Cross-tax elasticities are heterogeneous

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Abstract

I study the heterogeneity of tax base spillovers resulting from corporate tax reforms in Europe by estimating country-by-country cross-tax elasticities from 2006 to 2018. Contrary to standard assumptions, I find both positive (substitutionary) and negative (complementary) cross-tax elasticities ranging from +8.5 to −8.9. As predicted by theory, this heterogeneity can be explained by the similarity of countries' consumption patterns, differences in factor endowments, the size of foreign market potential, and the existence of low-tax jurisdictions. These results recommend caution when using average (often substitutionary) elasticities to predict the spillover effects of corporate tax reforms.

JEL: H32; H25; F23

Keywords: corporate tax; tax base spillovers; cross-tax elasticities; heterogeneous effects

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1 Introduction

Corporate tax reforms do not occur in a vacuum. Rather, one country's corporate tax reform can affect another country's tax base—a phenomenon described as a corporate tax base spillover. Tax base spillovers are contentious because they mean a country's tax base is dependent on its neighbours' tax rates.[1] The existing empirical literature assumes that tax base spillovers are homogeneous across countries: that when one country cuts its tax rate, it will affect all its neighbours' tax bases in approximately the same way. But this assumption is tenuous, since multinational firms—which are the main drivers of tax base spillovers—might respond to tax cuts in very different ways depending on their organisational form. And a multinational's organisational form depends on the pair of countries in question.

To explore the heterogeneity of tax base spillovers, I estimate corporate cross-tax semi-elasticities for 425 country-pairs in Europe using data on multinational firms from 2006 to 2018. I find that cross-tax elasticities are heterogeneous: they can either be positive (substitutionary) or negative (complementary). More importantly, I show that this heterogeneity is not random. Rather, it can be explained by specific country-pair characteristics which incentivise or attract specific multinational organisational forms. For four main organisational forms, I combine the country-pair conditions in which those organisational forms are predicted to arise, with theoretical predictions of each organisational form's optimal response to a tax reform in an affiliate country. These theoretical predictions help us to understand the observed heterogeneity in corporate cross-tax elasticities.

First, I estimate novel country-by-country cross-tax elasticities at the intensive margin. This cross-tax elasticity is defined as the semi-elasticity of taxable income in country j with respect to the tax rate in country i: $e_{ij} = \frac{\partial \pi_j}{\partial \tau_i} \frac{1}{\pi_j}$, where π_j is the profits of the multinational firm in country j, and τ_i is the tax rate of country i. This elasticity quantifies the responsiveness of multinational firm profits in one country to tax changes in other countries where the multinational firm operates. I estimate cross-tax elasticities using firm-level data on multinational affiliates with domestic firms as the comparison group. The main estimates of cross-tax elasticities range from -8.9 to $+8.5$, implying that multinational firms might *increase or decrease* profit in a country by up to 9% in response to a 1 percentage point tax cut in another country.

Second, I use these novel country-by-country cross-tax elasticities to examine the determinants of heterogeneity in tax base spillovers. I test four central predictions stemming from theories of multinational firms, and uncover four new patterns. First, countries with more similar consumption patterns have more substitutionary spillovers. Second, countries with larger foreign market potential generate more substitutionary spillovers with their tax reforms. Third, countries with more dissimilar labour skill endowments have more complementary spillovers. Fourth, tax reforms by low-tax countries generate more complementary spillovers. This paper presents novel evidence to help us understand the heterogeneity of tax base spillovers across country-pairs.

This paper makes an important contribution to the literature on the cross-border effects

[1] In 2011, the IMF, OECD, United Nations and World Bank (2011) recommended G-20 countries should "undertake 'spill over' analyses of the impact of any significant changes in our own tax systems on those of developing countries". The IMF (2014) suggests that spillovers are sizable, and in turn propose a range of policy measures to limit adverse spillovers.

of corporate tax changes by explicitly modeling and explaining the heterogeneity in intensive-margin cross-tax elasticities.[2] Works such as IMF (2014) and Crivelli et al. (2016) do not consider this heterogeneity, but find that tax base spillovers are substitutionary on average. I show that substitutionary average spillovers are likely made up of both complementary and substitutionary tax base spillovers. The combination of complementary and substitutionary spillovers relates to an important ideological discussion about whether home and foreign investment are complements or substitutes (Feldstein, 1995; Desai et al., 2005; Goldbach et al., 2019). The application of cross-tax elasticities to this setting is new, although it has been explored in other contexts such as Griffith et al. (2014) for the location of ownership of intellectual property; Arulampalam et al. (2019) for the location of merger and acquisition targets; and Merlo et al. (2020) for the location of multinational affiliates in response to thin-capitalization rules.

This paper proceeds as follows. In Section 2, I outline the data on multinational and domestic firms used in this paper. In Section 3, I describe the strategy for identifying country-by-country cross-tax elasticities—including the use of the inverse hyperbolic sine and exact matching—and present the estimated cross-tax elasticities. Section 4 presents four predictions about the nature of cross-tax elasticities based on the theory of the multinational firm. In Section 5, I take this theory to the data by testing these four predictions using the estimated cross-tax elasticities and aggregate country-pair chatacteristics. I conclude in Section 6.

2 Data

I use data from Bureau van Dijk's Amadeus database on companies operating in 26 European countries from 2006 to 2018.[3] Amadeus provides administrative financial accounts from business registers collected by local Chambers of Commerce across Europe. For most European countries, it is a requirement for firms of all sizes to file balance sheet information. However, the data does not provide complete coverage. The Amadeus database also contains firm ownership information. I limit the scope to firms with operating revenue greater than or equal to EUR 1 million, total assets greater than or equal to EUR 2 million, and 15 or more employees. I clean the data as suggested by Kalemli-Ozcan et al. (2015).[4] Using the statistical classification of economic activities in the European Community (NACE) Revision 2, I keep only firms operating in the non-financial business economy.[5]

[2] This is a broad literature including De Mooij and Ederveen (2003, 2008); Feld and Heckemeyer (2011); Becker and Riedel (2012); Becker et al. (2012); Davies et al. (2016); Hines Jr and Rice (1994); Huizinga and Laeven (2008); Riedel (2018).

[3] These countries are Austria, Belgium, Bulgaria, Czechia, Germany, Denmark, Estonia, Spain, Finland, France, the United Kingdom, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, and Slovakia. I do not use data from Malta and Cyprus since there are not enough observations. Note that there is no data for Denmark prior to 2012, but I keep Denmark in the study.

[4] I keep only data which reflects accounts over a 12-month period. If the financial account closes on or before June 1 it is counted as the previous financial year, otherwise it is counted as the current financial year. This is not a major problem as most financial accounts close at the end of the year. All companies with Bureau van Dijk identification numbers that do not accurately reflect the country that the data says they are located in are removed. All values are expressed in euros converted using Eurostat's average annual exchange rate data. Where any negative value is observed for total assets, the entire company is dropped. Where there are firm-year duplicates, I keep only the most recent observation since this is likely due to a change in the accounting period.

[5] This includes sectors of industry, construction and distributive trades and services. More specifically, Eurostat considers the non-financial business economy to be captured by NACE Revision 2 Sections B to J and L to N,

Multinational affiliates are identified as corporations with a global ultimate owner who is also the global ultimate owner of affiliates located in other countries.[6] In this paper I define ownership as a shareholder owning 51 percent or more of the firm's equity, similar to the International Financial Reporting Standards' definition of control needed for consolidation of financial statements.[7] Data from Bureau van Dijk has the substantial benefit of capturing cross-border ownership structures. I observe multinational groups with an average of 7.2 multinational affiliates, spanning an average of 3.4 of the 26 countries.[8]

To measure the corporate tax rate, I use the top statutory corporate income tax rate from Eurostat.[9] Note that the corporate tax rate used here is the non-targeted rate, so that it includes no special rates for small firms or any other potential benefit structure that a country has. This measure of the tax rate also includes any existing surcharges or local taxes where applicable. If the surcharges vary or are targeted at the largest companies, then the top surcharge rate or local tax rate is used. This corporate tax rate therefore most closely represents the corporate tax rate facing the typically large multinational firms that are under examination here.

