, employment, exports, and other features). More precisely, these data are for foreign affiliates'[28] gross investment in tangible assets, both new and existing (Eurostat, 2012).

The sample covers inward FAI into 32 host countries from 187 parent countries over the period 1998-2016 for the United States and 2003-2016 for all other countries: this makes a total of 1,630 observations in the main sample. The sample of host countries is mainly limited to advanced economies, and all but four are EU members.[29] Collectively, they account for more than half of the global FDI stocks for each year in our sample.

Figure 2 compares levels of inflows of FAI and FDI over the period 2003-12, both for all host countries in the sample and for the subset of EU members.[30] What emerges—beyond an impression of the importance of EU hosts in our dataset—is that, both in general and for EU hosts in particular, FAI is far lower than FDI, suggesting that double counting is indeed extensive in the latter, and is also less volatile. Notable too is that the gaps between the FDI and FAI have widened substantially. In our sample of host countries, over 10 years in which FAI and FDI data overlap, aggregate FAI was about 50 percent of FDI, broadly consistent with recent findings: as mentioned above, 'phantom' investments seem to account for around 40 percent of FDI.

[27] These can be accessed at, respectively: https://www150.statcan.gc.ca/n1/pub/13-607-x/2016001/145-eng.htm, https://www.bea.gov/data/intl-trade-investment/activities-us-affiliates-foreign-mnes, and https://ec.europa.eu/eurostat/web/structural-business-statistics/data/database.

[28] Meaning entities that are majority owned by ultimate parents that reside in a different country and can determine those affiliates' general policies.

[29] The host countries covered (with the * indicating non-EU members) are: Austria, Belgium, Bosnia and Herzegovina (*), Bulgaria, Canada (*), Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway(*), Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, the United Kingdom and the United States (*). All those listed as EU members were members throughout the sample period used for estimation.

[30] Here and in results reported below we combine FDI data from the IMF Coordinated Direct Investment Survey (CDIS) and UNCTAD. Bilateral CDIS data are available starting in 2009; these are stock data, from which we back-out flows using the perpetual inventory method, as $I_t = K_t - \delta K_{t-1}$, with $\delta = 0.195$. Bilateral UNCTAD data are publicly available only to 2012.

Figure 3 compares FDI and FAI from different types of parent country into the host countries in our sample, expressing each series in shares relative to the total. The key differences highlighted above—that FAI is reported by ultimate parent and reflects real investment, whereas FDI is reported by immediate parent and reflects financial flows—appear evident in the data. Over the sample period, low tax countries, defined as those with a statutory tax rate in the first quartile of the distribution (which means a statutory tax rate of less than about 20 percent), account for a greater share of FDI than of FAI (Panel (a)). The same is true, and even more marked, in relation to investment hubs, defined as countries with an average FDI/GDP ratio of above 150 percent (Panel (b)).

Importantly, many of the observations in the FAI dataset—around 34 percent—are zero.[31]

4 Empirical Strategy

This section describes the approach taken to estimation.

4.1 Specification and Other Data

The focus of interest to which the analysis in Section 2 points is the impact of the $I-METR$ and, more generally, of its key components: the rate differential Δ_h, the host country $KF\text{-}METR$ and—operating through some channel not captured in the modeling above—the parent country $KF\text{-}METR$. Taking $1/(1+\Delta_h) \approx 1-\Delta_h$, and now with many parent countries and time periods, we take as our most general estimating equation:

$$\begin{aligned}\mathbb{E}(FAI_{hpt}) = \exp(&\beta_{\Delta}\Delta_{hpt} + \beta_{MH}M_{ht} + \beta_{MP}M_{pt} + \beta_{M\Delta}(M_{ht} \times \Delta_{hpt}) \\ &+ \beta_{\Delta^2}\Delta^2_{hpt} + \boldsymbol{\beta_1'}\mathbf{x}_{ht} + \boldsymbol{\beta_2'}\mathbf{z}_{pt} + \boldsymbol{\beta_3'}\mathbf{g}_{ph}),\end{aligned} \tag{8}$$

where FAI_{hpt} denotes bilateral investment I_{hpt} in tangible capital goods in host country h (of which there are 32) from ultimate parent country p (of which there are 187) in year t (running from 1998 to 2016), scaled by the lagged capital stock in h attributable to investment from

[31] This is also the case for FDI, with around 43 percent of zeroes.

p, $K_{hp,t-1}$.[32] The tax terms Δ_{hpt}, M_{ht}, and M_{pt} are as defined in Section 2, now adding subscripts as appropriate. So, for instance, the critical tax differential term is

$$\Delta_{hpt} = \alpha_{hpt}\left(\frac{\sum_{j\neq h} T_{jt}\delta_{hjpt} - T_{ht}}{1 - T_{ht}}\right). \tag{9}$$

The controls in (8) comprise time-varying macro variables in the host ($\boldsymbol{x}_{ht}$) and parent countries ($\boldsymbol{z}_{pt}$), along with host-parent time-invariant bilateral variables ($\boldsymbol{g}_{ph}$). We include among these controls a set of host country-year (a_{ht}) and parent country (c_p) fixed effects, except that when estimating the impact of the host country King-Fullerton marginal effective tax rate M_{ht} we replace a_{ht} by year fixed effects (b_t). We cluster standard errors by host country to account for correlations within host countries over time.

The expected signs of the tax terms in (8) are implied by the analysis in Section 2. All else equal, an increase in the rate differential Δ_{hp}—reflecting a reduction the statutory rate in the host country h and/or an increase in the weighted average of statutory rates elsewhere[33]—is expected to increase FAI from p into h, so that $\beta_\Delta > 0$. This effect is less, however, the higher is the initial differential, so that β_{Δ^2} is expected to be negative. A higher $KF\text{-}METR$ in the host country, M_h, on the other hand, is expected to reduce investment into h; so the expectation is that $\beta_{MH} < 0$. In contrast, the $KF\text{-}METR$ in the parent country M_p (indeed that in any country other than the host h) is predicted by the analysis above not to affect FAI into h, so that $\beta_{MP} = 0$; but we have noted too that there may be circumstances in which there might be some (likely positive) effect. For the interaction term, the nonlinearity in (4) suggests that $\beta_{M\Delta} > 0$: as noted earlier, a tax differential Δ_{ph} that is more favorable to investment in h dampens the adverse impact of a higher host marginal effective rate M_h. Sufficiency of the $I\text{-}METR$ in characterizing real investment decisions, as implied by Proposition 1, corresponds to the restrictions $\beta_\Delta = -\beta_{MH} = \beta_{M\Delta} = -\beta_{\Delta^2}$ and $\beta_{MP} = 0$.

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[32] For this purpose, the bilateral stock of FAI is imputed using the perpetual inventory method, using an assumed depreciation rate of 0.195. The results this gives for the US are very close to the direct reports in the BEA data, giving some confidence that the estimates are reasonably accurate.

[33] In the presence of complementarities, corresponding to negative weights δ_{hjp}, such an increase might arise from a reduction in statutory rates; in the empirics that follow, however, the weights will all be non-negative.

4.2 Data

To implement (8), we augment the FAI dataset with additional information on tax rates and macroeconomic conditions. Statutory tax rates are headline corporation tax rates drawn from the IMF World Tax Rate Database. Data on $KF\text{-}METR$s are from the Oxford University Centre for Business Taxation Database;[34] these, however, are available only for a subset of 46 out of 187 parent countries and for 28 of the 32 host countries in our dataset.[35]

The FAS data provide useful information, at the bilateral host-parent level, on several further aspects of foreign affiliate activity, including sales, exports, number of workers, and value-added. Additional macroeconomic indicators are taken from the World Bank's *World Development Indicators*. Bilateral gravity variables are from CEPII;[36] we also control for standard gravity variables such as the physical distance between two countries, and common language or colonial ties that may shape cross-border investment. When estimating the effect of the host country $KF\text{-}METR$, and therefore, unable to include effects a_{ht}, we instead include year fixed effects and several additional control variables, varying over both parent and host countries, which have been found to be important determinants of cross-border investment. These include country-level GDP, capital account openness, trade openness, exchange rate, inflation, and government expenditure.[37] We of course control for macroeconomic variables of parent countries when we include a_{ht}.

Table 1 reports the descriptive statistics for the main variables used in the empirical analysis.[38]

It remains to specify the weights used in constructing the rate differential term, Δ_{hp}.

[34]At: https://oxfordtax.sbs.ox.ac.uk/cbt-tax-database.

[35]The exceptions are Cyprus, Malta, Latvia, and Lithuania.

[36]Centre d'Etudes Prospectives et d'Informations Internationales, see Head and Mayer (2014).

[37]Capital account openness is measured using the Chinn-Ito index, which is standardized between zero and one (Chinn and Ito, 2006), with higher values indicating greater openness. Trade openness is defined as exports plus imports as a share of GDP. The inflation rate is the annual percentage change in the consumer price index.

[38]Additional summary statistics (by host country) are provided in Appendix tables C.1 and C.2. The former summarizes the main tax variables, while the second summarizes the average, minimum, maximum number of parent countries per host country in a given year. The first and last years in the dataset with available FAI data are also listed.

Recalling (7), the typical element δ_{hjpt} is the proportion of the marginal revenue from increased investment in h from an ultimate parent in p which accrues in j relative to all such revenue accruing outside h. This of course depends, as seen above, on the nature of the production relations between the affiliates within the underlying multinationals. With insufficient degrees of freedom to estimate these, a priori restrictions on the weights are needed. In our baseline case, and in part with the EU in mind, we proceed in terms of the integrated market case above mentioned in Section 2. For this, it is readily shown, $\delta_{hjpt} = F_{jpt}/\sum_{j\neq h} F_{jpt}$: that is, the appropriate weights are in this case simply production shares outside of host h. Lacking production data, however, we construct a sales-based measure, weighting the statutory rate in country j, as it affects investment in h parented in country p, by: $\delta_{hjpt} = Sales_{jpt}/(Sales_{pt} - Sales_{hpt})$, where $Sales_{jpt}$ denotes sales in year t by affiliates in country j whose ultimate parents are in country p. This would indeed correspond to production shares if each entity sold into a final market at a common price; in other cases, since the sales are recorded by the location of the affiliate (not that of the purchaser), it seems a reasonable proxy. In all cases, the weights are lagged one period to address potential endogeneity with time t investment decisions. The α's are then constructed as the ratio of sales of affiliates parented in p in all foreign countries except for h to all foreign affiliates sales by p at time t. As described later, we extend this approach to allow for differential tax effects across EU hosts and also consider the use of alternative (capital- and export-based) weighting schemes among the robustness checks.

4.3 Estimation

Estimation is generally by Pseudo Poisson Maximum Likelihood (PPML), which has been widely used in the FDI and trade literatures to address the problem of pervasive zeroes. The appeal of this estimator is that in the presence of many zeroes it requires no distributional assumptions but only the correct specification of the conditional mean in equation (8): on the properties and applications of PPML more widely, see Santos Silva and Tenreyro (2006); Cameron and Trivedi (2013) and Santos Silva and Tenreyro (2022). A less attractive feature of PPML is that it elides the extensive and intensive margins of decision; we also report below results from the Heckman two-step estimator that aims to unpack them.[39]

5 Cross-border Tax Effects on Inward FAI

This section presents baseline results from the use of the FAI data just described, looks at their robustness and some extensions, draws lessons, and then explores further the differences arising from the use of data on FAI rather than FDI.

5.1 Baseline Results

Table 2 reports baseline results from the estimation of equation (8) on the full sample. The first column enters separately the various tax terms other than the parent $KF\text{-}METR$, which is taken up later. The coefficients are evidently significantly different from each other, so that sufficiency of the I-METR is rejected. In terms of its underlying components, the coefficient on the rate differential term is highly significant, has the expected sign, and is large. The host country $KF\text{-}METR$ enters with the expected (negative) sign but is not statistically significant; the same is true of the squared rate differential term.[40] Contrary to expectation, the interaction term, intended to capture possible non-linear effects, enters negatively, and with some significance.

The remaining columns of Table 2 focus more closely on effects through the rate differential, Δ_{hpt} and the host $KF\text{-}METR_h$, with corresponding adjustments to fixed effects and control variables.

Columns (2)-(4) focus on possible spillovers from statutory corporate tax rates, in all cases including host country-year and parent country fixed effects. Column (2) shows that the rate differential term Δ_{hpt} has a positive and statistically significant relationship with FAI. And the effect is large, with an implied semi-elasticity with respect to the rate differential, β_Δ, of

[39] One recent application of the PPML in a related context, for example, is Damgaard, Elkjaer and Johannesen (2019), which uses the Poisson model to estimate the differential impact of gravity-type variables on real versus phantom investment.

[40] This is in contrast to the finding of non-linear effects (typically focusing on the higher order terms of the tax rates) in, for example, Bénassy-Quéré, Fontagné and Lahrèche-Révil (2005), Dowd, Landefeld and Moore (2017) and Bratta, Santomartino and Acciari (2021).

2.7. For interpretation, and comparison with previous work, it is helpful to translate this into a semi-elasticity with respect to the difference in statutory rates themselves, $\sum_{i \neq h} T_i \delta_i - T_h$, which, recalling (5), requires multiplying β_Δ by $\alpha_h/(1-T_h)$. The median value of α_h in the data being 0.98, and the average statutory rate around 25 percent, for simplicity we report semi-elasticities with respect to the underlying difference in statutory rates as $\beta_\Delta/(1-0.25)$.[41] For column (2), for example, this gives an estimated semi-elasticity of 3.6. The implication is that a one percentage point decrease in the host country statutory tax rate or increase in the weighted average of statutory rates in other investment locations is associated with a 3.6 percent increase in the ratio of FAI to (lagged) capital in the host country.

Column (3) allows for distinct effects of the host's statutory rate and the weighted average of those elsewhere by decomposing Δ_{hpt} into its two components, one relating to the weighted average tax rate outside the host country h and the other to the statutory rate in h: we refer to these as "non-host" and "host" components respectively. Both effects have the expected sign and, as theory predicts, are not significantly different from each other. And the implied effects are again large, with semi-elasticities (again scaling each by $\alpha_h/(1-T_h)$) of around 4. This is noticeably larger than the values commonly cited as consensus views, a point we return to later. The negativity of the non-host effect, it is also worth emphasizing, runs counter to the possibility of strong cross-border complementarities in production across alternative locations for inward investment (since in that case, with positive weights δ_{hj}, one would have expected to find a positive impact of rates abroad on FAI in the host country.)

The use of sales-based weights in constructing the tax differential term seems most immediately plausible when potential hosts operate in an integrated market, which for empirical purposes is in turn most appealing as a benchmark for the subset of EU members. When considering investing into some EU host country, for example, and whatever the parent country, statutory tax rates elsewhere within the EU may matter more than those outside the single market. To explore this, we construct distinct rate differential terms for EU and non-EU countries. Specifically, for each EU host country we measure its scale relat-

[41] For the impact on FAI of changes in the host country rate, this ignores the effect operating through the denominator of Δ_{hpt}. This results in an under- (over-)statement of the impact on FAI where the host rate is below (above) the weighted average elsewhere, but on average this effect should be negligible.

ive to the EU market for all foreign affiliates from a given parent country, and for each non-EU host country we measure its scale relative to the non-EU market: that is, we take $\delta_{hjpt,\mathbb{1}\{h\in EU\}} = Sales_{hpt}/\sum_{j\in EU} Sales_{jpt}$, and $\delta_{hjpt,\mathbb{1}\{h\notin EU\}} = Sales_{hpt}/\sum_{j\notin EU} Sales_{jpt}$, respectively. The results of doing so, in column (4), point to tax spillovers on FAI that are strongest for investment entering the single market, though still both large and significant outside it.