3 Estimating country-by-country cross-tax elasticities

This section describes the empirical strategy used to estimate country-by-country cross-tax elasticities. First, I explain the transformation of the variable of interest, which is profit or loss before taxes. Second, I describe the specification I use to estimate these elasticities. Third, I discuss identification. Fourth, I present the estimated cross-tax elasticities.

3.1 The inverse hyperbolic sine

The parameter of interest is the semi-elasticity of profit in country j with respect to the tax rate in country i. To transform the data in a manner that allows me to estimate the semi-elasticity while still keeping zero-valued and negative-valued observations, I use the inverse hyperbolic sine of profits. The inverse hyperbolic sine transformation, defined by the "arcsinh" notation, is given by the formula:

$$\text{arcsinh}(\pi_j) = \ln\left(\pi_j + \sqrt{\pi_j^2 + 1}\right). \tag{1}$$

It is used in practice by: Bahar and Rapoport (2018) for migration, trade, and foreign direct investment data; Clemens and Tiongson (2017) for income data; and by McKenzie (2017) for

and also including Group S95.

[6] I will refer to these as multinational firms, while the whole multinational including all affiliates will be referred to as the multinational group.

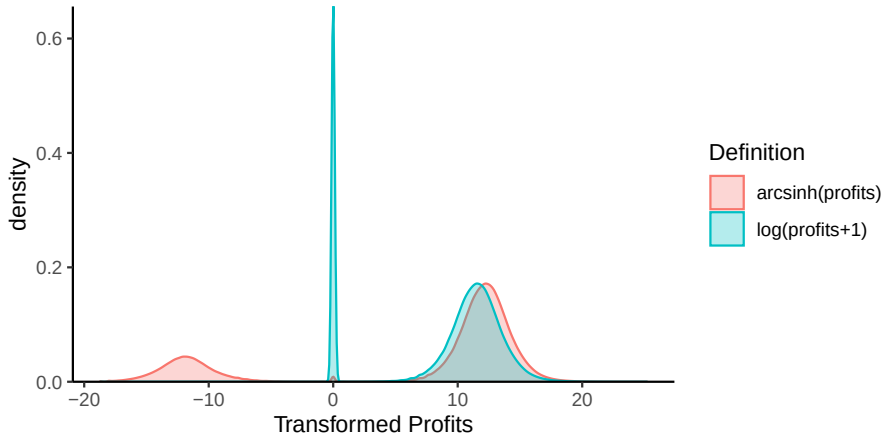
[7] That the shareholder has the power to direct the firm's activities affecting its return, that the shareholder is exposed to variable returns from the firm, and that the shareholder has the ability to use that power to affect the firm's returns. While this may occur with minority shareholders, I have chosen the conservative definition of ownership, since this is the only case I can be sure that control exists.

[8] Note that financial statement data is presented in dynamic form while ownership data is static as at 2018.

[9] I re-estimate these results using the effective marginal tax rate calculated by ZEW Leibniz Centre for European Economic Research, PWC, and the University of Mannheim (2020). These results are included in the appendix.

firm profits.[10]

Figure 1: Comparing the distributions of profits under log and arcsinh transformations



Note on Figure 1: This figure plots the kernel density estimates of the distributions of log transformed profits and of inverse hyperbolic sine transformed profits. The natural log distribution is transformed by setting all negative values to zero, then adding 1. This makes it as comparable to the inverse hyperbolic sine as possible. Note that without this transformation, the excess distribution at zero would not be observed.

Economists frequently estimate semi-elasticities by transforming profits using the natural logarithm. But the natural log of negative numbers is undefined, meaning that this strategy only keeps observations where firms are profitable. The common alternative strategy is to set negative values to zero, then add 1 to all observations. While this keeps all observations, in economic terms it truncates the firm's response effectively at zero (the log of 1). This implies that losses are not accounted for in calculating the behavioural response, therefore artificially shrinking the size of the estimated response. This is especially important for multinational firms for whom losses can not only be carried forward, but can sometimes also be offset at the group level. Losses have been shown to be part of the firm's optimal response to corporate tax changes (Johannesen et al., 2016; Hopland et al., 2018; Koethenbuerger et al., 2019). Figure 1 shows just how different the distributions of log profits and of arcsinh profits are. While for positive values the distributions are very similar in shape, firms record losses in a significant number of observations. The difference between these distributions highlights the importance of taking an approach that allows losses to be an optimal response to tax changes.

3.2 Empirical strategy

A multinational firm's profits in country j are a function of the tax rates in all countries in which it operates. For each firm m operating in country j, a dummy D_{mi} captures whether it

[10] Bellemare and Wichman (2019) show that we can convert the inverse hyperbolic sine to traditional semi-elasticities using the formula:

$$\frac{\partial \pi_j}{\partial \tau_i}\frac{1}{\pi_j} = \hat{e}_{ij} \cdot \cosh(\text{arcsinh}(\pi_j)) \cdot \frac{1}{\pi_j} = \hat{e}_{ij} \cdot \frac{\sqrt{\pi_j^2 + 1}}{\pi_j},$$

where $\hat{e}_{ij}$ is the coefficient from a regression of $\text{arcsinh}(\pi_j)$ on τ_i. For large enough values of π_j, the estimated coefficient $\hat{e}_{ij}$ will be almost equivalent to the semi-elasticity. For example, if $\pi_j = 100$, then the second term in the final expression $\sqrt{(\pi_j^2 + 1)}/\pi_j = 1.00005$. Even at this low value of profits, the adjustment is marginal and becomes insignificant for the averages of π_j I use to recover the semi-elasticity.

has an affiliate operating in country i as well. For domestic firms, this dummy is always equal to zero by definition. The key assumption of this estimation strategy is that only multinational groups with an affiliate in country i are directly affected by country i's tax rate change.

To identify the effect of country i's tax reform, I compare the change in profits in country j of a firm with an affiliate in country i against the change in profits of a firm similarly located in country j, but without an affiliate in country i. Implictly, two types of firm are being used for comparison: domestic firms in country j and multinational firms with an affiliate in country j but not in country i. These comparison units form the counterfactual: what would that multinational affiliate's profits be in country j if the tax rate in country i did not change?

Implementing this strategy means expressing each firm's profits in country j as a function of all countries' tax rates. Each tax rate is first interacted with a dummy D_{mi} that captures whether the firm has an affiliate in country i. To estimate the spillover effect between a pair of countries, I multiply each of 22 country-i tax rate terms by a full set of 26 country-j dummies, D_j. That is, I effectively estimate the effect of each country i's tax rate change separately for each country j. The equation I estimate to recover country-by-country cross-tax semi-elasticities is:

$$\text{arcsinh}(\pi_{mjt}) = \alpha_m + \gamma_{jkt} + \sum_{j \neq i}^{N} \sum_{i=1}^{N} e_{ij} \cdot D_{mit} \cdot D_j \cdot \tau_{it} + \varepsilon_{mt}. \tag{2}$$

where π_{mjt} and τ_{it} are profits in country j and the tax rate in country i, respectively. Note that m indexes the firm, j is the country being affected by the spillover, i is the country whose tax rate changes, and k is a grouping variable. Firm fixed effects are included as α_m and group-specific time effects are included as γ_{jkt}. Note that $D_{mit} = 0$ when $i = j$, meaning I do not estimate own-country tax elasticities. Note that I also include a set of dummies which capture years in which a country was added to or removed from a multinational group's set of affiliate locations. This is done to eliminate variation in D_{mi} that stems from changes in the multinational network. I focus only on variation that comes from changes in the tax rate τ_i.