Columns (5)-(6) of Table 2 focus on the impact of the host country $KF\text{-}METR$, M_h, adjusting fixed effects and control variables as described above. The coefficient β_{MH} on M_h thus captures the average effect of the host country's $KF\text{-}METR$ on inward FAI with the inclusion of time-variant host-country controls.

In column (5), the host country $KF\text{-}METR$ enters with the expected negative sign, but is far from significance. The statutory rate differential, however, remains highly significant, though the semi-elasticity now falls to around 2.3.

Adding in Column (6) the interaction between the host country $KF\text{-}METR$ and the statutory rate tax differential, this again proves statistically significant and of unexpected sign, just as in column (1). Assessing the full effects of the rate differential Δ_{hpt} and the host $KF\text{-}METR$ thus requires taking account of the interaction between the two. This is done in Figure 4. The upper panel shows that throughout the sample range the rate differential tends, overall, to have both a positive and a statistically significant effect on FAI; the only exceptions are for host countries with extremely large $KF\text{-}METR$s (10 percentage points or more above the average rate differential term). For the host $KF\text{-}METR$, in the lower panel, the sign of the overall effect flips depending on the initial level of the statutory rate differential. For host countries with relatively large rate differentials (that is, when the host country rate is relatively low), an increase in the host $KF\text{-}METR$ does indeed have a negative effect on inward FAI. At the average level of the rate differential, however, the effect of the host $KF\text{-}METR$ remains insignificant; when the differential is below average, the effect is near positive but remains insignificant. These results thus suggest that FAI in host countries with lower $KF\text{-}METR$s and higher rate differentials behaves most closely in line with the predictions from Section 2. Why the interaction operates with the opposite sign to that theoretically expected, however, remains for now unclear.

The analysis in Section 2, reflected in the estimating equation (8) gives no role to any $KF\text{-}METR$ outside the host country h, whether in the parent country or elsewhere. Nevertheless, as also seen, cross-country comparisons of $KF\text{-}METR$s often serve as benchmarks in evaluating national policies and reforms, and one can think of reasons why marginal effective rate outside the host country might have some impact on inward investment there: perhaps through capital constraints, as noted above, or perhaps though locational fixed costs, discussed later. The empirical question is thus whether inward real investment flows into a host country h are truly affected by $KF\text{-}METR$s anywhere else.

This issue is explored in Table 3. The sample is now considerably smaller than for the results above, since observations on the $KF\text{-}METR$ are available for only 46 parent countries. To isolate the implications of this, Column (1) of Table 3 reports the same specification as Column (1) in Table 2 using this reduced sample: the results are essentially unchanged. Addressing the question at hand, column (2) adds the $KF\text{-}METR$ in the parent country. The coefficient on this proves to be negative—the opposite of what, if anything, might be expected—and insignificant, while that on the rate differential is essentially unchanged. Column (3) adds the average $KF\text{-}METR$ across all countries other than the host; the coefficients on both non-host $KF\text{-}METR$s are insignificant. And using the lowest of all $KF\text{-}METRs$ among all non-host countries, in column (4), the effect is again insignificant. There is thus simply no sign of cross-border tax spillovers operating through the $KF\text{-}METR$ in countries other than the host. Spillovers through the statutory rate differential, meanwhile, remain sizable and strongly significant throughout Table 3.

5.2 Extensions

This subsection extends the discussion and analysis to distinguish between extensive and intensive margins of the FAI decision, allows for 'pure' profit shifting through devices that do not in themselves affect multinationals' consolidated profits, and compares the effects of tax measures for real investment of worldwide and territorial parents.

'Pure' profit shifting

The analytical framework of Section 2 that has underpinned the empirics so far precludes pure profit shifting in the sense of wholly artificial arrangements intended to reduce the multinational group's total tax liability. To the extent that the amount of profit shifted through such arrangements is directly affected by real production decisions, however, their impact can be captured in that framework. Suppose for instance that the affiliate in h produces an intermediate input used by that in j, so that $R_j = r(K_j, F_h) - c.F_h$, for some function $r(.)$, where c denotes the internal transfer price. Then $\partial R_j / \partial F_h$ will differ from zero to the extent that the transfer price differs from the marginal product of the intermediate in its use by j; if the transfer price is set higher than that, for instance, then $\partial R_j / \partial F_h < 0$.

Many other forms of profit shifting, however, are not directly related to production: debt shifting, for example, and routing through tax-favored conduit countries. The latter, as stressed above, is particularly relevant here as being a key driver of the distinction between FAI and FDI data. While FAI data looks though pure conduits to identify the ultimate parent of any affiliate in some host country, the real investment decisions of the multinational can of course nonetheless be expected to reflect its awareness of any tax savings that it can enjoy by the use of such conduits. This means that the potential use of conduits as means of tax avoidance cannot be ignored in understanding FAI data. Importantly, however, if the use of conduits is not connected to real investment decisions, then it reduces *average effective rates* but has no effect on the *marginal* effective rates that guide real investment decisions.

It may be, nonetheless, that real production can itself facilitate transactions-based tax avoidance, for example by meeting 'substance' tests required to draw on advantageous treaty provisions. To allow for this, it has become standard practice in the literature to suppose there to be some real cost associated with deploying devices of pure profit shifting. Suppose, for example, that shifting profits of S_j into country j requires costs of the form $(S_j)^2/(2\phi\rho K_j)$ (with cost parameter $\phi > 0$), capturing the idea that these costs are lower to the extent that there is real production activity in j.[42] Adding the possibility of such explicit profit shifting to the setting above, it is shown in Appendix A that (3)-(7) of Proposition 1 continue to hold, but now with

[42] This approach dates back to Hines and Rice (1994), with recent applications including Suárez Serrato (2019) and Beer et al. (2023).

$$I\text{-}METR_h \equiv \frac{M_h - \Delta_h(\delta, \boldsymbol{T}) - \phi\Omega_h(\omega, \boldsymbol{T})}{1 + \Delta_h(\delta, \boldsymbol{T})} \tag{10}$$

where $\Omega_h(\cdot) \equiv (\sum_{j=1}^{N} T_j\omega_j - T_h)^2/(2(1-T_h))$ and $\omega_j \equiv K_j/\sum_{i=1}^{N} K_i$. The distinction between the two forms of profit shifting entering (10), Δ_h and Ω_h, is evidently subtle. The former, 'implicit' profit shifting, captures the role of production decisions in directly affecting the allocation of taxable profits; the latter captures the role of production in facilitating the use of other instruments to shift profits.

While conceptually subtle, the distinction nevertheless has clear empirical implications, through the squaring of the statutory rate differential in the pure profit shifting term Ω_h but not in the term Δ_h that relates to implicit shifting. Loosely, implicit profit shifting increases investment in low tax countries *and* reduces it in high tax ones; pure profit shifting, in contrast, increases investment in *all* countries, including low tax ones (because investing there, given the assumed avoidance technology, makes it easier to escape taxation in the high tax ones). For example, it was seen in Section 2 that an increase in T_j for some $j \neq h$ will increase investment in h through the implicit profit shifting channel route if $\partial R_j/\partial F_h < 0$; through the pure profit shifting channel, however, it will have the opposite effect, tending to reduce investment in h, if T_h is initially above the weighted average of all statutory rates elsewhere.

Exploring this, Table 4 reports an alternative specification which includes the pure profit shifting term Ω_{hp}.[43] This enters, counter to expectation, with negative sign, and is far from significance. The coefficients and significance of the rate differential and host country $KF\text{-}METR$, meanwhile, are broadly unchanged relative to most of the baseline results in Table 2. Statutory rate differentials thus leave a clearer mark on real investment through their impact on implicit profit shifting than they do through explicit forms of profit shifting that have received more attention.

Worldwide vs. territorial tax systems

The framework of Section 2 also presumed all national tax systems to be 'territorial,' in

[43] Since M_h and $-\Omega_h$ enter identically into the $I\text{-}METR$, and recalling the definition of Ω_h following (10), the ratio β_Ω/β_{Mh} in principle identifies the shifting cost parameter ϕ; we do not, however, pursue this here.

the sense that the only taxes levied are those of the host country. The polar opposite case is that of 'worldwide' taxation, meaning—in its purest form—that the parent country will top up any taxes paid in the host country to the level applied by the country in which it resides, applying a credit for any taxes paid to the host country. The implication is that the tax paid to the host country is less relevant for inward FAI when the parent resides in a country applying worldwide taxation, because the final tax paid will be that of the residence country. In practice, for reasons touched on in a moment, the distinction between territorial and worldwide systems is not as sharp as this sounds. Nevertheless, a meaningful distinction of this kind can be made, and we do so by constructing a list of territorial corporate tax system using PWC World Tax Summaries.[44] Table 5 reports results allowing tax effects to differ according to the regime applied by the parent country.

In column (1), the coefficient of the rate differential is large and highly significant whether the parent is from a worldwide or a territorial country—but somewhat smaller (and less significant), as the considerations above would suggest, in the worldwide case. A similar story emerges in column (2), where the rate differential is split into its host and non-host components and the effects of each allowed to differ according to the regime applied by the residence country. There the effect of the host rate is both smaller and less significant when the parent is from a worldwide country. That it is not zero is consistent with two respects on which worldwide taxation in practice differs from its textbook form. One is that application of residence country taxation can often be avoided, not least by deferring repatriation of profits to the parent: this has been common practice, for instance, among US multinationals. The other is that host country tax remains final if it is above the tax due under residence country rules: no refund is paid to offset the excess.[45] The important point, however, is that the impact of the rate differential remains large and significant for FAI from parents in worldwide countries, and that host and non-host components continue

[44]Which countries we designate as having territorial or worldwide systems is indicated in Supplementary Appendix Tables C.2 and C.3.

[45]Some sign of this effect is at work emerges on comparing results across subsamples with positive and negative rate differentials (indicating host rates below and above that in the ultimate parent respectively): the effect of the rate differential is lager in the former case: see Supplementary Appendix Figures C.1 and C.2.

to be large and of similar magnitude, though significance is somewhat less.

Distinguishing extensive and intensive margins of FAI

A disadvantage of the PPML estimator, noted above, is that it elides investment effects across the extensive and intensive margins.[46] Given the prevalence of zeroes in the data, the distinction is evidently one of some importance and interest. In the framework of Section 2, such zeroes arise when the (group-wide) marginal revenue product of the first unit of investment in some country is negative. An alternative modeling approach is to suppose there to be some fixed cost F_j of investing in country j. Denoting after-tax profit in country j by $\pi_j(K_h, \boldsymbol{K_{-h}}) \equiv (1-T_i)\big(R_i(K_h, \boldsymbol{K_{-h}}) - \rho(1+M_i)K_ij - F_j\big)$, where $\boldsymbol{K_{-h}}$ denotes the $(N-1)$-vector of capital invested in all jurisdictions other than h (and, for simplicity, the fixed cost is assumed to be tax-deductible), a necessary condition for the multinational to invest in h is then that doing so yields group profits at least as high as can be obtained by investing only elsewhere, so that

$$\underset{\{K_h, \boldsymbol{K_{-h}}\}}{max} \sum_{j=1}^{N} \pi_j(K_h, \boldsymbol{K_{-h}}) \;\; \geq \;\; \underset{\boldsymbol{\{K_{-h}\}}}{max} \sum_{j\neq h}^{N} \pi_j(0, \boldsymbol{K_{-h}}). \tag{11}$$

Denoting by K_i^* and K_i^{**}, respectively, the solutions to the problems on the left and right of (11), and decomposing the proportional difference in affiliate net revenue into systematic and idiosyncratic components as, in obvious notation, $R_j^{**} = (1+\lambda^R + u_j^R)R_j^*$ and similarly $K_j^{**} = (1+\lambda^K + u_j^K)K_j^*$, rearranging (11) gives the condition

$$R_h^* - \rho(1+M_h)K_h^* \;\; \geq \;\; \lambda^R R^*\left(1 + \left(\frac{T_h - \sum_{j\neq h} T_j \omega_j^R}{1-T_h}\right)\right) - \lambda^K \rho K^* \sum_{j\neq h}\left(\frac{(1-T_j)(1+M_j)}{1-T_h}\right)\omega_j^K + u_h \tag{12}$$

where $R_j^* \equiv R_j(K_h^*, \boldsymbol{K_h^*})$, $R^* \equiv \sum_{j\neq h} R_j^*$ and $\omega_j^R \equiv R_j^*/R^*$ (with K_j^*, K^*, and ω_j^K defined analogously), and u_h absorbs the idiosyncratic elements in the comparison with the counterfactual of investment in h being constrained to zero.[47]

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[46]The distinction between the extensive and intensive margins has been made in previous work using FDI data: examples include Davies and Kristjánsdóttir (2010) and Canton, Solera et al. (2016).

[47]Specifically,

$$u_h \equiv \frac{F_h}{1-T_h} + R^* \sum_{j\neq h} u_j^R \left(\frac{1-T_j}{1-T_h}\right) - \rho K^* \sum_{j\neq h} u_j^K \left(\frac{(1-T_j)(1+M_j)}{1-T_h}\right).$$

The key implication of (12) is that the location decision in this setting depends not only on the statutory rate differential and host KF-$METR$, much as above, but also (through the second term on the right of 12) the capital-weighted average of KF-$METRs$ outside the host country. This opens up a route through which King-Fullerton effective rates elsewhere may have cross-border spillover effects even in the absence of a group-wide capital constraint: while having no impact on the intensive margin, in the presence of fixed location costs they may impact the extensive margin. This, intuitively, is because they affect the overall average effective tax rates available on investment elsewhere. Through this route, and just as in which the multinational is capital-constrained the impact of higher KF-$METRs$ outside host country h would be expected to be increased investment in h.

To assess intensive and extensive margins separately, Table 6 reports results from estimating this structure as a Heckman-type self-selection model, including fixed effects at both stages and controls as described above. The second stage (intensive margin) specification for $ln(FAI)$ is much as above, now with inclusion of the inverse Mills ratio. The first stage (extensive margin) is as in (12) with the inclusion of the inverse Mills ratio. For identification purposes, we impose the theory-based exclusion restriction that the weighted average KF-$METR$ enter the first but not the second stage; we consider also the exclusion of personal income tax and VAT rates along with the ratio of tax revenue to GDP. Throughout, the rate differential term is calculated using (lagged) sales as weights.

In columns (1) and (2) of Table 6, the average of non-host KF-$METR$s is weighted by (lagged) capital stocks, as (11) suggests. Under each set of exclusion restrictions, the rate differential is significant and with expected sign at both stages. The host KF-$METR$ enters (only) the second stage with significance, but with unexpected sign. Using instead sales weights, in columns (3) and (4), the rate differential is again highly significant at both stages and somewhat larger, especially at first stage, while the host KF-$METR$ enters the second stage with both significance and the expected sign.

Across all columns, the non-host weighted average KF-$METR$ is insignificant in all but one case, in which it takes counter-intuitive sign; this reinforces our earlier finding of no cross-border spillovers from this source, though it also weakens faith in our main exclusion restriction.

Interpreted, for this and other reasons,[48] with some caution, we take these results to be broadly consonant with the findings above of effects from the host $KF\text{-}METR$ that are at best ambivalent, of no cross border spillovers from $KF\text{-}METRs$ elsewhere and of significant and sizable effects from the statutory rate differential. For the last of these, there are perhaps some signs of a stronger impact on the extensive than on the intensive margin. That is as might be suggested by simple views of investment decisions depending only on domestic tax considerations once location decisions, reflecting assessment of tax and other options over a range of countries, have been taken. But the signs here are that international statutory rate differentials nonetheless matter a good deal at the intensive margin too, consistent with the potential importance of the kind of production-related implicit profit shifting highlighted in Section 2 above. Across both stages, the semi-elasticity implied by the results in Table 6 are very, and perhaps implausibly large, ranging from 4.4 to over 10.[49]

5.3 Robustness

This subsection explores various dimensions of the robustness of the key results from the baseline analysis.