This results in a matrix of semi-elasticities e_{ij} with dimensions $i \times j$, where each element is a spillover from country i's tax rate reform to country j's tax base. I do not consider the effect of the corporate tax reform on the country's own tax base so the diagonal entries are empty.

I allow for random coefficients. That is, I assume that there is non-independence in the estimated country-pair coefficients for each country changing its tax rate. I assume that the underlying parameters are themselves random variables, so that $e_{ij} \sim \mathcal{N}(e_i, \sigma_i) \; \forall \; i$. The benefit of this approach compared to estimating each elasticity separately is that I partially pool resources to capture the similarity among elasticities. It provides a regularization or shrinkage effect by drawing on the idea that elasticities generated by a single country's tax rate change may have some things in common. This approach is used by Griffith et al. (2014), Arulampalam et al. (2019) and Merlo et al. (2020) to estimate cross-border responses.

3.3 Identification

There is a systematic difference in firm size between multinational firms and domestic firms, measured by total assets: on average, multinational firms are larger than domestic firms. To temper this concern I do two things. First, I use disaggregated time fixed effects, splitting

firms into industry-size groupings. Second, I consider a reweighting approach based on those industry-size groupings.

Each firm is placed into a country-industry-size bin, which represents its comparison group. To create these comparison groups I calculate size groupings within industry grouping levels. I use the NACE 2-digit level as the primary industry grouping. Size groupings are created by breaking firms into quintiles based on average real total assets over the period under investigation.[11] These bins are used both as the level of disaggregation of time fixed effects, and to create covariate balance across multinational and domestic firms.[12]

I use a simple covariate balancing method. I apply exact matching to these bins to produce weights that reflect the coarsened exact matching weights proposed by Iacus et al. (2011). The weight a firm m in group k gets at time t is w_{mkt}. All multinational firms receive a weight $w_{mkt}(\text{mne}) = 1$. Using $N_{kt}(\text{dom})$ to denote the domestic number of firms in group k at time t and $N_{kt}(\text{mne})$ to denote the number of multinational affiliates in group k at time t, then a domestic firm in group k receives a weight:

$$w_{mkt}(\text{dom}) = \frac{N_{kt}(\text{mne})}{N_{kt}(\text{dom})} \times \frac{N(\text{dom})}{N(\text{mne})}. \tag{3}$$

The terms $N(\text{dom})$ and $N(\text{mne})$ measure the number domestic and multinational firm observations in the data. All unmatched firms receive a weight of zero, effectively discarding it from the analysis. Matching provides a non-parametric way of controlling for the potentially confounding influence of firm type and firm size. Coarsened exact matching is an intuitive method that gives full control over the level of remaining covariate imbalance, based on the size of the groupings. The more narrow the group, the lower the level of remaining covariate imbalance. However, if too many observations are discarded by narrowing the groupings too much, inference may be inefficient.

3.4 Results

I now present the estimates of country-by-country cross-tax elasticities using the empirical strategy described in Equation 2. I include a dummy to capture the United Kingdom's change from a residence-based to a source-based corporate tax system. I also include dummies to capture changes in Finland, Greece and Luxembourg's transfer pricing regulations. There are 9.4 million observations in this estimation.

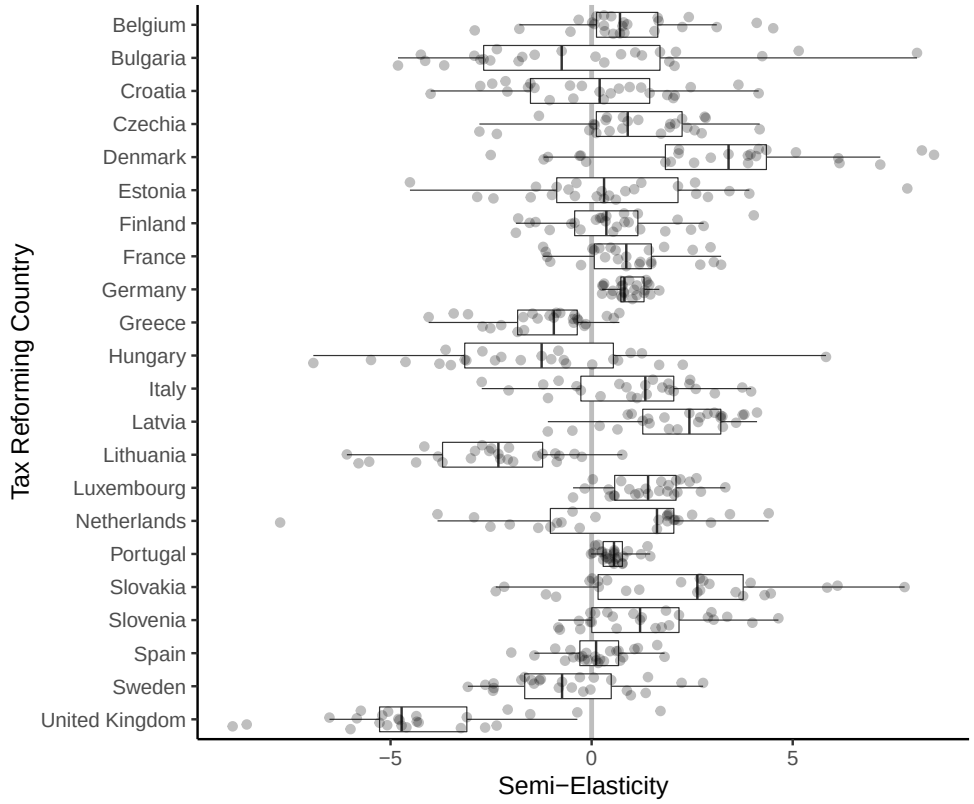
The estimated country-pair elasticities (e_{ij}) are presented graphically in Figure 2, grouped by the country changing its corporate tax rate.[13] Each country's elasticity is interpreted as the

[11] Where domestic firms fall outside of the range of the distribution of multinational firms in their comparison group, they are excluded from the analysis. That is, domestic firms that are smaller than the smallest multinational firm in its comparison group are dropped.

[12] In the Appendix (Figure 8) I present estimates grouping firms at the NACE Section level, the NACE 2-digit level, and the NACE 4-digit level as industry groupings within each country. Groupings at the country level and NACE Section level are broken into size deciles; groupings at the NACE 2-digit level are broken into quintiles; and groupings at the NACE 4-digit level are broken into quartiles.

[13] The full matrix of country-pair cross-tax elasticities is included in the appendix. I also include a range of alternative specifications in the appendix: assuming independence of elasticities; using the log of profits; without coarsened exact matching weights; using different definitions of industry groupings; and using the effective marginal tax rate.

Figure 2: Country-pair cross-tax elasticities by country



Note on Figure 2: This figure plots the estimated elasticities e_{ij} for 425 country pairs in the data using a random effects model. The cross-tax elasticity for a country's tax reform is allowed to vary by firm location, assuming dependence across the elasticities. The middle line of the box marks the median elasticity for each country, while the outer edges of the box mark the 25th and 75th percentiles. The right whisker extends to the largest value no further than 1.5 times the inter-quartile range, while the left whisker extends to the smallest value at most 1.5 times the inter-quartile range.

percentage change in multinational firm profits in neighbouring countries resulting from a one percentage point increase in the named country's corporate tax rate. A coefficient of 1 implies a resulting 1 percent increase in profits, while a coefficient of -1 implies a 1 percent decrease. An increase implies that spillovers are substitutionary, while a decrease implies that spillovers are complementary.

The results show significant heterogeneity in the estimated cross-tax elasticities. This heterogeneity is most distinct for countries such as Estonia or Croatia which have almost the same number of positive elasticities as negative elasticities. With the country-by-country approach, I can observe the heterogeneity for these countries, but a simple average elasticity would likely be close to zero. Some countries generate mainly positive elasticities (such as Denmark or Luxembourg) or mainly negative elasticities (such as Lithuania or the United Kingdom).

Of these 550 cross-tax elasticities, 131 have 90% confidence intervals that do not include zero.[14] This is approximately 24 percent of the elasticities estimated. Of these, 85 are positive and 46 are negative. In total, 355, or 65 percent of the elasticities are positive, implying that cross-tax elasticities are mostly substitutionary. This helps to explain the fact that substitu-

[14]Standard errors are clustered at the multinational group level.

tionary effects are often observed *on average* after aggregating across a wide range of countries.

The heterogeneity in cross-tax elasticities is stark and economically significant. Heterogeneity exists not just across countries, but within countries too. It is clear that a single average elasticity does not provide an informative assessment of the spillover effects of a corporate tax reform. These results highlight the importance of disaggregating cross-tax elasticities before estimating spillover effects. Not only do we find that cross-tax elasticities vary in *magnitude*, but critically, they also vary in *direction*.

There is precedent for this ambiguity, even when estimating aggregate responses. For example, Becker and Riedel (2012) examine the effect of tax changes on firm cross-border investment. They find complementarity in cross-border investment, but substitutionary effects when considering artificial profit shifting.

4 Heterogeneity in theoretical cross-tax elasticities

To help us *understand* this heterogeneity, I present four theories of the multinational firm, each representing a different organisational form. Each organisational form arises to take advantage of some set of country-pair characteristics. In each case, I derive the sign of the expected cross-tax elasticity. Therefore, using the theories of the multinational firm, I provide predictions of what country-pair characteristics are expected to give rise to substitutionary or complementary cross-tax elasticities.

4.1 Horizontal multinationals

A horizontal multinational firm replicates economic activity across countries to avoid trade barriers or transport costs arising from servicing a foreign market (Markusen, 1984; Brainard, 1993; Yeaple, 2003). Horizontal multinational firms arise when there is an opportunity to access a new market. Horizontal multinational firms are more likely to exist when two countries share similar consumption patterns, since multinationals will be searching for markets similar to the ones they have already been successful in (Markusen and Venables, 2000).

To see the expected spillover, consider a multinational with productive capacity in two countries, $f(k_1)$ and $f(k_2)$ respectively, where k is capital and $f'(k) > 0$, $f''(k) < 0$. The firm has capital K, which it allocates between k_1 and k_2. The firm seeks to maximise its global profits, where r is the cost of capital:

$$\max_{k_1,k_2} \quad \Pi^{\text{horizontal}} = \underbrace{(1-\tau_1)(f(k_1)-rk_1)}_{\text{Country 1}} + \underbrace{(1-\tau_2)(f(k_2)-rk_2)}_{\text{Country 2}} \qquad \text{s.t.} \quad k_1 + k_2 = K.$$

Taking first order conditions and using the implicit function theorem, the change in country 2's tax rate gives an optimal response:

$$\frac{dk_1}{d\tau_2} = \frac{-(f'(k_2)-r)}{(1-\tau_1)f''(k_1)+(1-\tau_2)f''(k_2)} > 0. \tag{4}$$

The term $dk_1/d\tau_2$ is positive, so that an increase in the corporate tax rate in country 2 will induce horizontal multinational firms to increase profits in country 1. Horizontal multinational

firms are expected to generate substitutionary spillovers.

Prediction 1 *The more similar are consumption patterns, the more substitutionary are the spillovers.*

4.2 Export-platform multinationals

A more complex organisational form has come to be common in the global landscape: export-platform multinationals (Hanson et al., 2005; Ekholm et al., 2007). Export-platform multinational firms set up affiliates countries not just to serve that domestic market, but also to export to third countries. An export-platform multinational is combines the horizontal multinational with the exporting firm. Low trade costs between a country and large consumer markets are the main reason for export-platform multinationals—what we commonly refer to as market access or market potential. Since export-platform multinationals face similar incentives as horizontal multinational firms, these tax spillovers are expected to be substitutionary as well.

Prediction 2 *The larger the foreign market potential, the more substitutionary are the spillovers.*

4.3 Vertical multinationals

Vertical multinationals arise so that firms can take advantage of differences in factor prices and factor endowments across countries (Helpman, 1984). Vertical multinational firms are more likely to arise, the larger is the difference in factor endowment.

Consider a multinational firm that produces an intermediate good x in country 2 which is needed for production of a final output in country 1. Assume this firm generates positive profits in both countries. The final output production function in country 1 is $y = f_1(x)$, with $f_1'(x) > 0$ and $f_1''(x) < 0$. The intermediate input in country 2 is most efficiently produced at cost $c_2(x)$ with $c_2'(x) > 0$ and $c_2''(x) > 0$. To focus on the movement of real factors, I assume the intermediate input is sold at an arm's length price w from the multinational affiliate in country 2 to the affiliate in country 1, with the price of the final output normalised to 1. The multinational maximises global profit:

$$\max_x \quad \Pi^{\text{vertical}} = \underbrace{(1-\tau_1)(f_1(x) - wx)}_{\text{Country 1}} + \underbrace{(1-\tau_2)(wx - c_2(x))}_{\text{Country 2}}.$$

To maximise global profit the multinational chooses x, which is the *output* in country 2 and the *input* in country 1. Using the implicit function theorem, the effect of a change in country 2's tax rate on profits in country 1 is $\partial\pi_1(x)/\partial\tau_2 = (\partial x/\partial\tau_2)\,(f_1'(x) - w)$. If marginal before-tax profits in country 1 are positive ($f_1'(x) - w > 0$), then the sign of $\partial\pi_1(x)/\partial\tau_2$ depends on the sign of $\partial x/\partial\tau_2$. This can be signed using the implicit function theorem for the first-order condition of the firm:

$$\frac{\partial x}{\partial \tau_2} = \frac{w - c_2'(x)}{(1-\tau_1)f_1''(x) - (1-\tau_2)c_2''(x)}. \tag{5}$$

Since $f_1''(x) < 0$ and $c_2''(x) > 0$, if marginal profit in country 2 is positive ($w - c_2'(x) > 0$), then $\partial x/\partial\tau_2$ is negative. An increase in the tax rate in country 2 reduces the production of the

intermediate good x, so that the firm reduces profit in country 1 in response to a tax increase in country 2.[15] Vertical multinational firms are expected to generate complementary spillovers.

Prediction 3 *The more different are factor endowments, the more complementary are the spillovers.*

4.4 Profit shifting multinationals

Multinational firms can use tax devices to shift profit from high-tax to low-tax jurisdictions without altering the pattern of their real economic activity (Heckemeyer and Overesch, 2017; Beer et al., 2020). Profit shifting is incentivised by large differences in corporate tax rates, or by other policies which allow multinational firms to significantly lower their effective tax burdens.

Consider a multinational firm which generates a fixed amount of real profit in country 1, π_1, but can shift profit across borders. Profit artificially shifted from country 1 to country 2 is denoted q_2 and incurs a cost $z(q_2)$, which is positive and increasing at an increasing rate in the level of profit shifted so that $z(q_2) > 0$, $z'(q_2) > 0$ and $z''(q_2) > 0$.[16] The firm's global profit function is:

$$\max_{q_2} \quad \Pi^{\text{artificial}} = \underbrace{(1-\tau_1)(\pi_1 - q_2) - z(q_2)}_{\text{Country 1}} + \underbrace{(1-\tau_2)(q_2)}_{\text{Country 2}}.$$

Using the implicit function theorem, I find:

$$\frac{dq_2}{d\tau_1} = \frac{1}{z''(q_2)} > 0, \quad \frac{dq_2}{d\tau_2} = -\frac{1}{z''(q_2)} < 0, \tag{6}$$

using $z''(q_2) > 0$. An increase in the tax rate in country 1 is expected to increase artificial profit booked in low-tax countries, while an increase in the tax rate in the low-tax country is expected to increase profit booked in the high-tax country. That is, profit shifting multinational firms are expected to generate substitutionary spillovers.