Investment dynamics

Adjustment costs of various kinds can give rise to more complex dynamic responses of FAI to taxation than the immediate adjustment presumed above. To allow for this, Table 7 reports in columns (1) and (2) results when including the lag of FAI in columns (1) and (2); including the differential term in the former, and its host- and non-host components separately in the latter. The coefficient on the rate differential, which now captures a short run impact, is highly significant and large at around 2.81. The same is true of the host and non-host components, which also remain essentially equal in magnitude respectively). The

[48]For instance, we ignore tax effects through the (always highly significant) inverse Mills ratio, and whether the u_h can reasonably be taken to have a common normal distribution (after normalization for scale) is unclear.

[49]Calculated from column (1), for example, as (1.792+1.490)/(1-0.25) = 4.38.

long run effects are of course even larger, with a semi-elasticity on the rate differential in column (1) of 5.25.[50]

These results need to be interpreted with particular caution, given the prospect of bias from the combination of lagged dependent variable and fixed effects. Efforts to address this, however (including for instance by the method of Wooldridge (2005)), ran into convergence issues of a type that are not uncommon with Poisson regression.[51]

Timing of tax effects

It could also be that FAI responds to taxation not (only) contemporaneously but (also) with some lag or that it reflects anticipated future tax policies. Various such possibilities are explored in the right hand part of Table 7. The results there show that lagged and future tax variables are indeed statistically significant (in columns (3) and (4) respectively), with the impact of the contemporaneous rate differential becoming smaller and somewhat less significant when both are included (in column (5)). For a fully anticipated permanent change, the semi-elasticity with respect to the rate difference is again much larger than the baseline, at around 6.1.[52]

Alternative weighting schemes and scaling

The focus in the benchmark analysis above was on the case in which the rate differential term Δ_{hp} reflects operation in an integrated market, which lent some persuasiveness to its construction by using sales as weights. But there are other possible structures of multinational activity consistent with the analysis in Section 2, each potentially pointing to a different set of weights.

The first two columns of Table 8 instead use capital weights, as an alternative approach to capturing interactions across affiliates directly related to their production: that is, we now take $\delta_{hjpt} = K_{jpt}/(K_{pt} - K_{hpt})$. In column (1) the impact of the rate differential is significant and noticeably larger than in the baseline results of Table 2. In column (2),

[50]Calculated as (2.811/(1-0.286)).(1-0.25).

[51]See for instance Santos Silva and Tenreyro (2011).

[52]Ignoring the insignificant lagged effect, this is calculated as (2.139+2.666)/(1-0.25).

however, splitting into host and non-host components the former becomes insignificant and takes counter-intuitive sign, while the latter, with the expected sign, becomes extremely large.

An alternative view of the interactions between affiliates might be in terms of vertical integration across the multinational as a whole, with affiliates producing at various stages of the supply chain and trading with one another. Weighting tax rates by sales (including within the group) would seem appropriate in this case too, but we also explore in columns (3) and (4) the alternative approach of weighting statutory tax rates by bilateral-exports: in obvious notation, $\delta_{hjpt} = EX_{jpt}/(EX_{pt} - EX_{hpt})$. The implied effect of the statutory rate differential measured in this way, however, is insignificant; and while the separated host and non-host components have the expected signs and are fairly close in magnitude, they too are insignificant.

We have also conducted but for brevity do not report robustness checks in which FAI is scaled by value-added, rather than by the capital stock. The rate differential term remains positive and statistically significant.

Endogeneity

A concern with regressions of the kind above is that countries' tax policies are potentially endogenous to the state of FAI: host countries may, for instance, reduce tax rates in order to boost inward investment that for some unobserved reason, is languishing. If so, the likelihood is of biases towards zero of the coefficient on the rate differential and that on the host rate alone: the risk, that is, is likely to be that our large tax effects found above are under-estimates.

The issue, nonetheless, is evidently an important one. Table 9 reports results including as instruments in all cases the first and second lags of the corresponding tax variable, taking, given the nonlinearity of the conditional mean, a control function approach (that is, including at the second stage residuals from the first stage estimates). In column (1), the coefficient on the rate differential is noticeably smaller and less significant than in the baseline results of Table 2 while the host $KF\text{-}METR$ appears in much the same way; from the insignificance of the residuals, however, there is little sign that results are in this case contaminated by endogeneity. Splitting the rate differential into host and non-host components, however, there are in column (2) signs of endogeneity; and, as the considerations above would suggest, the coefficient on the host component becomes markedly large while that on the non-host part remains much as found above. The same is true in column (3), where the instrument set is expanded to include shares of personal income tax and VAT in total revenue and the population of the host country. Overall, the impression is that in so far as endogeneity is an issue the main implication is indeed likely to be some understatement of investment effects from the host country statutory rate.

An alternative structure of fixed effects

It has become common in the trade literature around gravity models to include host-parent fixed effects, as for example in Glick and Rose (2016) and Head and Mayer (2014). We have not done so above because this impedes identification of the effect of the host country $KF\text{-}METR$, which shows relatively little variation over time; when excluding the host $KF\text{-}METR$ we have instead used host-year and parent effects. In Table 10 we take the alternative approach of using host-parent and year effects, looking in turn at the rate differential and its components. Effects are somewhat smaller, and with a more marked difference between host and non-host effects, than generally found above, but remain quite strongly significant.

5.4 Assessment

These empirics lead to several reasonably clear-cut conclusions. One is that the $I\text{-}METR$, while theoretically appealing, does not serve well as a sufficient statistic for cross-border tax effects on tangible investment, at least as it has been operationalized here. This reflects very different impacts from its main components: the cross-border rate differential, in turn decomposed into host and non-host effects, and the host $KF\text{-}METR$.

The former, reflecting the difference between the statutory rate in the host country and a weighted average of those available elsewhere to the parent investor, has a highly significant and very large effect, especially but not only where markets are more highly integrated. While the point estimates above vary quite widely, between the extremes ofaround 1.6 to 10.1, they tend to be notably higher than the 2.5 or so reported as benchmark in De Mooij and Ederveen (2003) and as median estimate in Feld and Heckemeyer (2011). Our preferred estimate would be around the 3.6 in the baseline results in column (2) of Table 2. We return shortly to the question of why our results point to stronger tax responsiveness than does the bulk of previous work.

Importantly, the semi-elasticities with respect to host and non-host statutory rates that emerge are much the same as those for the difference between them. There are thus strong signs of spillover effects at work through this route. (The meta-analyses, recall, look only at the effects of the host country rate.)

The impact of the host country $KF\text{-}METR$, in contrast, appears close to zero and insignificant. This is somewhat more in line with, for example, the conclusion that Feld and Heckemeyer (2011) draw from their analysis, though we are not aware of any other study comparable to that here in relating the $KF\text{-}METR$ to a measure approximating cross-border tangible investment.

There also emerges a significant interaction between the rate differential and the host $KF\text{-}METR$, tending to diminish the impact of the former while making more likely a negative impact of the latter. The puzzle, however, is that the sign of the interaction runs counter to that suggested by theory.

Finally, but importantly, we find no spillover effects from the $KF\text{-}METR$ in either the parent or non-host countries—an issue that, so far as we are aware, no previous study has addressed. And this is so on both the intensive and, perhaps more surprisingly, the extensive margin of FAI. Rankings of countries by $KF\text{-}METR$s have little real bearing on cross-border decisions on tangible foreign investments.

5.5 Comparing Tax Effects in FAI and FDI Data

Before applying these results to the analysis of the global minimum tax, it remains to explain why the semi-elasticities emerging from the analysis here are noticeably higher than those in much of the previous literature. The natural suspicion is of course that this difference somehow arises from the use of data on FAI rather than, as in much of literature, on FDI. There are indeed hints from some previous work (albeit mainly on U.S. data) that effects are stronger when looking specifically at investment in plants, closer to the concept of real investment underlying FAI data, rather than at FDI.[53]

As a first step towards establishing and explaining whether one should expect any systematic difference in apparent tax responsiveness emerging using FAI and FDI data, Table 11 reports results taking each in turn as dependent variables in an estimating equation of the form of equation (8). The sample period, dictated by the availability of bilateral FDI data, is 2003-2016, and so somewhat different from that of the baseline results of Table 2.[54] Columns (1) and (3) include the composite tax differential, columns (2) and (4) its distinct components.

For FAI, the semi-elasticity on the differential term in column (1) is much as in the baseline, and so too (though somewhat smaller) are the the coefficients on the host[55] and

[53]Again, see De Mooij and Ederveen (2003) and Feld and Heckemeyer (2011), though note too that the evidence has not been overwhelming: the former finds (p.688) "...no strong evidence that studies using [Property, Plant and Equipment] data yield higher semi-elasticities than those using FDI."

[54]In effect, we lose several years of observations for FAI parented in the United States (for which the data starts in 1997).

[55]The term 'host' is less apt in the FDI than in the FAI context, since there is no presumption that inward

non-host components in column (3). All, moreover, are highly significant. In the FDI data, in contrast, while the coefficients on the statutory rate terms take the expected sign they are in all cases not only much lower but also insignificant. In all columns the host $KF\text{-}METR$ enters with the expected negative sign, and is again insignificant in the FAI data. It proves significant, however, in the FDI data—though only moderately so.

While this result—that tax effects are stronger using FAI data than FDI data—is not wholly unexpected given some previous work, it may nonetheless seem counter-intuitive: Might one not, to the contrary, expect the tax-motivated use of conduit arrangements, picked up directly in FDI statistics but not in FAI, to generate tax effects that are more marked, not less, in FDI data?

Some explanation can be found, however, in the narrative around Table 1 in Section 3 and Figure 1. Suppose, for instance, that the statutory rate in host country H is reduced, so that real investment there by the parent in UP increases; and suppose moreover that this is financed by increasing both direct investment from UP to H and conduit investment from UP through IP to H. In the FAI data the aggregate of these two flows, FAI from UP to H, is indeed identified as responding to the tilting of the tax differential in favor of investment in H. In the FDI data, the increased FDI flows from both UP and IP to H are also in line with the shift in tax differentials. But the FDI data also picks up the increased flow from UP to IP: that is, the conduit country IP experiences an increase in inward FDI even though in tax terms it has become less attractive. In this way, FDI flows through conduit countries can dilute the apparent impact of taxation on investment. And, given the significance of conduit activities, the downward bias this implies in measured tax effects may be sizable.

6 The Global Minimum Tax and Tangible Investment

A centerpiece of the G20/OECD-led agreement of October 2021, and now in the process of implementation ('Pillar Two'), is the proposed adoption of a minimum effective corporate tax rate of 15 percent. The primary motivation behind this is to limit the shifting of paper profits and tax competition for both investment and shifted profits. The impact on productive

flows remain as real investment.

investment, however, which one might expect to be a central consideration, has received surprisingly little analytical attention,[56] though some have expressed concern that there will be will be significant collateral damage in the form of reduced investments.[57] These are issues that the analysis and results above are well-suited to illuminate.

To this end, as providing some sense of the pattern, direction and magnitude of effects on tangible investment, we compare, for each host-parent country pair, fitted FAI in 2016 to predicted FAI in the presence of a minimum tax set at varying levels, using for this purpose the coefficients corresponding to the baseline specification in column (5) of Table 2, which allows for effects through both the rate differential term (fairly moderate in size, by the standard of the full set of results above) and the $KF\text{-}METR$ in the host country.[58] In doing so, we model the minimum tax as simply a restriction on the permissible rate of corporation tax although, in practice, the Pillar 2 rules are more complex than this.[59] Nor do we take account of the possible strategic implications of adopting a minimum tax: it might be that this will lead countries that it does not directly affect to change their own tax rates.[60] In

[56]Exceptions are UNCTAD (2022) and OECD (2020*c*), which focus primarily on quantifying the impact on effective rates; the former then applies semi-elasticities reflecting the existing literature, the latter allows only for investment effects through the $KF\text{-}METR$. Some attention has also been paid to the question of whether, by narrowing rate differentials, the minimum tax will generate improvements in the cross-country allocation of capital: we do not address this issue.

[57]As, for example, Bunn (2021).

[58]For simplicity we ignore the interaction term. Note too that we set aside the possibility of an impact through the traditional profit shifting route Ω_h, which was found to be insignificant in the results above.

[59]Broadly, their essence is the application to each entity within any multinational group with global turnover of more than €750 million of a 'top up' tax, at a rate equal to the excess of 15 percent over the effective (not statutory) rate of domestic corporate taxation, to a base comprising accounting profit less a 'carve out' calculated as a fixed proportion of payroll and tangible capitals: see Devereux, Vella and Wardell-Burrus (2022) and UNCTAD (2022) for more detail. An important implication of the feature that the minimum is applied at the level of the entity, not that of the country, is that an entity operating in a country that has a statutory rate above the minimum may nonetheless be subject to a top-up tax if it benefits from some form of tax incentive that brings its effective rate below the minimum. The inability to deal with this is a clear disadvantage to our use of country-level data. Similarly, we cannot restrict the analysis to multinational groups above the €750 threshold; the analysis that follows, however, is in terms of percentage changes in the I/K ratio, and so can be interpreted as applying to in-scope multinationals, though with the proviso that there are some signs that large and (as many in this group will be) highly profitable multinationals are somewhat less tax-responsive than others (Millot et al. (2020)).

[60]There are now several papers on this issue, including Hebous and Keen (2021), Johannesen (2022) and Janeba and Schjelderup (2022); an empirical assessment of the revenue implications of induced changes in tax rates is in International Monetary Fund (2022).

abstracting from such considerations,[61] the results are far from being a full assessment of the investment implications of Pillar 2, but we believe are potentially instructive nonetheless.

The focus is thus on the impact of the minimum rate through two channels: the rate differential term Δ_h in the host country—which, importantly, will capture not only any rate change induced by the minimum in the host country itself but also those induced in the much larger number of other potential host countries— and the host country $KF\text{-}METR$. Computing the effect of a minimum tax on the rate differential is simply a matter of replacing each T_j by $max(m, T_j)$. This is likely a reasonable approximation, notwithstanding the additional complexities noted above.[62] The post-minimum $KF\text{-}METR$ is computed by simply recalculating it the minimum rate whenever it binds, which will generally imply an increase. This is somewhat problematic, because the structural base changes introduced by the minimum matter a good deal, and imply that the impact may be strongly circumstance-specific: In some cases, the $KF\text{-}METR$ might even fall. The common expectation, however, appears to be that $KF\text{-}METR$s will generally increase, and this directional effect at least is captured by the recalculation just described.[63]

Conceptually, the effect on FAI through the $KF\text{-}METR$ in the host country is straightforward: any minimum-induced increase will reduce inward FAI. With $KF\text{-}METR$s seen above to have no role outside the host country, there are through this route no spillover effects on countries that are not themselves constrained by the minimum.

The effects through the statutory rate differentials Δ_h, both at country level and (especially) in aggregate, are more subtle. They are easiest to see by supposing that all countries carry the same weight δ_{hj}, so that the weight attached to each tax rate is the proportion of countries setting that rate. Assuming further, for simplicity, a continuous distribution of tax rates prior to implementation of the minimum, with density $f(T)$ and distribution $F(T)$

[61] One issue that need not concern us, however, is the vexed question of which country collects the revenue from any top-up tax: from the perspective of the investor, that is immaterial.

[62] The operation of the carve out means that effective rates will generally be lower than the minimum rate itself—and for this reason we at some points below consider rates somewhat below the proposed 15 percent—but to the extent that the carve out covers financing costs, the minimum rate applies to rents and so is analogous to the statutory rate in the formalization above.