Prediction 4 *Tax spillovers between low-tax and high-tax countries are expected to be more substitutionary.*

5 Understanding the heterogeneity in cross-tax elasticities

In this section, I test these four predictions about the relationship between cross-tax elasticities and the characteristics of each pair of countries. First, I discuss the data used to take this theory to the data. Second, I present the results of this analysis.

[15] Boehm et al. (2019) find strong evidence that the relationship between imported and domestic inputs is close to the Leontief technology. More specifically, they find that the short-run elasticity of substitution between domestic and imported inputs is close to zero. This model is a simple approximation of their result. I achieve this by assuming that the intermediate input produced in country 2 is the only input the firm needs for production in country 1.

[16] This cost function is standard in the literature, assuming the cost of profit shifting to be the probability of being caught multiplied by the fine imposed if caught (Devereux et al., 2008).

5.1 Data on country-pair characteristics

To capture the cross-country patterns described in the theoretical section, I use aggregate data for the period 2006 to 2018 where available. Since these elasticities are for the entire period, I take an average of the entire period for the aggregate data.[17]

To measure the similarity in consumption patterns I use data on the final consumption expenditure of households by consumption purpose. I use two separate measures. First, I use the log absolute difference in total consumption measured in millions of current euros. This measures the overall level of consumption, assuming that countries at similar levels of consumption consume similar types of commodities. Second, I use the share of total consumption accounted for by each of 47 consumption categories. I simplify this to a single measure by finding the Euclidean distance between each pair of countries' vectors of consumption shares. I take the log of this Euclidean distance. This captures similarity of consumption patterns directly, by identifying what share is spent on each type of commodity, even if the overall level of consumption is very different across the two countries.

To measure the size of foreign market access, I use the Head and Mayer (2004) measure of foreign market potential. It builds on work by Redding and Venables (2004) to derive a measure of the export demand that a country faces given its trade relationship with its neighbours and the market potential of those neighbours. This measure adjusts the aggregate expenditure of each country's neighbours by the freeness of trade with that country. A description of the data used is provided by Head and Mayer (2011), and I use data for 2003 in the following estimation.

To measure the difference in factor endowments, I use a measure of labour skill endowments, since labour is the main location-specific factor endowment in each country (Yeaple, 2003). To proxy labour skill endowment, I use the share of active workers who have a tertiary education or are employed in science and technology. I take the absolute difference between these shares for each pair of countries.

To measure the difference in corporate income tax rates, I use the average top statutory corporate tax rate from 2006 to 2018. I include dummy variables for whether each country in the pair is considered a tax haven. Tax havens are defined as the five countries on the European Parliament (2019) list which are in my dataset: Belgium, Hungary, Ireland, Luxembourg, and The Netherlands.

5.2 Testing the theoretical predictions

These results require care in their interpretation: a positive coefficient can be either described as more substitutionary or less complementary. To discipline our thinking, these observed results will be interpreted in the context of the theoretical predictions in Section 4. The results of four specifications are presented in Table 1. To give greater emphasis to more precisely estimated elasticities, the estimates in columns two and four are weighted by the value of the t-statistic originally calculated for each estimated elasticity. In the final two specifications I include additional control variables: the log of GDP of both countries, and dummy variables indicating whether the countries are part of the Euro area.

[17] Aggregate data are obtained from Eurostat, with the exception of foreign market potential, which is provided by CEPII.

Table 1: Meta-Regression on Country-Pair Semi-Elasticities

	Dependent variable:			
	Cross-tax elasticity (e_{ij})			
	(1)	(2)	(3)	(4)
Absolute difference in education/sci-tech	-0.018	-0.072^{***}	-0.035^{*}	-0.076^{***}
	(0.019)	(0.026)	(0.018)	(0.023)
Log absolute difference in aggregate consumption	-0.298^{***}	-0.757^{***}	-0.084	-0.261^{**}
	(0.064)	(0.089)	(0.081)	(0.103)
Log absolute difference in consumption patterns	-0.768^{**}	-1.003^{**}	-1.124^{***}	-1.634^{***}
	(0.340)	(0.462)	(0.327)	(0.418)
Is tax haven (reform country)	-1.553^{***}	-2.933^{***}	-2.509^{***}	-4.890^{***}
	(0.363)	(0.463)	(0.361)	(0.436)
Is tax haven (affected country)	0.026	0.086	0.148	0.163
	(0.339)	(0.465)	(0.334)	(0.431)
Reform country tax minus affected country tax	0.020	0.046^{**}	0.063^{***}	0.148^{***}
	(0.013)	(0.019)	(0.018)	(0.023)
Log of foreign market potential (reform country)	0.896^{***}	1.569^{***}	1.353^{***}	2.386^{***}
	(0.178)	(0.246)	(0.178)	(0.228)
Log of foreign market potential (affected country)	-0.240	-0.282	-0.303^{*}	-0.427^{*}
	(0.174)	(0.246)	(0.175)	(0.228)
Log of GDP (reform country)			-0.752^{***}	-1.475^{***}
			(0.109)	(0.130)
Log of GDP (affected country)			0.118	0.307^{**}
			(0.106)	(0.130)
Euro area member (reform country)			0.094	0.580^{**}
			(0.224)	(0.285)
Euro area member (affected country)			0.544^{**}	0.410
			(0.227)	(0.282)
Constant	-4.257	-7.373	-4.577	-8.268^{*}
	(3.779)	(5.458)	(3.556)	(4.771)
Weighted		Yes		Yes
Observations	550	550	550	550
R^2	0.115	0.229	0.224	0.416

Note on Table 1: The dependent variable in this model is the set of semi-elasticities estimated in Figure 2. Estimates are weighted by the value of the t-statistic of the estimated elasticity. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

First, I find that a smaller absolute difference in consumption levels and in consumption patterns implies a more positive value of the cross-tax elasticity. This matches Prediction 1: countries with more similar consumption patterns are more likely to play host to horizontal multinationals, which are expected to generate substitutionary spillovers.

Second, the greater the market potential in the country changing its tax rate, the more substitutionary is the spillover. This suggests that a country with greater market access attracts profit away from its neighbours when it lowers its tax rate. This aligns with the theory of export-platform multinationals as in Prediction 2. As a bonus, I find that the larger is the country whose profits are being affected, the less substitutionary is the spillover.

Third, I observe that the greater is the difference in skill endowments between two countries, the more complementary is the spillover. This matches Prediction 3: the more different are factor endowments, the more likely spillovers are to be complementary due to the presence of vertical multinational firms.

Fourth, I find evidence which suggests our simplistic approach to low-tax countries and profit shifting might be an inappropriate way to understand the tax base spillovers they cause. I find

two patterns which invalidate Prediction 4. First, being exposed to a reform from a tax haven country actually induces a more *complementary* spillover than for a non-haven country. Second, the more negative is the difference in the corporate tax rate (reform country minus affected country), the more *complementary* is the spillover. That is, if a low-tax country is the one changing its tax rate, we expect the spillover to be more complementary than if a high-tax country is changing its tax rate. This evidence suggests that low-tax countries (or tax havens) might actually reduce the distortionary effect of the corporate tax, thereby increasing the firm's ability to invest in non-haven countries—as per the 'positive view' of havens (Dharmapala, 2008). This finding is backed by recent evidence from Suárez Serrato (2018), Schwab and Todtenhaupt (2019) and Albertus (2019) who find that access to tax havens allows multinational firms to reduce their cost of capital or their average tax burden, and therefore increase economic activity in non-haven countries. A more in-depth theory of profit shifting would help us to rationalise this finding (Desai et al., 2006; Johannesen, 2010; Hong and Smart, 2010; Klemm and Liu, 2019). For example, Suárez Serrato (2018) shows that the multinational firm's user cost of capital in the non-haven country is lowered by the marginal benefit from profit shifting. This marginal benefit is the difference in the tax rates between the non-haven and tax haven countries. As Hines Jr and Rice (1994) point out, this might make investments profitable that were previously unprofitable.