[63] The impact of the minimum tax on $KF\text{-}METR$ remains to be fully characterized, though see for example International Monetary Fund (2023), Mintz (2022) and UNCTAD (2022).

and taking α_h to be constant at unity, with a minimum tax rate of m the rate differential in host h is

$$\Delta_h(m) = \frac{mF(m) + \int_m^1 Tf(T)dT - \max(m, T_h)}{1 - \max(m, T_h)}. \tag{13}$$

Differentiating with respect to m, for countries that are obliged by the minimum to raise their rate ($T_h < m$), gives, after some simplification,

$$(1-m)^2 \frac{\partial \Delta_h(M)}{\partial m} = -\int_m^1 (1-T)f(T)dT \leq 0, \tag{14}$$

An increase in the minimum rate thus reduces inward investment in all countries that it constrains: they never recover from the adverse investment effect of the minimum even though, with further increases, they come to benefit from spillover effects as the minimum comes to constrain more countries. More straightforwardly, for countries that are not constrained by the minimum ($T_h > m$)

$$\frac{\partial \Delta_h(M)}{\partial m} = \frac{F(m)}{1 - T_h} > 0, \tag{15}$$

so that they always gain investment as the minimum rate increases, since that makes them unambiguously more tax-attractive.

Country-specific results[64] are shown in Figure 5. Importantly, most of the host countries in the sample have relatively high statutory tax rates: in only six is it fifteen percent or lower. Reflecting this, at a minimum rate of 15 percent all countries other than Bulgaria, Bosnia and Herzegovina, Ireland, and Cyprus would see a small increase in their inward FAI.[65] Higher minima, of course, bind more countries, and in several cases the investment effects become very pronounced: at a minimum rate of 20 percent, for example, Bulgaria and Ireland see reductions in inward FAI of around 18 and 16 percent respectively, while FAI into Spain increases by nearly 7 percent.

Figure 6 shows the numbers of host countries that gain/lose FAI at each level of the

[64]Note that in all calculations we continually update levels of FAI as the minimum is increased: the effects of increasing the rate from 20 to 21 percent, for example, reflect the effects of the increases up to 21 percent.

[65]Two countries have initial rates of 15 percent (Latvia and Lithuania), so are unaffected by a minimum rate of 15 percent.

minimum rate: only at a minimum rate of 24 percent does the number of countries losing inward FAI rise to equal that of those gaining. As the minimum rate increases, so too does the disparity between those who receiving more inward FAI and those receiving less: as Figure 6 shows, the 'winners' gain increasingly more FAI (both on average and in aggregate), while the growing number of 'losers' lose increasingly more FAI (also on average and in aggregate).

Turning to effects on total inward FAI across all 32 host countries, Figure 7 shows the predicted changes at various levels of the minimum rate. The effect through the statutory rate differential, shown by the light bars, while seen above to be ambiguous in principle proves to be both positive and increasing (though at a decreasing rate) throughout the range shown—the explanation of which is taken up below. The dark bars show the change due to the increased $KF\text{-}METR$s in the constrained countries. Through this channel, as noted above, aggregate FAI unambiguously decreases.

The effect through the statutory rate differential is evidently the stronger of the two for the wide range of minimum rates considered. The increase in aggregate FAI is initially modest: less than a one percent at a minimum of 15 percent. The effect on aggregate FAI peaks at a minimum of around 21 percent, with a 3 percent increase in aggregate FAI. The increase (relative to the absence of a minimum) declines thereafter, but only vanishes at a minimum rate of 29 percent. Collectively, far from suffering a reduction in real investment from adoption of the global minimum, the host countries in our sample stand to gain, in terms of inward FAI, from adoption of even a minimum rate far higher than ever envisaged in the discussions leading to Pillar Two.

With inward real investment rising in some countries and falling in others, the finding that the impact of the minimum rate is to increase aggregate FAI over such a wide range of minima is an empirical finding, not a theoretical one. It reflects a general feature of the joint distribution of tax rates and levels of FAI in the sample. To see this, note from (8) that the impact of FAI into any country j from the minimum-induced change in the rate differential[66] term is $dFAI_j = FAI_j \beta_\Delta d\Delta_j$. Imagine then that the minimum simply requires the lowest-tax country, 1, which initially has a rate of zero,[67] to raise its rate by some amount

[66]Here assuming for simplicity a single parent country.

[67]This serves to abstract from effects operating through the denominator of Δ_1, which would dampen the

A. Then FAI into country 1 itself falls by $\beta_\Delta FAI_1.A$. while in every other country j, it rises by $\beta_\Delta FAI_j\delta_{j1}A$, so that fall in total investment elsewhere is $\beta_\Delta \sum_{j\neq 1} FAI_{j1}\delta_{j1}A$. Assuming further that in all j the same weight is attached to tax rates in all countries, the condition for aggregate FAI to increase when a binding minimum rate is applied to the lowest tax country becomes that $(1/(N-1)\sum_{j\neq 1} FAI_j > FAI_1$: that is, the level of FAI in that lowest-tax country be below the average level elsewhere.

Generalizing this, it is shown in Appendix B that (in the continuous case as above) it is sufficient for an increase in the minimum rate to increase aggregate FAI that $E[FAI|T < m] < E[FAI]$, so that the average level of FAI in countries constrained by the minimum is below that across all countries. To the extent that smaller countries tend to have lower statutory tax rates (as many models of tax competition predict, and as is the case in our dataset),[68] and given too that most of the host countries in our sample are, viewed in a global setting, relatively high tax ones, there are thus systematic reasons to suppose that a minimum tax rate, at least at moderate levels, will increase aggregate FAI into these countries.

This finding of an increase in total FAI as a consequence of adopting a global minimum tax is in stark contrast to the slight reduction found by others: of around 2 percent, for instance, in the baseline estimates of UNCTAD (2022).[69] This reflects two differences in approach. First, that here builds on fully articulated and empirically estimated cross-border relationships rather than applying presumed elasticities to constructed effective tax rates. Second, the result here is not an estimate of an overall global effect but of the effect on 32 host countries that, in global terms, are relatively high tax ones. Those countries, nonetheless, account for more than half of global FDI—and they are the ones that have been driving the international tax reform agenda.

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reduction in FAI_h: more generally, the condition that follows is thus sufficient for an increase in aggregate FAI.

[68] On the theory point, see for instance Keen and Konrad (2013); on the data point, Supplementary Appendix Figure C.3 confirms that size, whether measured by GDP or population, is positively correlated with the statutory tax rate.

[69] Devereux et al. (2020), Hanappi and Cabral (2022) reach broadly similar conclusions.

7 Conclusions

Using a newly assembled dataset that does not suffer from fundamental limitations of FDI statistics, and guided by a simple analytical framework that highlights the possibility of implicit profit shifting through real investment decisions, the purpose here has been to revisit the questions of the extent to which, and through precisely which channels, international corporate tax arrangements affect aggregate cross-border tangible investment. Addressing that has also enabled an analysis of what the implications for tangible investment might be of what is likely the most profound of the fundamental reforms of the international tax architecture now underway: the adoption of a global minimum corporate tax.

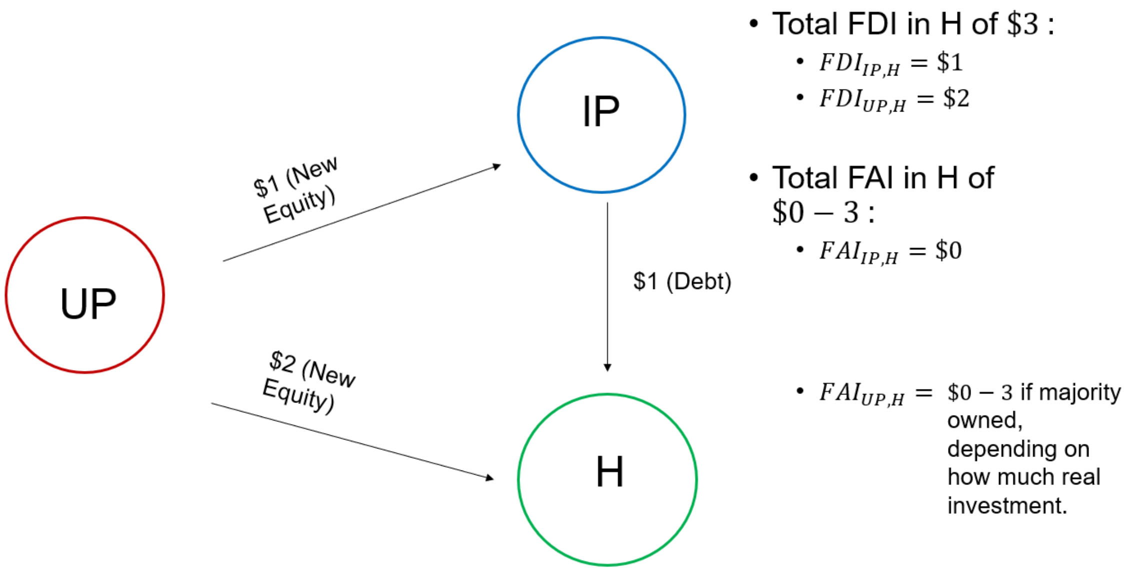
There emerge effects of statutory tax rates on tangible investment that, across a wide range of specifications, are strongly significant and large relative to prior consensus values. Moreover, spillover effects from tax rates elsewhere appear to be about as large as the investment effects of the host country's own tax rate. Our preferred estimated semi-elasticity, with respect to both the host statutory rate and the weighted average of rates elsewhere, if pressed to provide one, would be around 3.6. This is noticeably higher than many previous estimates. The reason, we have argued, is that a dampening of apparent tax effects is an inherent consequence of the conduit arrangements that are reflected in the FDI data that have commonly been used, but which are not present in FAI statistics. These effects from statutory rates, moreover, are consistent with the relatively little recognized channel of implicit profit shifting through tax-induced changes in real investment decisions. Indeed effects through this route appear empirically to dominate any associated with profit shifting by means of artificial arrangements lacking real substance, which have received much more attention both in the literature and from policy makers. Spillover effects from statutory rates appear, as one might expect, to be stronger within the relatively integrated market of the EU, but they are nonetheless also marked outside.

The impact of the traditional closed economy King-Fullerton marginal effective tax rate, in contrast, is weak at best. This is more in line with previous findings, though it also tends to refute the idea that the composite effective rate derived in the theoretical part above (the $I\text{-}METR$) can serve as a sufficient statistic for tax effects on inward FAI. Interaction effects—–often neglected in trying to understand 'which' tax rate matters for cross-border investment—require some qualification of the results for both the cross-border differential in statutory rates and the host marginal effective rate, but do not overturn the broad empirical conclusions on each. Requiring much less qualification is the finding that closed economy marginal effective tax rates outside the host country have little if any impact on inward FAI, and this is so even when some impact might be expected given fixed location costs impacting the extensive margin of investment. The implication is that league tables of marginal effective tax rates cast very little light on the relative tax attractions for multinationals of investing in alternative countries.

Applying these results to the analysis of the global minimum tax, due for implementation from 2024, the strength of the spillover effects through statutory tax rates mean that FAI into the (relatively high rate) host countries in our sample would be expected to increase with the imposition of a minimum rate at the proposed level of 15 percent. This is in sharp contrast to a view that increases in marginal effective rates as a consequence of the minimum tax (leaving aside the question of whether and when that will indeed be the consequence) will tend to depress real investment. Indeed while inward tangible investment into some host countries in the sample would fall at higher levels of the minimum, the total across all is predicted to increase up to a minimum of close to 30 percent.

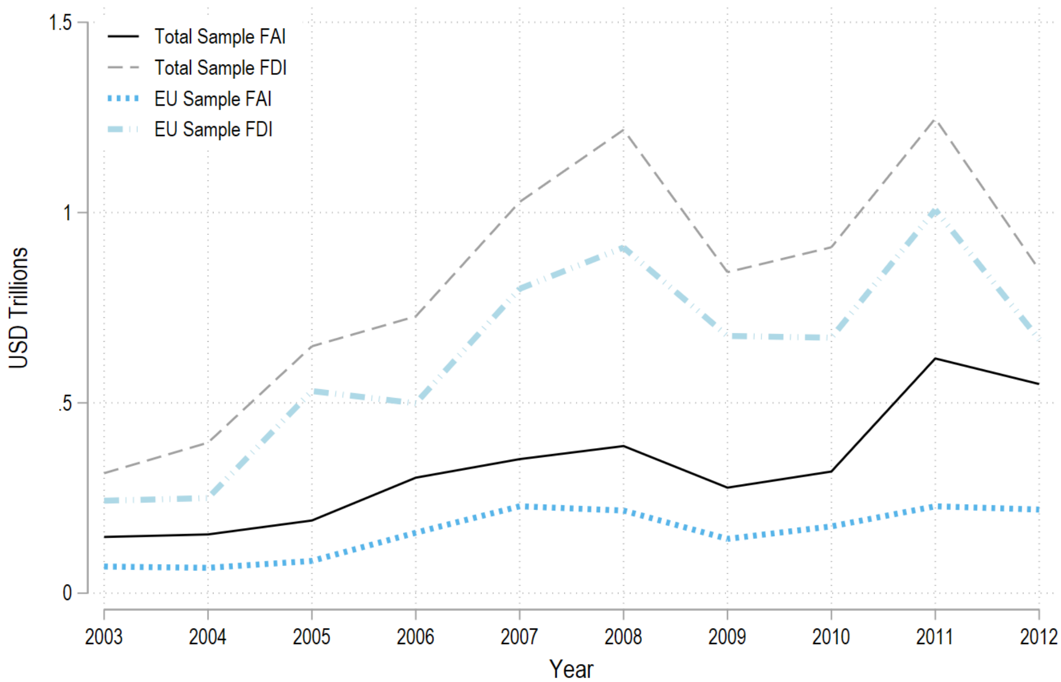
There remain, of course, many open issues. These include, for example, understanding and testing the implications of the potentially very different commercial structures of multinational enterprises for the appropriate weighting of statutory rates in evaluating cross-border spillovers. The direction of the interaction effects noted above also remain conceptually puzzling; and, on the policy side, the characterization of the minimum tax reform taken here is highly simplistic. Nonetheless, the analysis casts some light on the surprisingly under-studied questions of how, and how much, the international tax system and the fundamental changes to it with which policymakers now need to grapple affect aggregate tangible cross-border investment.

Figure 1. FDI and FAI: An example



Notes: UP is the country of the ultimate parent, IP is the country of the immediate parent, and H is the host country of investment. If the entity in H has a minority foreign ownership, it is not recorded as a 'foreign' affiliate and so $FAI_{UP,H}$ is equivalent to zero.

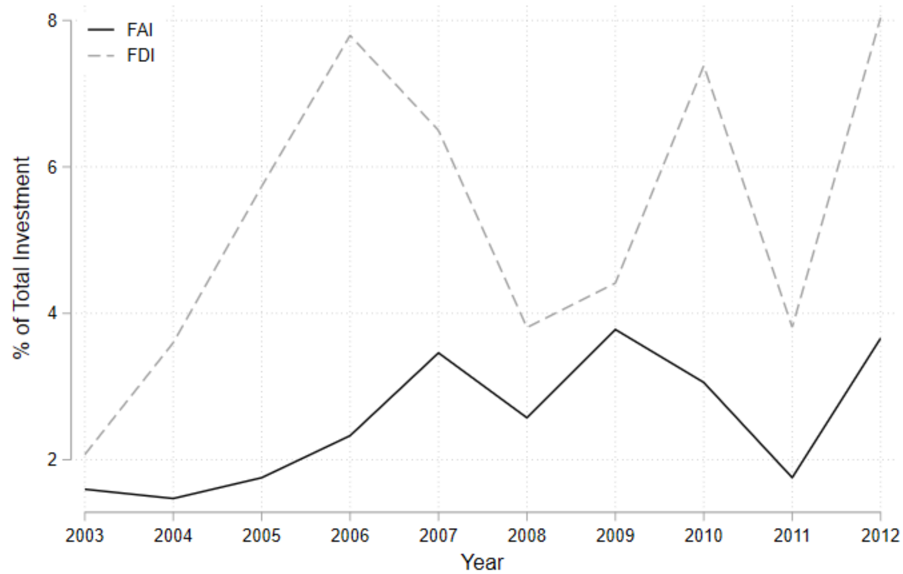
Figure 2. FAI vs. FDI
Total Hosts in Sample vs. EU Host Sample



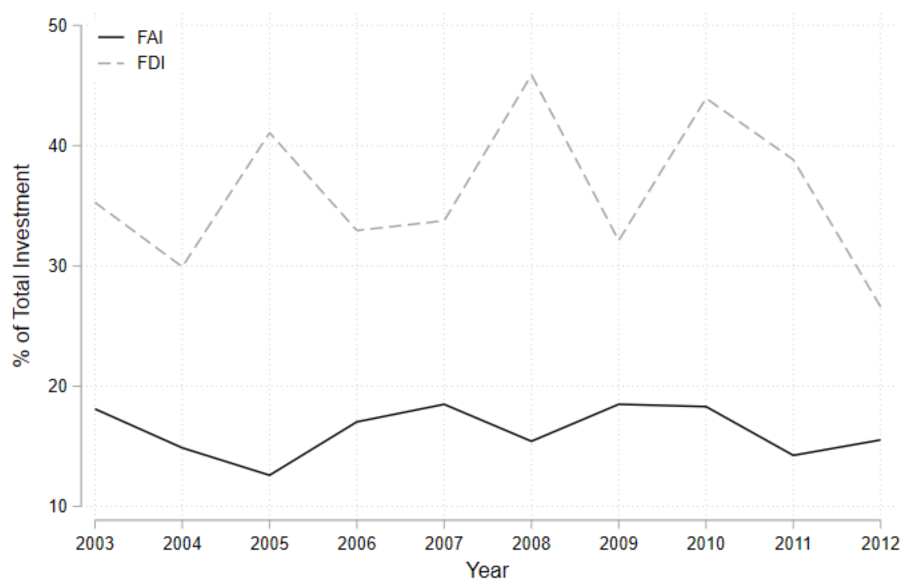
Note: This figure compares the FAI and FDI series for the sample period of 2003-2012. Four trends are shown: for the time series of FAI and FDI in aggregate for the full sample, and for the time series of FAI and FDI in aggregate across the EU countries in our sample.

Figure 3. FAI vs. FDI: By Parent Economy Characteristics

(a) Low-Tax



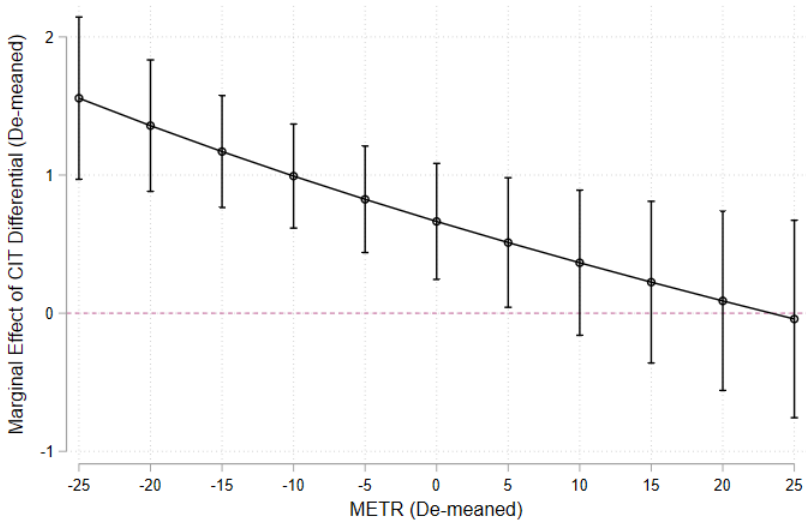
(b) Investment Hubs



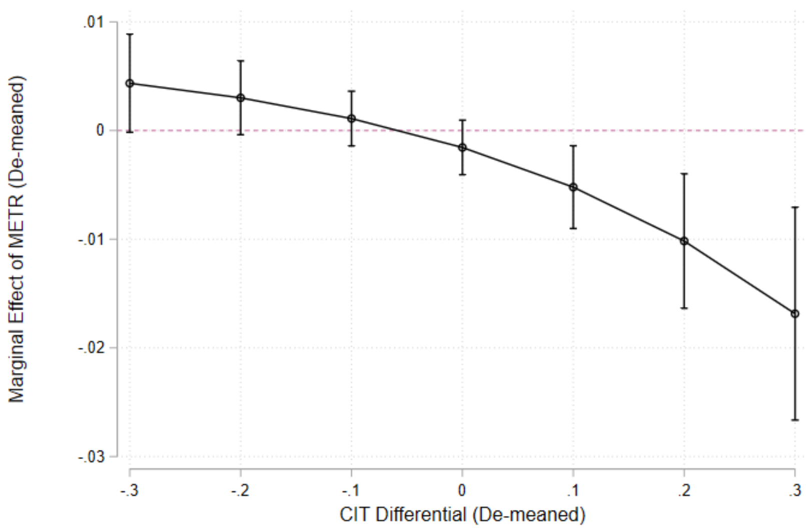
Notes: This figure compares the share of FAI or FDI relative to total FAI or FDI by parent economy characteristics. These characteristics include: low-tax parents, defined as economies with a statutory Corporate Income Tax (CIT) rate less than 20 percent (panel (a)) and investment hubs (panel (b)).

Figure 4. Non-linear Effects of Corporate Tax Rates

(a) Marginal Effects of CIT Differentials

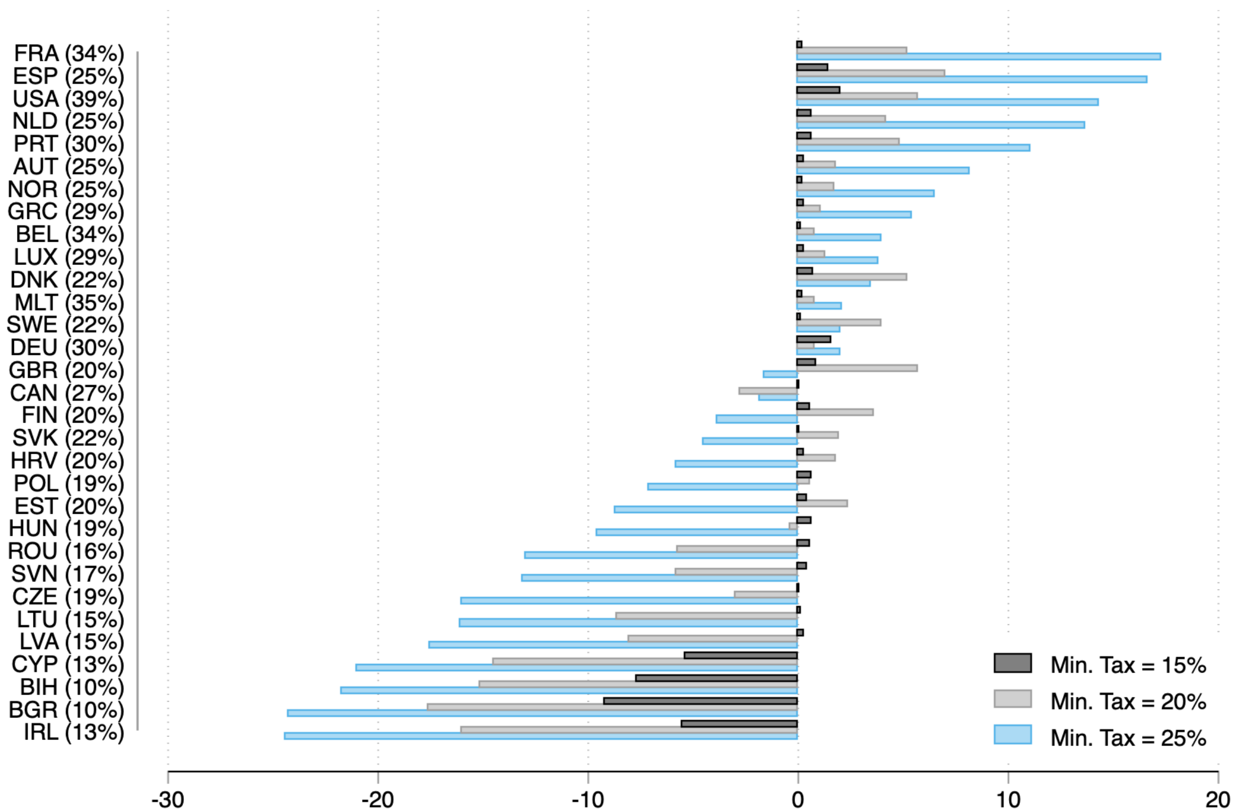


(b) Semi-elasticities of Host METR



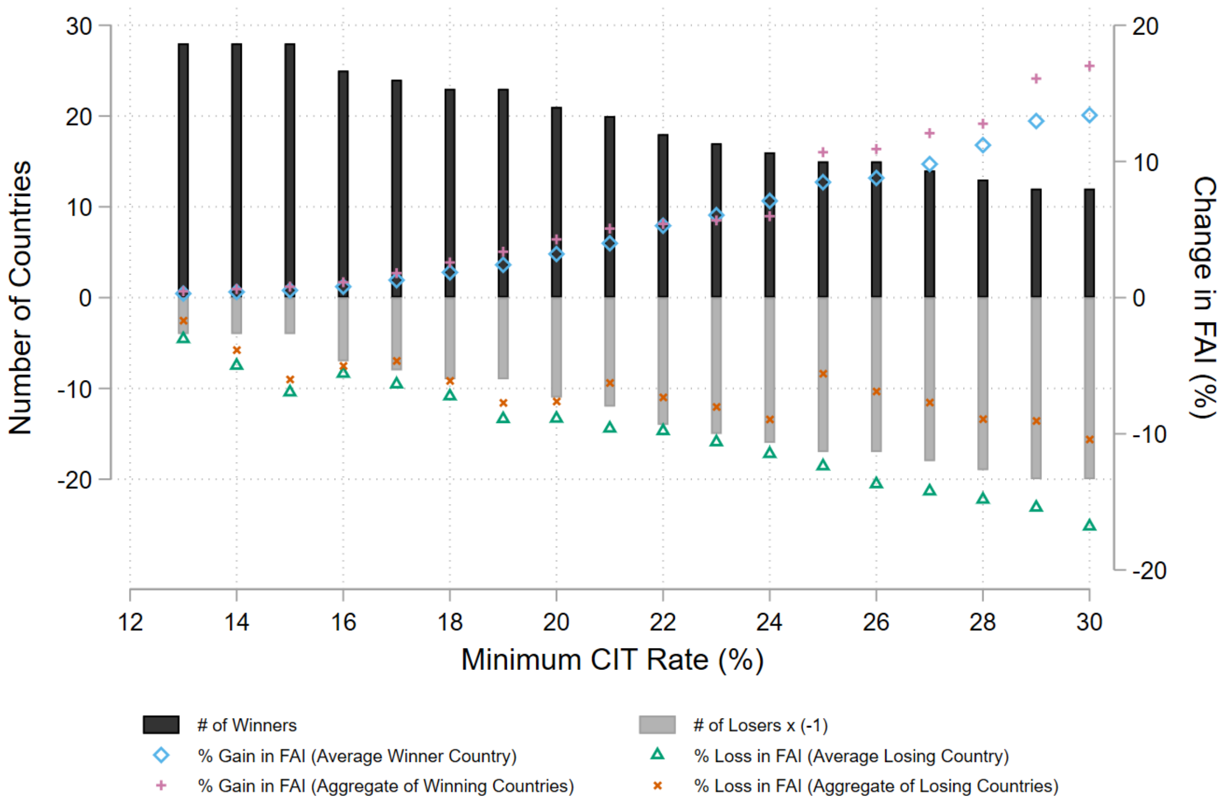
Notes: The top panel shows marginal effects of the corporate income tax (CIT) differential along the distribution of Host KF-METR values; the bottom panel shows semi-elasticities (which are equivalent to marginal effects) of the Host KF-METR along the distribution of CIT differential values. The dots correspond to point estimates, and the lines extending from each dot are 95-percent confidence bands. The range on the x-axis in panel (a) is -25 to 25. The range on the x-axis in panel (b) is -0.3 to 0.3. The de-meaning prior to interaction means that the coefficient on the main KF-METR term is to be interpreted as the effect of the KF-METR at its mean value (that is, when the demeaned differential = 0). The same applies to the main differential term: the coefficient there is the effect of the differential when the KF-METR is at its average value.

Figure 5. Distribution of Investment Impact and Minimum Taxation



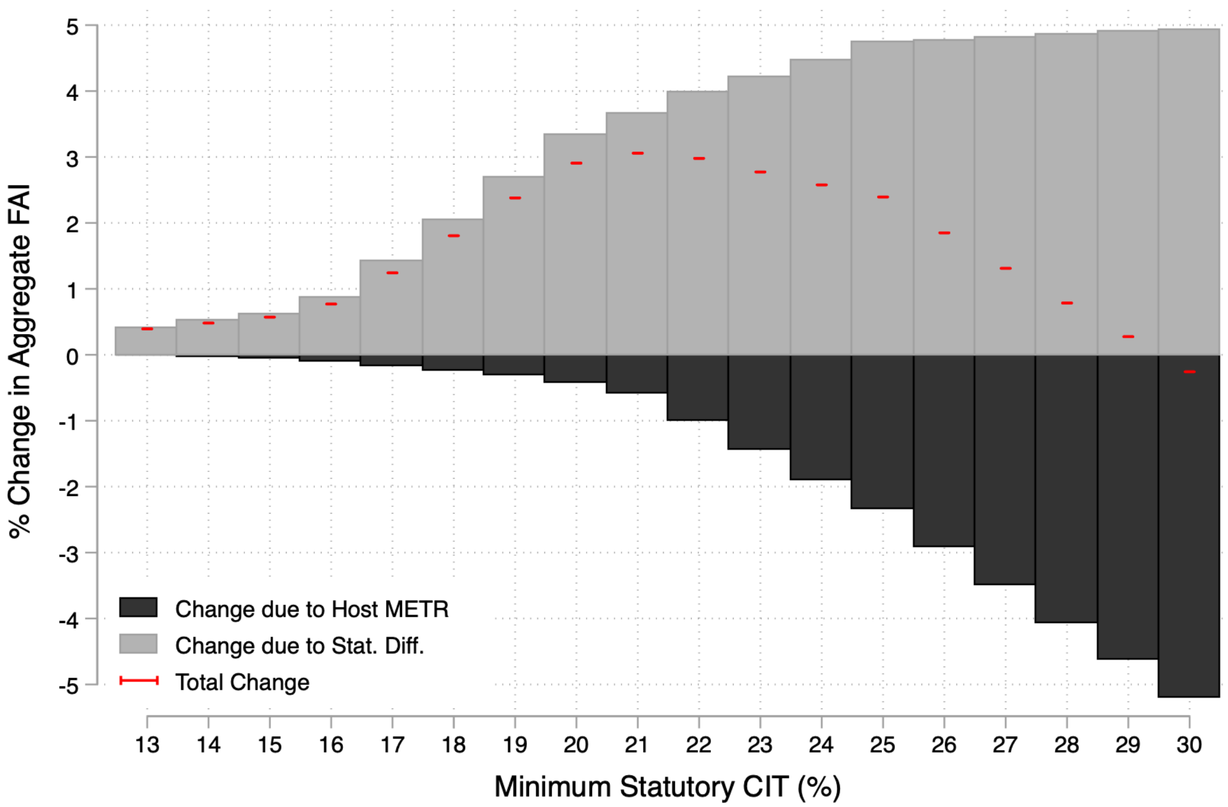
Notes: This figure plots the percentage change in inward FAI across the 32 host countries in our sample, at minimum tax rates of 15, 20 and 25 percent. The simulation uses FAI for the year 2016. The statutory CIT rate in each country is shown in parentheses on the vertical axis. For the Host KF-METR and rate differential specific effects, see Supplementary Figure C.4.