The evidence shows us that the observed heterogeneity in cross-tax elasticities is not entirely random. Rather, country characteristics create incentives which shape the nature of multinational firms' optimal decisions in the face of a tax reform. The theory of the multinational firm helps us to put some structure on the way in which cross-tax elasticities vary across country-pairs. To summarise these results: I find more similar consumption patterns give more substitutionary spillovers; less similar labour endowments give more complementary spillovers; tax cuts in tax havens or low-tax countries generate complementarities for their neighbours; tax cuts in non-havens may shift profits away from tax havens; larger foreign market potential makes spillovers more substitutionary for the reform country, but less substitutionary for the affected country.[18]

6 Conclusion

This paper provides new evidence on the heterogeneity of tax base spillovers. I find country-by-country cross-tax semi-elasticities ranging from -8.9 to +8.5 at the intensive margin between European countries. This heterogeneity is supported by economic theory, and suggests that cross-tax elasticities might fall along a continuum determined by the nature of the relationship between each pair of countries. Country pairs with more similar consumption patterns have more substitutionary spillovers; a country with larger foreign market potential generates larger substitutionary spillovers; country pairs with more dissimilar labour skill endowments have more complementary spillovers; and tax reforms by tax havens generate more complementary spillovers. These results suggest that tax base spillovers are heterogeneous, and equips us with some idea of how to predict that heterogeneity.

[18] Similar results are found when reestimating the elasticities using effective marginal tax rates and reestimating the meta-regression. Results are included in the appendix.

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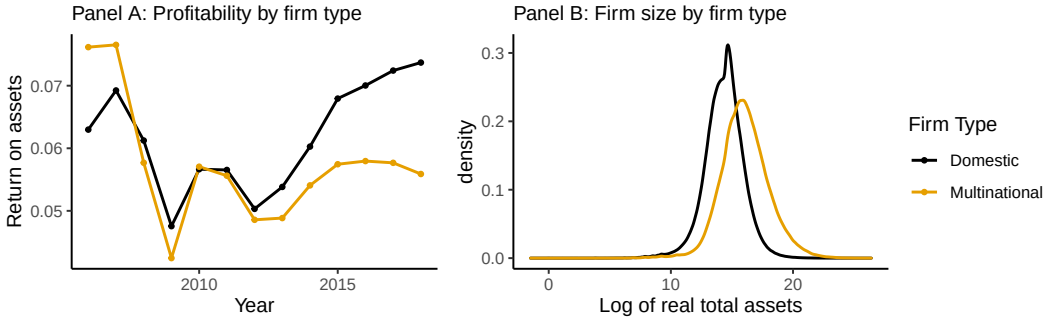
Appendix

Table 2: Number of firms in each country by type

	Number of firms			
Country	Domestic	Multinational	Total	% Multinational
Austria	4,724	4,172	8,896	46.90
Belgium	43,608	9,553	53,161	17.97
Bulgaria	29,695	2,036	31,731	6.42
Czechia	29,441	6,176	35,617	17.34
Germany	53,853	14,454	68,307	21.16
Denmark	23,584	5,505	29,089	18.92
Estonia	8,646	1,750	10,396	16.83
Spain	177,739	15,663	193,402	8.10
Finland	23,028	3,807	26,835	14.19
France	147,333	29,989	177,322	16.91
United Kingdom	55,936	29,241	85,177	34.33
Greece	13,411	946	14,357	6.59
Croatia	12,299	1,513	13,812	10.95
Hungary	34,966	2,507	37,473	6.69
Ireland	5,036	3,932	8,968	43.84
Italy	249,897	18,545	268,442	6.91
Lithuania	6,057	968	7,025	13.78
Luxembourg	4,550	4,655	9,205	50.57
Latvia	8,335	1,190	9,525	12.49
Netherlands	5,815	4,207	10,022	41.98
Poland	60,464	9,559	70,023	13.65
Portugal	45,930	4,774	50,704	9.42
Romania	41,618	4,759	46,377	10.26
Sweden	56,831	12,218	69,049	17.69
Slovenia	9,623	1,290	10,913	11.82
Slovakia	17,945	3,185	21,130	15.07

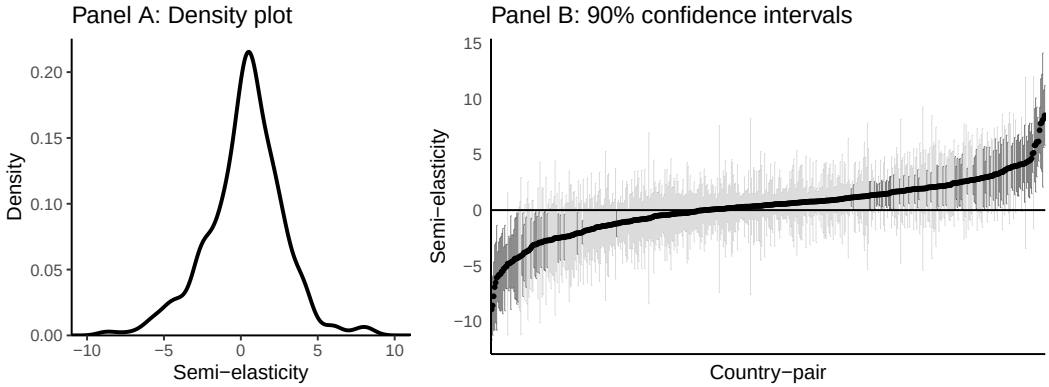
Note on Table 2: This table presents the number of unique firms located in each country of each type—domestic only or multintional affiliate. This is taken from the sample of financial data in the Amadeus dataset, where multinational firms are defined as corporations with an ultimate owner who is also the ultimate owner of affiliates located in other countries.

Figure 3: Comparing the characteristics of multinational and domestic firms



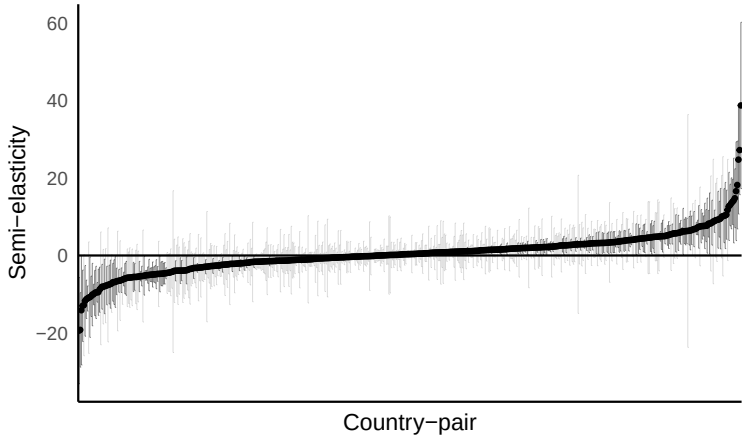
Note on Figure 3: Panel A plots the average return on assets by firm type from 2006 to 2018 in the Amadeus database. Panel B plots the kernel density distribution of real total assets by firm type over the entire database. Variation in average real total assets over time is insignificant.

Figure 4: Summary of country-pair elasticities



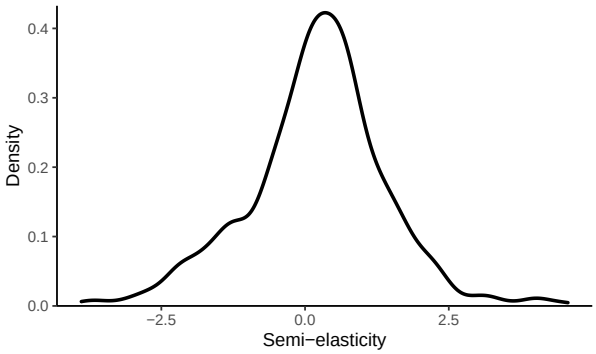
Note on Figure 4: The estimated elasticities presented in this figure are from the baseline model in Section **??**. Panel A plots the distribution of the estimated country-pair semi-elasticities. Panel B plots the estimated semi-elasticities for each country pair as black dots, with the estimated 90% confidence intervals represented as vertical lines. Intervals that do not include zero are in bold.

Figure 5: Country-pair elasticities estimated as independent coefficients



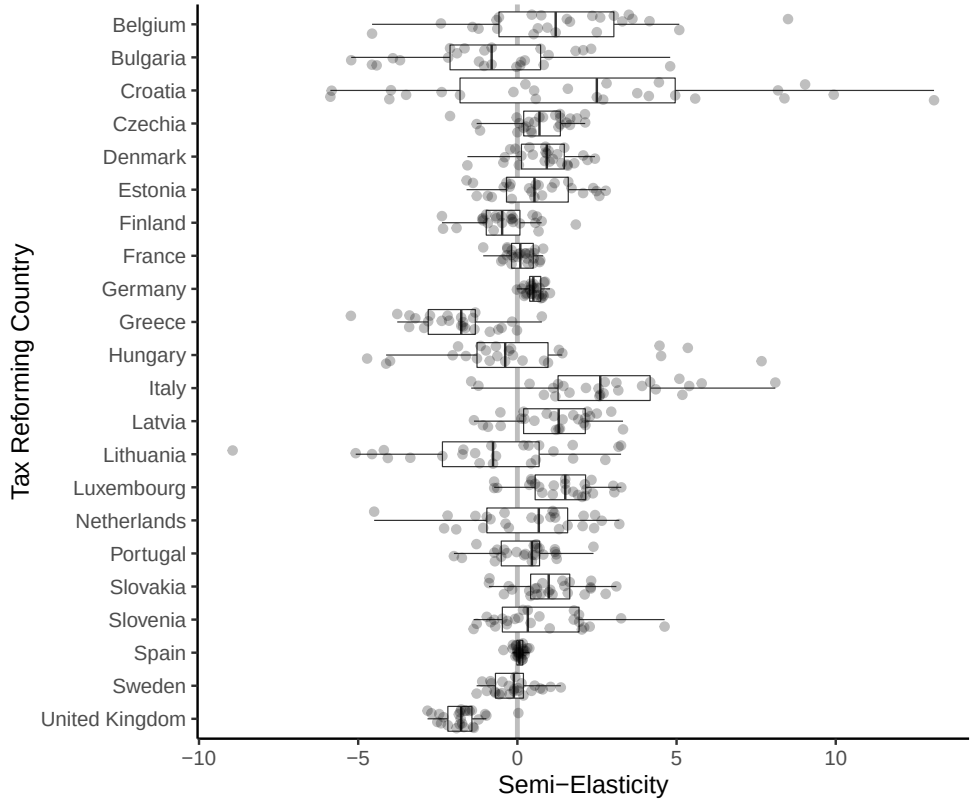
Note on Figure 5: This figure re-estimates the main model assuming all country-pair elasticities to be independent. The model includes NACE 2-digit-size-year fixed effects, and are reweighted using coarsened exact matching weights. This figure plots the estimated semi-elasticities for each country pair as black dots, with the 90% confidence intervals represented as vertical lines. Intervals that do no include zero are in bold. The estimated elasticities are larger than assuming coefficients are drawn from a random distribution.

Figure 6: Distribution of country-pair elasticities using log profits as dependent variable



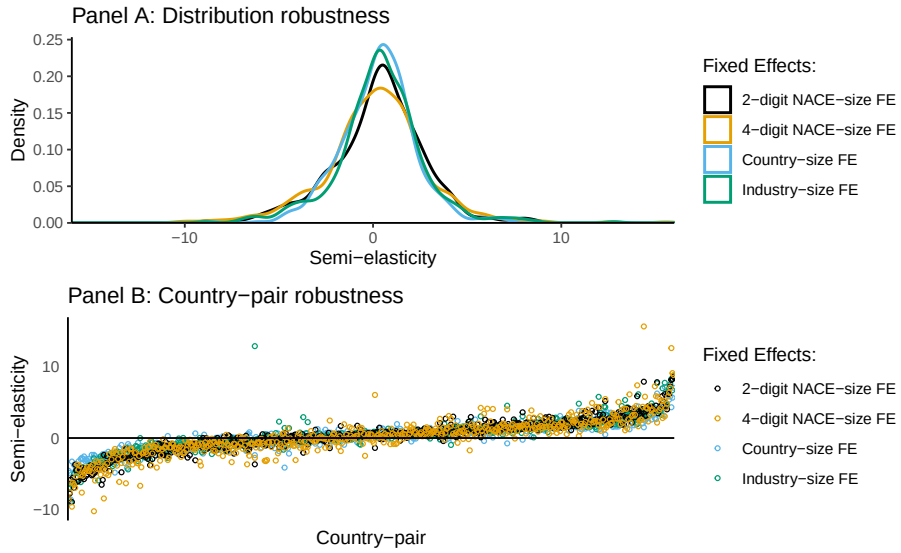
Note on Figure 6: This figure shows the density distribution of cross-tax elasticities when estimated using the log of profits truncated at zero plus one. The model includes NACE 2-digit-size-year fixed effects, and are reweighted using coarsened exact matching weights. These estimates are much smaller: the range of elasticities is -3.8 to +4.6, compared to -8.9 to +8.5 for the main model. The median estimate is also significantly smaller: 0.27 compared to 0.47 in the main model.

Figure 7: Cross-tax elasticities for EMTR



Note on Figure 7: This figure shows how cross-tax elasticities vary using the effective marginal tax rate rather than the statutory tax rate. This incorporate changes to both the tax rate and the tax base. There is greater variation in this tax rate, meaning there are more countries reflected here and more elasticities—650 compared to 550. Importantly, the patterns of cross-tax elasticities remain essentially the same compared to the central estimates using the statutory corporate tax rate.

Figure 8: Summary of country-pair elasticities



Note on Figure 8: This panel extends the estimated semi-elasticities to four types of year fixed effects based on different industry groupings. Panel A plots the distribution of the estimated country-pair semi-elasticities for each level of year fixed effects. Panel B plots the estimated semi-elasticities for each country pair for each level of year fixed effects. Panel A shows that there is no significant difference in the distributions. Panel B shows the estimates are robust for each country pair. The 2-digit-NACE-size fixed effects are the most similar to the other estimates, with an average Euclidian distance of 29.3, compared to 32.8, 32.1, and 37.3 for the country-, industry-, and 4-digit-NACE-size fixed effects respectively. The 2-digit-NACE-size fixed effects also has the largest number of 90% confidence intervals that do not include zero: 129 compared to 108,102, and 103 for the country-, industry-, and 4-digit-NACE-size fixed effects respectively.