Figure 6. Numbers of ‘Winners’ and ‘Losers’ at Various Minimum Rates



Notes: This figure shows the number of countries that would gain or lose inward FAI at minimum tax rates between 13 and 30 percent. The number of ‘winning’ countries (in terms of gaining FAI), on the left hand scale, is indicated by the black bars, while the number of ‘losing’ countries is indicated by the grey bars. On the right-hand scale, the blue diamonds indicate the percentage gain in FAI for an average winning country, while the pink +’s denote the aggregate percentage gain in FAI across all winning countries; the green triangles denote the percentage loss in FAI for the average losing country, while the red x’s denote the aggregate percentage loss in FAI across all losing countries.

Figure 7. Aggregate FAI and Minimum Tax Rates



Notes: This figure plots the percentage change in aggregate FAI into the 32 host countries at minimum tax rates ranging from 13 to 30 percent. These results correspond to corporate tax rates and FAI for the year 2016. The light grey bars show the impact of the minimum rate through the statutory rate differential, the dark grey bars show the impact through the KF-METR, and the red lines show the total impact.

Table 1. Summary Statistics

Panel A: Tax Variables	Mean	SD	P10	P50	P90
Rate Differential	0.043	0.108	-0.091	0.030	0.183
Rate Differential, EU Hosts	0.015	0.087	-0.091	0.000	0.124
Rate Differential, Non-EU Hosts	0.000	0.014	0.000	0.000	0.000
Non-Host Component	0.289	0.168	0.000	0.337	0.474
Non-Host Component, EU	0.228	0.153	0.000	0.282	0.391
Non-Host Component, Non-EU	0.004	0.039	0.000	0.000	0.000
Host Component	0.246	0.157	0.000	0.249	0.435
Statutory CIT Rate	24.587	7.301	16.000	25.000	35.000
Host KF-METR	13.535	8.838	2.833	13.080	24.661
Panel B: Investment Variables					
I/K (FAI)	0.416	0.862	0.000	0.191	0.954
I/K (FDI)	0.421	1.592	0.000	0.054	0.790
FAI (mil. USD)	469.338	2730.990	0.000	4.385	666.202
Lag K (mil. USD)	1835.101	17882.450	0.000	13.134	2054.840
Log(FAI)	2.355	2.797	0.000	1.478	6.502
Panel C: Weights					
Sales Share (Lagged)	0.027	0.127	0.000	0.000	0.023
Capital Share (Lagged)	0.036	0.159	0.000	0.000	0.024
Export Share (lagged)	0.060	0.176	0.000	0.001	0.142
Panel D: Zeroes		Share			
I/K (FAI)		33.79 %			
I/K (FDI)		44.98 %			

Notes: There are 12,630 observations in our main sample. Panel A shows summary statistics for tax-related variables. The (statutory corporate tax) rate differential term is defined as the weighted difference scaled by (100-host country statutory rate) and multiplied by α, as in equation (4). The statutory rate and KF-METR are shown in percentages. Panel B shows summary statistics for investment variables. I/K ratios are investment flow divided by lagged capital stock, for the type of investment indicated (foreign affiliate investment and foreign direct investment, respectively). The summary statistics for I/K in the FDI dataset are associated with a different sample (N=17,442). Panel C summarizes the data used to construct the rate differential: weights by sales, capital and exports. Panel D shows the proportions of observations for FAI and FDI in our main sample that are zero.

Table 2. Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)
Rate Differential	1.630***	2.667***			1.745***	1.637***
	(0.571)	(0.605)			(0.508)	-0.523
Non-Host Component			2.764***			
			(0.659)			
Host Component			-2.607***	-1.495***		
			(0.631)	(0.414)		
Non-Host Component (EU)				2.080***		
				(0.530)		
Non-Host Component (Non-EU)				1.344**		
				(0.599)		
Host KF-METR	-0.004				-0.003	-0.004
	(0.003)				(0.005)	(0.003)
Rate Differential × Host KF-METR	-0.071**					-0.070***
	(0.029)					-0.025
(Rate Differential)^2	-0.101					
	(1.477)					
Observations	12,630	12,630	12,630	12,630	12,630	12,630
Pseudo-R^2	0.129	0.165	0.164	0.165	0.128	
Controls:	Host, Parent	Parent,	Parent,	Parent,	Host, Parent	Host, Parent
	Bilateral	Bilateral	Bilateral	Bilateral	Bilateral	Bilateral
FEs:	Year	Host-Year,	Host-Year,	Host-Year,	Year	Year
	Parent	Parent	Parent	Parent	Parent	Parent

Notes: All specifications are estimated in PPML using an unbalanced panel of all available host-parent-year observations. The dependent variable is the I_t/K_{t-1} ratio for inward FAI. Specifications (1), (5) and (6) include host country, year, and parent country fixed effects, and the following characteristics of the host and parent countries (as indicated): GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Specifications (2) to (4) include host country-year fixed effects and parent country fixed effects, and the following characteristics of the multinational firm's parent country: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Standard errors, in parentheses, are clustered by host country. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. All specifications control for bilateral host-parent characteristics including distance (in log) and an indicator for common official language.

Table 3. Spillovers from KF-METRs outside the Host Country?

	(1)	(2)	(3)	(4)
Rate Differential	1.501***	1.497***	1.487***	1.384**
	(0.514)	(0.513)	(0.510)	(0.543)
Host KF-METR	-0.002	-0.002	0.001	-0.006
	(0.004)	(0.004)	(0.009)	(0.006)
Parent KF-METR		-0.005	-0.002	-0.005
		(0.006)	(0.009)	(0.006)
Mean Non-host KF-METR			0.137	
			(0.342)	
Lowest Non-host KF-METR				-0.018
				(0.013)
Constant	-31.598**	-32.426**	-34.436**	-32.072**
	(12.503)	(12.679)	(13.496)	(12.673)
Observations	8,008	8,008	8,008	8,008
Pseudo-R^2	0.0816	0.0817	0.0817	0.0819
Controls:	Host, Parent	Host, Parent	Host, Parent	Host, Parent
	Bilateral	Bilateral	Bilateral	Bilateral
FEs:	Year, Parent	Year, Parent	Year, Parent	Year, Parent

Notes: All specifications are estimated in PPML regression using an unbalanced panel of all available host-parent-year observations for which the parent-country KF-METR is available. All specifications include parent country and year fixed effects, and the following characteristics of the host and parent countries: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 4. 'Pure' Profit Shifting

	(1)
Rate Differential	1.832***
	(0.480)
Host KF-METR	-0.003
	(0.005)
Pure profit shifting (Ω)	-0.043
	(0.033)
Observations	12,630
Pseudo R^2	0.129

Notes: The dependent variable is I_t/K_{t-1}, and estimation is by PPML. Year and parent country fixed effects are included, as well as controls for host, parent and gravity variables. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 5. Taxation in the Parent Country: Worldwide vs. Territorial

	(1)	(2)
Rate Differential $\times$ Territorial Parent	3.208***	
	(0.524)	
Rate Differential $\times$ Worldwide Parent	2.707**	
	(1.158)	
Non-Host Component $\times$ Territorial Parent		3.076***
		(0.592)
Non-Host Component $\times$ Worldwide Parent		2.982**
		(1.163)
Host Component $\times$ Territorial Parent		-3.212***
		(0.525)
Host Component $\times$ Worldwide Parent		-2.457**
		(1.072)
Observations	11,208	11,208
Pseudo-R^2	0.180	0.180
Controls:	Parent	Parent
	Bilateral	Bilateral
FEs:	Host-Year	Host-Year
	Parent	Parent

Notes: All specifications are estimated in PPML. The dependent variable is the I_t/K_{t-1} ratio for FAI. All specifications include parent country and host country-year fixed effects, and the following characteristics of the multinational firm's parent country: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Distance between the host and parent, and a dummy variable indicating whether they share a common language are also included. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 6. Heckman Selection Model

	First (extensive) stage			
	(1)	(2)	(3)	(4)
	FAI> 0	FAI> 0	FAI> 0	FAI> 0
Rate Differential	1.792***	2.107***	4.427***	5.621***
	(0.526)	(0.648)	(1.594)	(1.418)
Host KF-METR	0.006	0.005	-0.022**	-0.025**
	(0.007)	(0.006)	(0.010)	(0.010)
Weighted Non-Host KF-METR (using capital)	-0.001	-0.001		
	(0.001)	(0.001)		
Weighted Non-Host KF-METR (using sales)			-0.001	-0.001*
			(0.001)	(0.001)
	Second (intensive) stage			
	(1)	(2)	(3)	(4)
	LnFAI	LnFAI	LnFAI	LnFAI
Rate Differential	1.490***	1.457***	1.839***	1.977***
	(0.405)	(0.420)	(0.394)	(0.420)
Host METR	0.013***	0.013***	0.009**	0.009**
	(0.004)	(0.003)	(0.004)	(0.004)
Inverse Mills	1.831***	1.955***	0.676***	0.742***
	(0.161)	(0.203)	(0.113)	(0.130)
Observations	4,666	4,006	4,322	3,731
Exclusion restrictions:	Weighted METR, by capital	Weighted METR, by capital VAT and PIT Rates Tax Revenue / GDP	Weighted METR, by sales	Weighted METR, by sales VAT and PIT Rates Tax Revenue / GDP
FEs at both stages:	Parent, Year	Parent, Year	Parent, Year	Parent, Year
Control variables at both stages:	Host, Parent Bilateral	Host, Parent Bilateral	Host, Parent Bilateral	Host, Parent Bilateral

Notes: These are Heckman selection results using an unbalanced panel of all available host-parent-year observations. By the argument set out in the text, the weighted average of KF-METRs outside the host country is included at the first stage but excluded at the second. This non-host country KF-METR term, is constructed in two ways: in columns (1) and (2) using capital-based weights, and in columns (3) and (4) using sales-based weights. Columns (2) and (4) include additional exclusion restrictions as indicated. Second stage results are from OLS specification using the log of the FAI ratio as a dependent variable on the restricted sample of positive FAI only, with an inverse Mills ratio. Standard errors are clustered at the host country level. In both stages we include the following controls for each of host and parent country: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Gravity variables are also controlled for. Parent and year fixed effects are included. ***, ** and * indicate significance at the 1, 5, and 10 percent levels respectively.

Table 7. More Complex Dynamic of Investment and Timing of Tax Response

	(1)	(2)		(3)	(4)	(5)
Rate Differential	2.811***		Rate Differential			2.139**
	(0.726)					(0.868)
Lagged I/K	0.286***	0.286***	Rate Differential (t-1)	1.920**		0.457
	(0.0335)	(0.0335)		(0.867)		(1.303)
Non-Host part		2.790***	Rate Differential (t+1)		4.348***	2.666***
		(0.823)			(0.811)	(0.676)
Host part		-2.825***				
		(0.671)				
Observations	9,637	9,637		9,637	9,612	7,430
Pseudo R^2	0.173	0.173		0.158	0.163	0.152

Notes: The dependent variable is I_t/K_{t-1}, where I is FAI flow and K is FAI stock. Estimation is by PPML. In columns (1) and (2) the baseline specification is augmented with the first-lag of the I/K ratio (that is, FAI flow at time $t-1$ scaled by FAI stock at time $t-2$). In columns (3)-(5) we augment the baseline specification with leads and lags of the CIT differential term. Host-year fixed effects and parent fixed effects are included, and parent country macroeconomic variables as well as bilateral gravity variables are included as control variables. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 8. Alternative Weighting Schemes in Constructing the Rate Differential Term

Weights:	Capital		Exports	
Dep Var:	I/K (FAI)		I/K (FAI)	
	(1)	(2)	(3)	(4)
Rate Differential	3.853***		0.508	
	(1.060)		(1.642)	
Non Host Component		5.015***		0.487
		(1.392)		(1.674)
Host Component		1.684		-0.405
		(2.915)		(1.819)
Constant	-38.441***	-29.396***	-42.616***	-42.576***
	(8.829)	(6.768)	(10.400)	(10.344)
Observations	12,630	12,630	12,630	12,630
Pseudo-R^2	0.169	0.229	0.161	0.161
Controls:	Parent	Parent	Parent	Parent
	Bilateral	Bilateral	Bilateral	Bilateral
FEs:	Host-Year,	Host-Year,	Host-Year,	Host-Year,
	Parent	Parent	Parent	Parent

Notes: All specifications are estimated in PPML using an unbalanced panel of all available host-parent-year observations. Specifications (1)-(2) use the rate differential weighted using shares of fixed capital (lagged). Specifications (3)-(4) use the rate differential weighted using shares of exports (lagged). Fixed effects included in each column are indicated in the table; also included are gravity variables and the following characteristics of the parent country: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 9. Endogeneity: A Control Function Approach

	(1)	(2)	(3)
Rate Differential	1.271		
	(1.164)		
Host-KF METR	-0.003		
	(0.004)		
Non-Host Component		2.930**	1.866
		(1.483)	(1.375)
Host Component		-4.924***	-4.271***
		(1.223)	(1.363)
Residual (Rate Diff.)	1.490		
	(1.226)		
Residual	-0.001		
(Host METR)	(0.017)		
Residual (Host Comp.)		-0.486	0.513
(Non-Host Comp.)		(1.376)	(1.268)
Residual		3.140***	2.512**
(Host Comp.)		(1.100)	(1.231)
Observations	13,483	12,765	12,077
Pseudo R2	0.153	0.169	0.186
Fixed effects	Parent, Year	Parent, Host-Year	Parent, Host-Year
IVs (no. of lags):	CIT Differential (2)	Host Comp. (2)	Host Comp. (2)
	Host METR (2)	Non-Host Comp. (2)	Non-Host Comp. (2)
			Host METR (2)
			VAT and PIT Rev. (1)
			Host Pop. (0)

Notes: The dependent variable is the I/K ratio for FAI. The specification is our baseline PPML, augmented with residuals from first stage regressions of tax variables. The residuals are predictions from first-stage regressions, with the instruments included as indicated in the table. We: 1) regress endogenous (tax) variables on instruments and controls, to retrieve predicted residuals, then 2) estimate PPML regressions with the first stage predicted residuals as controls. With this approach standard errors tend to be underestimated. Fixed effects are included as indicated in the table. Macroeconomic variables as well as bilateral gravity variables are included as control variables. Standard errors in parentheses are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 10. Country-Pair Fixed Effects

	(1)	(2)
Rate differential	1.212***	
	(0.307)	
Non-host Component		1.805***
		(0.357)
Host Component		-0.767**
		(0.391)
Observations	8,744	8,744
Pseudo R2	0.166	0.168
Fixed Effects	Host-Parent	Host-Parent
	Year	Year

Notes: All specifications are estimated in PPML. The dependent variable is the I_t/K_{t-1} ratio for FAI. All specifications include host-parent and year fixed effects, and the following characteristics of the multinational firm's parent country: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Distance between the host and parent, and a dummy variable indicating whether they share a common language is also included. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 11. Cross-border Tax Effects: FAI vs. FDI