Table 3: Meta-Regression on Country-Pair Semi-Elasticities using EMTRs

	Dependent variable:			
	Cross-tax elasticity (e_{ij})			
	(1)	(2)	(3)	(4)
Absolute difference in education/sci-tech	0.040	0.062*	0.036	0.065*
	(0.029)	(0.038)	(0.029)	(0.037)
Log absolute difference in aggregate consumption	−0.265***	−0.753***	−0.121	−0.397**
	(0.100)	(0.130)	(0.130)	(0.161)
Log absolute difference in consumption patterns	−0.411	−1.629**	−0.432	−1.882***
	(0.505)	(0.654)	(0.506)	(0.663)
Is tax haven (reform country)	−0.423	−0.855	−1.027*	−2.231***
	(0.522)	(0.708)	(0.540)	(0.745)
Is tax haven (affected country)	0.434	1.268*	0.632	1.320*
	(0.522)	(0.685)	(0.540)	(0.715)
Reform country tax minus affected country tax	0.054***	0.119***	0.080***	0.201***
	(0.020)	(0.026)	(0.026)	(0.035)
Log of foreign market potential (reform country)	0.792***	1.212***	1.137***	1.755***
	(0.267)	(0.361)	(0.281)	(0.372)
Log of foreign market potential (affected country)	−0.433	−0.810**	−0.507*	−0.835**
	(0.267)	(0.348)	(0.281)	(0.363)
Log of GDP (reform country)			−0.587***	−1.150***
			(0.170)	(0.212)
Log of GDP (affected country)			0.127	0.266
			(0.170)	(0.209)
Euro area member (reform country)			−0.108	0.485
			(0.360)	(0.473)
Euro area member (affected country)			0.201	−0.129
			(0.360)	(0.471)
Constant	−1.243	6.753	−1.423	5.967
	(5.725)	(8.003)	(5.672)	(7.849)
Weighted		Yes		Yes
Observations	650	650	650	650
R^2	0.073	0.169	0.097	0.212

Note on Table 3: The dependent variable in this model is the set of semi-elasticities estimated using the effective marginal tax rate. Estimates are weighted by the value of the t-statistic of the estimated elasticity. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 4: Matrix of country-pair semi-elasticities (tax reform country as rows)

	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK
BE	0.33	0.88	2.42	-0.32	0.31	0.82	0.01	1.57	1.67	0.54	0.07	4.51	0.12	-2.91	3.11	0.31	0.70	0.49	2.25	-1.80	0.80	0.77	4.11	0.89	1.64	-0.52
BG	-2.52	-2.76	-0.28	2.10	-1.81	-0.74	0.10	-4.25	5.15	0.73	-2.68	1.25	-2.92	2.06	-3.67	-1.72	0.32	-4.14	4.24	-4.82	1.08	1.70	8.09	-2.35	1.93	-1.42
CZ	2.25	-2.79	0.12	1.04	-1.31	1.96	0.77	2.74	1.16	-0.06	0.08	2.56	4.18	2.84	0.35	1.94	2.08	0.38	0.78	-2.36	0.90	1.73	2.38	0.05	2.81	0.45
DE	0.31	0.77	1.36	1.39	0.91	1.12	0.73	0.50	0.29	1.13	0.75	0.81	1.33	0.73	1.46	0.53	1.01	1.06	0.76	0.81	0.27	1.43	1.68	0.26	1.30	0.94
DK	1.83	2.16	3.95	3.89	-1.09	3.09	3.40	5.08	4.35	-0.14	1.97	8.21	8.51	3.89	-2.51	4.16	-0.30	2.55	2.96	-1.19	6.16	4.09	7.18	-0.27	2.17	6.13
EE	3.92	-2.44	-0.57	-0.99	1.06	-0.38	0.57	0.31	0.25	-4.52	0.60	-1.51	2.57	0.43	7.85	-0.41	1.24	2.60	-1.38	0.13	2.15	-0.87	2.89	0.84	3.43	-2.85
ES	-0.23	0.09	0.16	1.63	1.81	0.46	0.71	0.12	0.11	-2.00	1.15	-0.91	-0.66	-0.46	0.67	0.78	-0.52	-1.42	0.21	-0.17	1.06	-0.13	-0.29	0.31	0.62	-0.09
FI	-0.28	0.54	-1.39	-1.88	-0.50	1.83	-0.42	-1.54	0.47	1.21	0.25	0.92	-1.04	2.14	2.79	0.11	0.35	1.15	0.63	4.03	0.81	-1.83	0.21	2.47	0.82	0.37
FR	-1.14	0.34	0.07	2.70	-1.03	0.19	1.48	0.86	0.02	0.89	0.60	3.22	0.47	1.18	-0.26	1.49	1.22	-1.11	1.80	0.66	1.42	2.96	2.51	-1.21	0.86	3.04
GB	-0.35	-4.61	-6.52	-4.81	-5.27	-3.25	-4.36	-5.08	-3.10	-2.09	-4.31	-5.74	-5.21	-5.84	-1.53	-5.06	-4.72	-2.36	-4.35	1.71	-6.00	-8.58	-8.93	-4.78	-4.30	-2.65
GR	-0.46	-1.34	-0.33	-1.84	-1.47	-2.25	-0.88	-0.18	-1.70	-1.68	-4.05	-1.22	-2.52	-0.14	-3.43	-0.78	0.69	-0.44	0.38	-3.07	0.55	-0.42	-0.94	-0.36	-1.04	-2.71
HR	-2.09	0.68	0.47	-2.77	-1.42	-0.24	-1.58	-2.14	-1.04	-2.47	0.95	2.07	0.05	3.65	1.88	4.15	0.20	-4.00	-0.45	2.46	0.30	-1.52	2.03	-0.54	1.23	1.44
HU	-2.40	-0.69	-5.49	-1.00	-0.64	-2.71	-3.63	-1.24	1.68	0.97	-3.11	-2.25	-6.92	-1.38	5.83	0.01	0.66	-3.50	-0.82	-3.78	-4.63	0.54	2.27	1.25	-3.16	-1.76
IT	-2.73	-1.20	0.87	1.91	-0.27	3.06	2.59	1.52	-2.06	0.99	1.13	1.33	2.04	-0.37	3.97	1.02	1.94	2.43	0.69	2.45	-0.82	1.76	0.22	-1.08	1.37	3.75
LT	-6.09	-3.82	-3.00	0.76	-5.53	-1.22	-2.06	-4.36	-0.24	-5.79	-2.72	-1.95	-4.16	-2.32	-3.71	-0.42	-2.51	-2.49	-2.09	-0.90	-0.87	-0.80	-2.27	-2.55	-2.90	-1.35
LU	1.09	2.61	2.13	1.73	0.45	3.33	2.10	0.55	-0.17	0.42	1.92	2.21	0.73	-0.46	0.03	1.40	1.68	1.40	2.72	1.35	1.17	2.05	2.44	1.88	0.94	0.57
LV	1.00	3.59	4.11	0.90	1.41	1.92	3.05	3.21	-1.09	1.44	3.26	3.21	3.25	0.64	2.13	2.65	3.76	2.70	2.12	2.43	1.81	3.80	2.88	-0.48	1.27	0.20
NL	3.44	-0.75	4.40	1.62	-0.47	-7.75	1.67	-0.86	-2.03	-1.33	-0.30	2.04	1.89	1.89	0.10	1.88	2.97	2.16	2.07	0.27	2.50	-1.03	-3.83	1.93	-2.52	-2.92
PT	0.26	-0.02	0.44	0.35	0.41	0.56	0.76	1.39	0.38	0.79	0.09	1.23	0.60	0.77	0.16	1.46	0.57	0.66	0.53	0.25	0.90	0.56	0.56	0.29	0.56	0.04
SE	-0.49	0.06	-1.49	1.35	-1.43	0.88	-1.66	-0.73	2.24	-0.29	1.40	-3.08	-2.64	-1.75	2.77	-1.26	0.98	-0.03	-2.45	0.49	-2.43	-2.44	-1.30	-0.57	-0.21	-0.81
SI	3.37	0.09	1.25	3.04	-0.03	2.17	0.39	-0.83	1.74	-0.28	1.85	-0.04	1.93	4.64	1.04	-0.79	0.52	-0.32	0.00	2.98	2.89	1.21	0.62	4.00	1.32	1.59
SK	0.16	-0.88	7.78	4.30	-0.05	0.39	2.63	1.18	2.69	0.18	0.01	3.58	3.95	2.70	-2.17	-1.14	3.77	-2.38	2.78	4.46	2.23	0.86	6.12	2.93	5.86	2.08