Dep. Var. is I/K corresponding to:	(1) FAI	(2) FDI	(3) FAI	(4) FDI
Rate Differential	1.738***	0.354		
	(0.508)	(0.647)		
Non-Host Component			2.010***	0.178
			(0.619)	(0.587)
Host Component			-1.648***	-0.814
			(0.520)	(0.623)
Host KF-METR	-0.003	-0.018*	-0.003	-0.017*
	(0.005)	(0.009)	(0.005)	(0.009)
Constant	-48.299***	-26.619*	-47.749***	-28.415**
	(10.644)	(14.407)	(10.575)	(14.487)
Observations	12,532	17,442	12,532	17,442
Pseudo-R^2	0.129	0.157	0.130	0.159
Controls:	Host, Parent Bilateral	Host, Parent Bilateral	Host, Parent Bilateral	Parent, Bilateral
FEs:	Year Parent	Year Parent	Year Parent	Host-Year, Parent

Notes: All specifications are estimated by PPML and include parent country and year fixed effects along with the following characteristics of the multinational firm's host and parent country: GDP (in log), capital account openness index, trade openness, inflation rate, government expenditure share, and exchange rates. Standard errors, in parentheses, are clustered by host. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

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Appendices

A Proof of Proposition 1

Attaching multiplier μ to the constraint that $\sum_{j=1} S_j = 0$, the Lagrangean for the multinational's problem is

$$\begin{aligned}\Pi = \sum_{j=1}^{N}(1-T_j)\Big[\Big\{R_j\big(F_1(K_1),...,F_N(K_N)\big) + S_j - \rho(1+M_j)K_j\Big\} - C(S_j,K_j)\Big] \\ + \mu\sum_{j=1}^{N} S_j,\end{aligned} \tag{A.1}$$

and so the necessary condition on K_h is that

$$(1-T_h)\Big\{\frac{\partial R_h}{\partial F_h}F_h' - \rho(1+M_h)\Big\} - \frac{\partial C}{\partial K_h} + \sum_{j\neq h}^{N}(1-T_j)\frac{\partial R_j}{\partial F_h}F_h' \leq 0. \tag{A.2}$$

Collecting terms in $F_h^{'}$, (A.2) implies

$$\begin{aligned}\Big((1-T_h)\frac{\partial R_h}{\partial F_h} + \sum_{j\neq h}^{N}(1-T_j)\frac{\partial R_j}{\partial F_h}\Big)F_h' &= \Big((1-T_h)\frac{\partial R}{\partial F_h} + T_h\Big(\sum_{j\neq h}\frac{\partial R_j}{\partial F_h}\Big) - \sum_{j\neq h}T_j\frac{\partial R_j}{F_h}\Big)F_h' \\ &= \Big(1-T_h+\alpha_h\Big(\sum_{j\neq h}T_j\delta_{hj} - T_h\Big)\Big)\frac{\partial R}{\partial F_h}F_h'\end{aligned} \tag{A.3}$$

where the first equality follows on using $\partial R_h/\partial F_h = \partial R/\partial F_h - \sum_{j\neq h}\partial R_j/\partial F_h$ and simplifying, and the second from rearrangement and recalling the definition of α_h in the text. Substituting (A.3) into (A.2) and rearranging gives

$$\Big(1-T_h+\alpha_h\Big(\sum_{j\neq h}T_j\delta_{hj} - T_h\Big)\Big)\frac{\partial R}{\partial F_h}F_h' \leq (1-T_h)(1+M_h) + \frac{\partial C}{\partial K_h} \tag{A.4}$$

Turning to the term $\partial C/\partial K_h$ on the right of (A.4), with shifting costs assumed to be of the form

$$C(S_i,K_i) = \Big(\frac{1}{2\phi\rho K_i}\Big)S_i^2, \tag{A.5}$$

the necessary condition on S_i requires that

$$(1-T_h)\phi\rho K_i - S_i + \mu\rho K_i. \tag{A.6}$$

Summing (A.6) over i, using $\sum_i S_i = 0$ and defining $\omega_i \equiv K_i/\sum_j K_j$, gives $\mu = -\sum_i(1-T_i)\omega_i$; substituted back into (A.6), this implies that $S_h = \phi\rho K_h(\sum_i T_i\omega_i - T_j)$. Using this in the implication of (A.5) that

$$\frac{\partial C}{\partial K_h} = -\Big(\frac{1}{2\phi\rho}\Big)\Big(\frac{S_h}{K_h}\Big)^2, \tag{A.7}$$

gives $\partial C/\partial K_h = -(\phi\rho/2)(\sum_{j\neq h}T_j\omega_j - T_h)^2$, where ω_j is as defined in the text. Using this in (A.4) and rearranging:

$$\frac{\partial R}{\partial F_h}F_h' \le \rho\left(\frac{(1-T_h)(1+M_h) - (\phi/2)(\sum_{j\neq h} T_j\omega_j - T_h)^2}{1 - T_h + \alpha_h(\sum_{j\neq h} T_j\delta_{hj} - T_h)}\right). \tag{A.8}$$

Dividing numerator and denominator on the right of (A.8) by $1 - T_h$ and rearranging gives the formulation in Proposition 1 but with the I-$METR$ defined as in (10). Setting $\phi = 0$ (corresponding to infinite shifting costs), Proposition 1 follows.

B Sufficient condition for a minimum tax to increase aggregate FAI

Recalling (8), the expected impact on FAI into host country h of an increase in the minimum rate is given by $FAI_h\beta_\Delta(\partial\Delta_h/\partial m)$; the effect on aggregate FAI thus has the same sign as $E[FAI_h\frac{\partial\Delta_h}{\partial m}]$. To sign this (maintaining the same assumptions as in Section 6), define $i(T,m) = 1$ if $T > m$ and zero otherwise and combine (14)-(15) to give

$$\frac{\partial\Delta_h}{\partial m} = \frac{F(m)}{1-T_h}i(T_h,m) - \frac{\int_m^1 (1-T)f(T)dT}{(1-m)^2}(1 - i(T_h,m)). \tag{B.1}$$

Noting in the first term that $T > m$ when $i(T,m) = 1$ and in the numerator of the second adding and subtracting $\int_m^1 mf(T)dt$, some rearrangement gives

$$(1-m)\frac{\partial\Delta_h}{\partial m} \ge F(m) - (1 - i(T_h,m)) + \left(\frac{\int_m^1 (T-m)f(T)dT}{1-m}\right)(1 - i(T_h,m)). \tag{B.2}$$

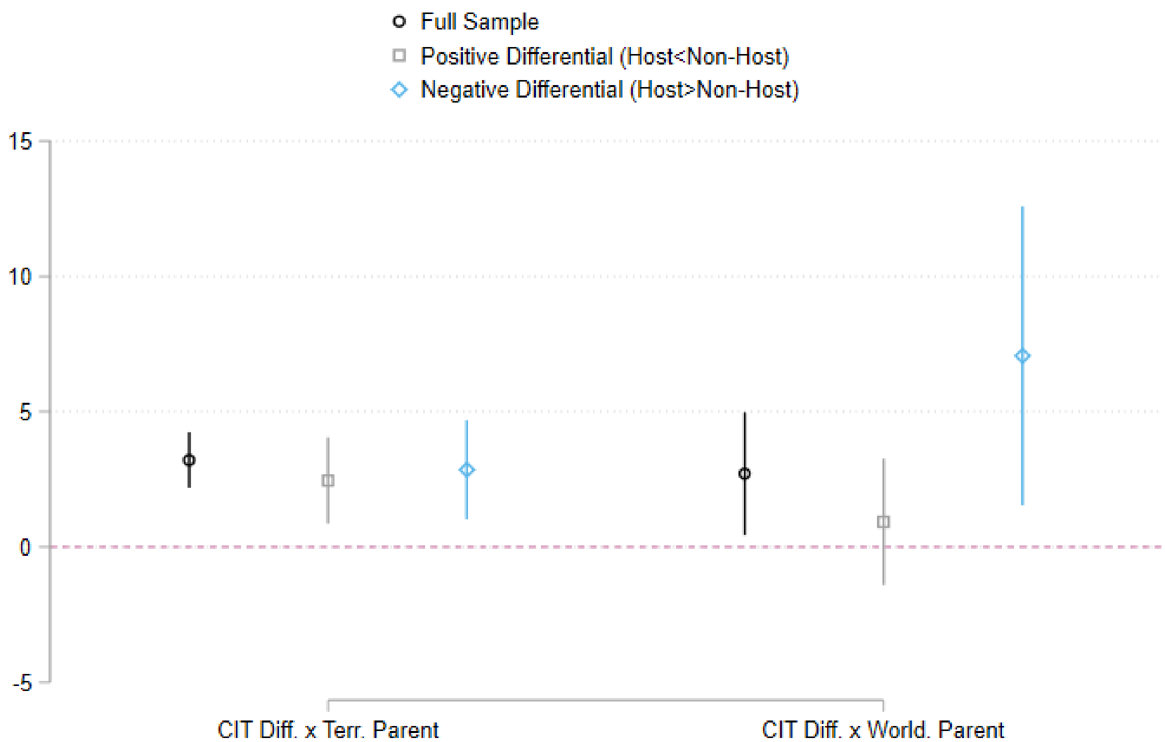
Since the final term in (B.2) is non-negative, multiplying by FAI_h and taking the expectation across all hosts gives

$$\begin{aligned}(1-m)E\left[FAI\frac{\partial\Delta_h}{\partial m}\right] &\ge F(m)E[FAI] - \int_0^m FAIf(T)dt \\ &= F(m)\Big(E[FAI] - E[FAI|T<m]\Big),\end{aligned} \tag{B.3}$$

from which the result follows whenever the minimum binds some countries.

C Supplementary Tables and Figures

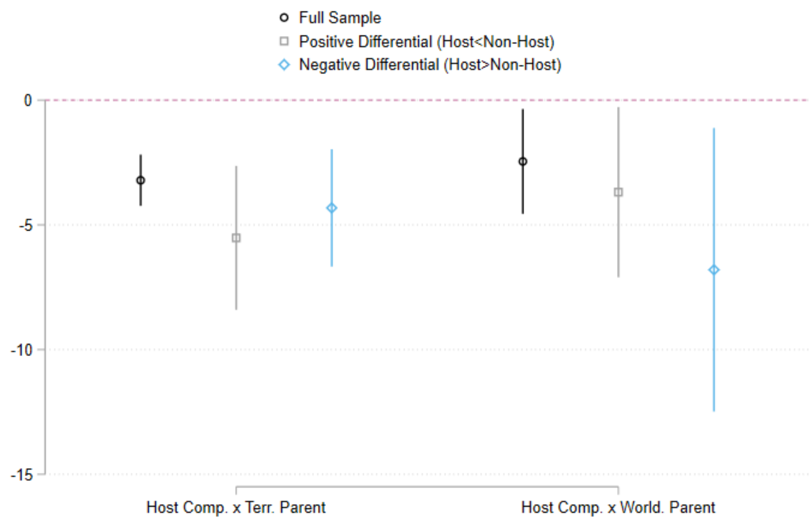
Figure C.1. Worldwide vs. Territorial Parent CIT Systems and the Rate Differential



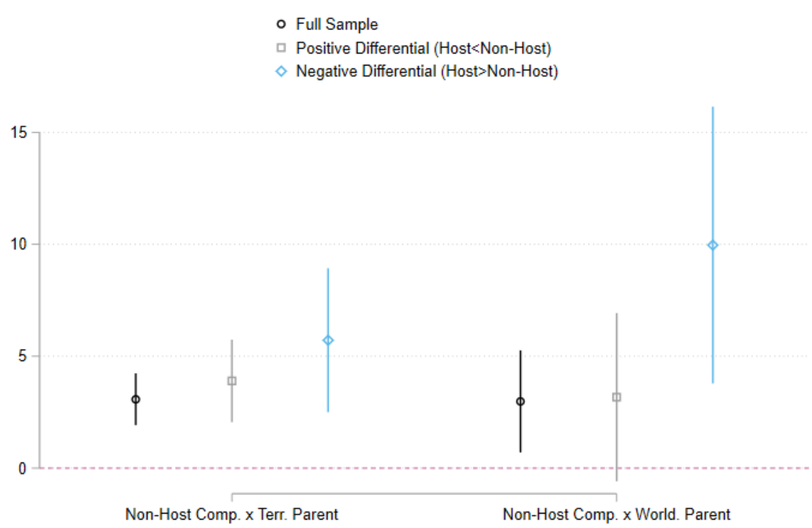
Notes: The figure shows the marginal effect of the CIT differential for three subsets of the sample: the full sample, restricted to observations with a positive differential (that is, bilateral pairs for which the differential term is greater than zero), and restricted to observations with a negative differential (that is, bilateral pairs for which the differential term is less than zero).

Figure C.2. Worldwide vs. Territorial Parent CIT Systems and the Differential Term Components

(a) Response of the Host Component



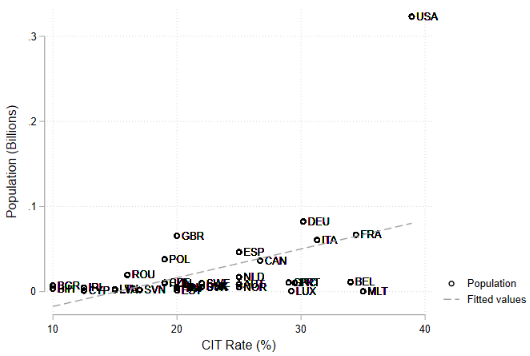
(b) Response of the Non-Host Component



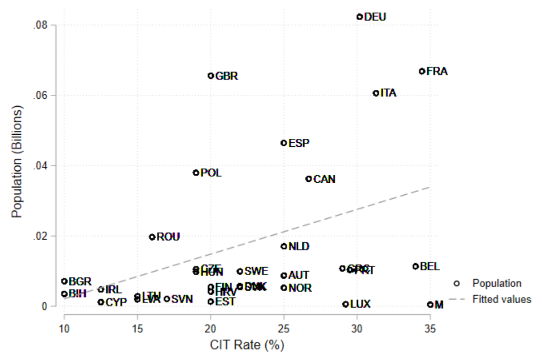
Notes: The top panel shows the marginal effect of the host component of the CIT differential for three sets of the sample: the full sample, restricted to observations with a positive differential (that is, bilateral pairs for which the differential term is greater than zero), and restricted to observations with a negative differential (that is, bilateral pairs for which the differential term is less than zero). The lower panel shows a similar set of results for those three samples in terms of the response of the non-host component of the differential.

Figure C.3. Size and Corporate Tax Rates in 2016

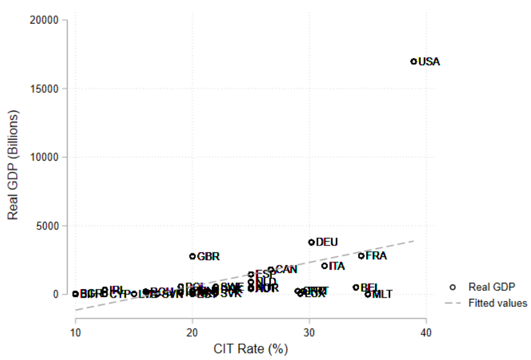
(a) Population vs. Stat. Rate (All)



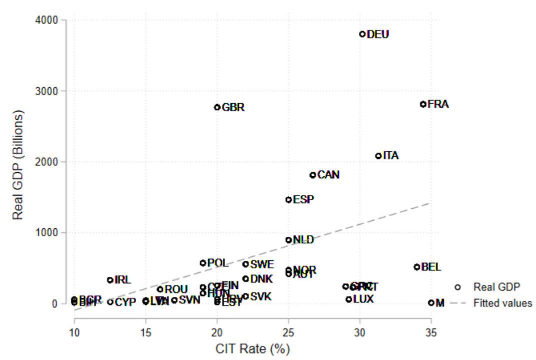
(b) Population vs. Stat. Rate (Ex-USA)



(c) GDP vs. Stat. Rate (All)



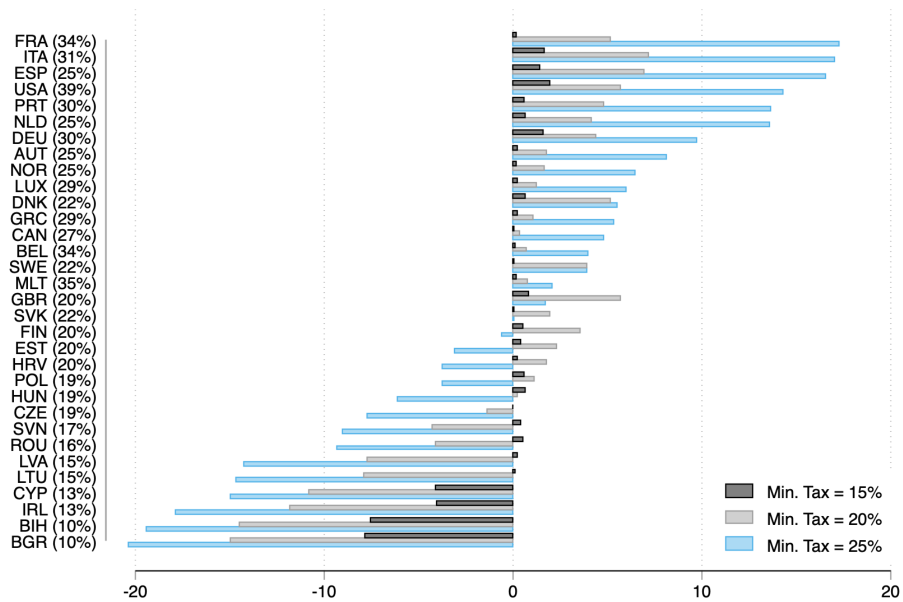
(d) GDP vs. Stat. Rate (Ex-USA)



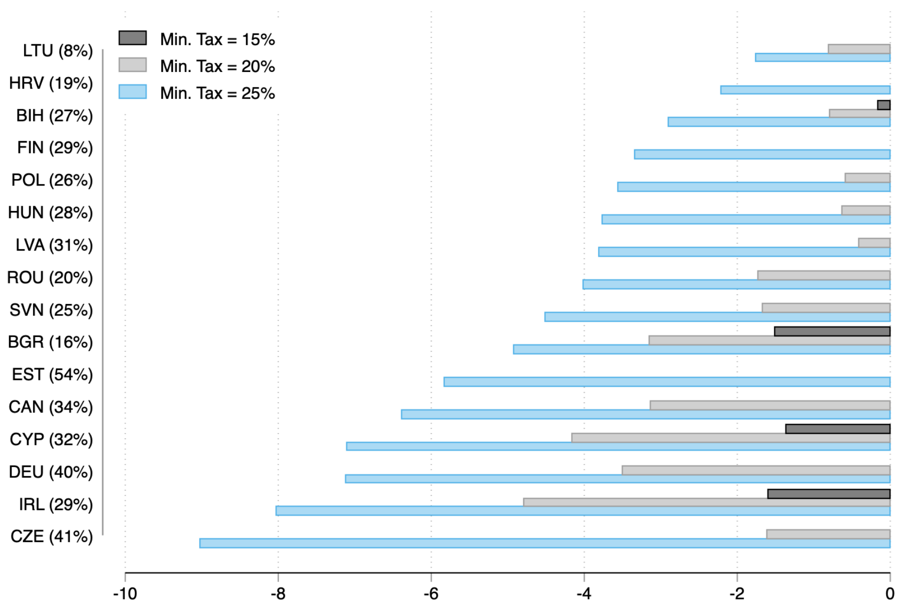
Notes: These figures show that our data is consistent with models of tax competition, which predict that smaller countries have lower tax rates. Each panel shows a scatter plot overlaid with a best-fit line. Either all countries or all countries excluding the USA are included, as the USA tends to be an outlier here.

Figure C.4. Heterogeneity by Corporate Income Tax Variables

(a) Effect of the CIT Differential



(b) Effect of Host KF-METR



Notes: The top panel shows the effect of the CIT differential on the percentage change in host country FAI, for three minimum tax scenarios (15, 20 and 25 percent as indicated). The lower panel shows the effect of host country KF-METR on the percentage change in host country FAI, for three minimum tax scenarios (15, 20 and 25 percent as indicated). For the latter figure, note that only host countries with KF-METRs initially below the minimum statuory rate are directly affected through this channel.

Table C.1. Summary of Main Tax Variables by Country

Variable: Statistic:	Statutory Rate Mean	Host KF-METR Mean	Rate Diff. Mean	Rate Diff. SD
Austria*	26.15	13.61	0.01	3.00
Belgium*	34.01	13.72	-0.05	0.22
Bosnia and Herzegovina	10.00	13.29	0.03	0.00
Bulgaria	12.12	3.29	0.08	4.00
Canada*	27.01	14.96	0.01	1.12
Croatia	20.00	7.29	0.03	0.00
Cyprus	11.20	12.05	0.07	1.52
Czechia*	21.73	9.88	0.03	3.73
Denmark*	25.70	16.76	0.01	2.16
Estonia*	21.90	33.42	0.04	1.86
Finland*	24.93	15.98	0.02	2.77
France*	35.63	18.01	-0.06	1.38
Germany*	33.17	18.33	-0.02	4.24
Greece*	24.43	10.93	-0.01	2.73
Hungary*	18.66	10.14	0.05	1.25
Ireland	12.50	7.51	0.06	0.00
Italy*	33.38	4.85	-0.04	2.88
Latvia	15.25	17.65	0.06	0.96
Lithuania	15.39	1.88	0.06	1.34
Luxembourg*	29.02	11.31	-0.02	0.34
Malta	35.00	56.17	-0.08	0.00
Netherlands*	27.10	11.69	0.00	3.38
Norway*	27.51	21.06	-0.01	0.90
Poland*	19.49	10.50	0.03	1.92
Portugal*	28.76	12.04	-0.02	2.17
Romania	17.15	6.63	0.07	3.00
Slovakia*	20.29	6.44	0.04	1.90
Slovenia*	20.76	9.91	0.03	3.13
Spain*	31.02	26.33	-0.03	2.79
Sweden*	25.79	15.65	0.01	2.47
United Kingdom*	26.26	20.34	0.01	3.72
United States	39.20	23.39	-0.06	0.13

Notes: Host countries that we treat as having territorial corporate income tax (CIT) system are indicated by *. "Rate Diff." refers to the rate differential term Δ_{hpt}.

Table C.2. Number of Parent Countries by Host Country and Years in the Data

Host Country	Mean	Minimum	Maximum	First Year	Last Year
Austria	101	5	148	2003	2016
Belgium	127	107	145	2010	2016
Bosnia and Herzegovina	126	110	145	2013	2016
Bulgaria	92	51	136	2003	2016
Canada	29	22	35	2011	2016
Croatia	102	7	133	2008	2016
Cyprus	69	2	159	2004	2016
Czechia	77	2	119	2003	2016
Denmark	90	24	147	2006	2016
Estonia	92	16	162	2003	2016
Finland	99	17	167	2003	2016
France	83	25	139	2003	2016
Germany	102	69	138	2007	2016
Greece	129	99	140	2012	2016
Hungary	97	19	136	2004	2016
Ireland	118	94	142	2008	2016
Italy	97	52	143	2003	2016
Latvia	80	22	157	2003	2016
Lithuania	98	40	153	2003	2016
Luxembourg	99	74	137	2009	2016
Malta	141	117	158	2008	2016
Netherlands	89	7	146	2003	2016
Norway	113	80	126	2008	2016
Poland	107	32	153	2007	2016
Portugal	91	14	155	2003	2016
Romania	72	25	112	2004	2016
Slovakia	89	28	153	2004	2016
Slovenia	62	12	147	2003	2016
Spain	85	41	153	2003	2016
Sweden	74	7	148	2003	2016
United Kingdom	65	3	123	2006	2016
United States	50	20	66	1998	2016

Notes: This table shows the number of parent countries with non-missing FAI data, for each host country in the dataset. Mean, minimum, and maximum refer to the average number of non-missing parent observations per host country-year, and the number of non-missing parent observations for the host country-year with the least and most observations, respectively. The last two columns show the range of dates for which FAI data is available for the host country.

Table C.3. All Parents in the Dataset: Worldwide and Territorial Classification

Worldwide:				**Territorial:**
Afghanistan	Côte d'Ivoire	Malaysia	St. Vincent and the Grenadines	Austria
Albania	Djibouti	Maldives	Sudan	Belgium
Algeria	Dominica	Mali	Suriname	Canada
Angola	Dominican Republic	Malta	Syrian Arab Republic	Czechia
Antigua and Barbuda	Ecuador	Marshall Islands	Taiwan, China	Denmark
Argentina	Egypt, Arab Rep.	Mauritania	Tajikistan	Estonia
Armenia	El Salvador	Mauritius	Tanzania	Finland
Australia	Equatorial Guinea	Mexico	Thailand	France
Azerbaijan	Eritrea	Micronesia, Fed. Sts.	Timor-Leste	Germany
Bahamas, The	Ethiopia	Moldova	Togo	Greece
Bahrain	Fiji	Mongolia	Tonga	Hungary
Bangladesh	Gabon	Montenegro	Trinidad and Tobago	Iceland
Barbados	Gambia, The	Morocco	Tunisia	Italy
Belarus	Georgia	Mozambique	Turkiye	Luxembourg
Belize	Ghana	Namibia	Turkmenistan	Netherlands
Benin	Grenada	Nepal	Uganda	Norway
Bhutan	Guatemala	New Zealand	Ukraine	Poland
Bolivia	Guinea	Nicaragua	United Arab Emirates	Portugal
Bosnia and Herzegovina	Guinea-Bissau	Niger	United States	Slovak Republic
Botswana	Guyana	Nigeria	Uruguay	Slovenia
Brazil	Haiti	Oman	Uzbekistan	Spain
Brunei	Honduras	Pakistan	Vanuatu	Sweden
Bulgaria	Hong Kong SAR, China	Panama	Venezuela, RB	Switzerland
Burkina Faso	India	Papua New Guinea	Vietnam	United Kingdom
Burma	Indonesia	Paraguay	Yemen, Rep.	
Burundi	Iran, Islamic Rep.	Peru	Zambia	
Cabo Verde	Iraq	Philippines	Zimbabwe	
Cambodia	Ireland	Puerto Rico (US)		
Cameroon	Israel	Qatar		
Central African Republic	Jamaica	Romania		
Chad	Japan	Russian Federation		
Chile	Jordan	Rwanda		
China	Kazakhstan	Samoa		
Colombia	Kenya	San Marino		
Comoros	Kiribati	Sao Tome and Principe		
Congo, Rep.	Kuwait	Saudi Arabia		
Costa Rica	Kyrgyz Republic	Senegal		
Croatia	Lao PDR	Serbia		
Cyprus	Latvia	Seychelles		
	Lebanon	Sierra Leone		
	Lesotho	Singapore		
	Liberia	Solomon Islands		
	Libya	South Africa		
	Lithuania	Korea, Rep.		
	Macao SAR, China	South Sudan		
	North Macedonia	Sri Lanka		
	Madagascar	St. Kitts and Nevis		
	Malawi	St. Lucia		

Notes: There is some time variation in our sample for countries with territorial CIT systems. Those include the following countries, which are designated as having worldwide CIT systems prior to the year indicated here: Czechia (2004), Estonia (2005), Finland (2005), Greece (2011), Poland (2004), Slovak Republic (2004), Slovenia (2004), and United Kingdom (2009). Note that the final year in our sample is 2016. The territorial and worldwide designation are obtained from PWC Tax Summary Reports, in particular a report titled "Evolution of Territorial Tax Systems in the OECD" from 2013.

Table C.4. Tax Rates in 2016

Host Country	Host KF-METR	Host Statutory Rate	Rate Differential
Austria	13	25	0.000
Belgium	14	34	-0.111
Bosnia and Herzegovina	14	10	0.121
Bulgaria	3	10	0.100
Canada	14	27	0.018
Croatia	8	20	0.036
Cyprus	12	13	0.086
Czechia	8	19	0.052
Denmark	14	22	0.022
Estonia	31	20	0.044
Finland	13	20	0.040
France	19	34	-0.070
Germany	18	30	-0.052
Greece	17	29	-0.044
Hungary	12	19	0.055
Ireland	8	13	0.086
Italy	-16	31	-0.058
Latvia	16	15	0.070
Lithuania	2	15	0.086
Luxembourg	11	29	-0.032
Malta	56	35	-0.116
Netherlands	8	25	0.002
Norway	19	25	-0.006
Poland	11	19	0.049
Portugal	12	30	-0.047
Romania	6	16	0.088
Slovakia	13	22	0.022
Slovenia	9	17	0.053
Spain	25	25	-0.004
Sweden	13	22	0.023
United Kingdom	18	20	0.049
United States	23	39	-0.104
Total	14	23	0.015

Notes: This table shows for each host country, for 2016, the KF-METR, statutory CIT rate and average over all parent countries p of the rate differential Δ_{hp2016}. KF-METR and the statutory CIT rate are in percent.

Table C.5. Distribution of the Statutory Rate Differential Term in 2016

Host country	Mean	S.D.	P10	P50	P90
Austria	0.000	0.074	-0.108	0.000	0.098
Belgium	-0.111	0.110	-0.268	-0.091	0.000
Bosnia and Herzegovina	0.121	0.100	0.000	0.111	0.266
Bulgaria	0.100	0.096	0.000	0.091	0.242
Canada	0.018	0.040	-0.004	0.000	0.076
Croatia	0.036	0.072	-0.039	0.000	0.149
Cyprus	0.086	0.090	0.000	0.063	0.222
Czechia	0.052	0.076	-0.018	0.006	0.166
Denmark	0.022	0.065	-0.050	0.000	0.125
Estonia	0.044	0.078	-0.046	0.000	0.175
Finland	0.040	0.075	-0.047	0.000	0.154
France	-0.070	0.102	-0.241	0.000	0.000
Germany	-0.052	0.079	-0.181	-0.006	0.023
Greece	-0.044	0.084	-0.178	0.000	0.046
Hungary	0.055	0.078	-0.028	0.014	0.166
Ireland	0.086	0.091	0.000	0.060	0.222
Italy	-0.058	0.089	-0.208	-0.001	0.009
Latvia	0.070	0.082	0.000	0.035	0.197
Lithuania	0.086	0.086	0.000	0.059	0.205
Luxembourg	-0.032	0.079	-0.175	0.000	0.038
Malta	-0.116	0.118	-0.288	-0.091	0.000
Netherlands	0.002	0.063	-0.093	0.000	0.091
Norway	-0.006	0.064	-0.095	0.000	0.086
Poland	0.049	0.075	-0.026	0.003	0.164
Portugal	-0.047	0.087	-0.179	0.000	0.042
Romania	0.088	0.083	0.000	0.065	0.214
Slovakia	0.022	0.070	-0.064	0.000	0.127
Slovenia	0.053	0.074	0.000	0.010	0.172
Spain	-0.004	0.076	-0.115	0.000	0.099
Sweden	0.023	0.072	-0.062	0.000	0.127
United Kingdom	0.049	0.080	-0.047	0.016	0.175
United States	-0.104	0.115	-0.278	-0.068	0.000
Total	0.015	0.104	-0.117	0.000	0.156

Notes: This table shows the distribution by host country of the rate differential Δ_{hp2016}.