Quantifying heterogeneous corporate tax base spillovers in Europe

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Abstract

Corporate tax base spillovers describe how one country's tax cut impacts other countries' tax bases. In this paper I quantify the size of corporate tax base spillovers which occur through multinational firms' intensive margin responses for 550 country-pairs in Europe. Both the cross-tax semi-elasticity of profit and the share of the tax base exposed to spillovers are very heterogeneous across country pairs. A corporate tax cut can either *increase* or *decrease* a neighbouring country's corporate tax base. Quantitatively, I find that a simultaneous 1 percentage point reduction in all neighbours' tax rates can change a country's corporate tax revenue between −7% and +3%. Conversely, a one percentage point reduction in one country's tax rate might be expected to change its neighbours' corporate tax revenue anywhere between −0.25% and +1%.

JEL: H32; H25; F23

Keywords: corporate tax; tax base spillovers; cross-tax elasticities; heterogeneity

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1 Introduction

Corporate tax reform does not take place in a vacuum. Rather, one country's corporate tax reform might affect another country's tax base—a phenomenon described as a corporate tax base spillover. Tax base spillovers are a source of contention in the international corporate tax system. Governments recognize how deeply intertwined the system is, and respond to tax base spillovers with their own tax reforms. Tax base spillovers influence our views about the optimal design of the international corporate tax system. 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.

In this paper I quantify corporate tax base spillovers for 550 country pairs in Europe. Spillovers are measured as the percentage change in one country's tax base resulting from another country's corporate tax cut. To measure the total tax base spillover, I estimate two parameters for each of the 550 country pairs. First, I measure the portion of the tax base in the affected country that is directly exposed to the tax reforming country: the cross-country tax base, B. Second, I measure the responsiveness of that portion of the tax base to the tax reform: the cross-tax semi-elasticity of taxable income, e. Spillovers between two countries i and j are measured by the product of these two parameters: $B_{ij} \times e_{ij}$.

The multinational firm is the main mechanism through which spillovers operate.[1] To estimate cross-tax elasticities, I use firm-level data on multinational affiliates with domestic firms as the comparison group. Both cross-tax elasticities and cross-country tax bases are very heterogeneous across country pairs. My preferred 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 rate cut in another country. The estimated shares of the tax base exposed between country pairs range from 0% to 73%. Using these estimates to quantify corporate tax base spillovers, I show that they are very heterogeneous across country-pairs and even when aggregated to the country level. Depending on the country, a one percentage point reduction all neighbouring countries' tax rates can *decrease* or *increase* corporate tax revenue anywhere from -7% to $+3\%$. Put another way, a country that cuts its corporate tax rate by one percentage point might *decrease* or *increase* its neighbours' corporate tax revenue anywhere from -0.25% to $+1\%$.

Theory predicts this heterogeneity: intensive margin responses of multinational firms to tax changes can either be substitutionary or complementary depending on their organisation as horizontal, vertical or profit-shifting multinationals. Each of these organisational forms are incentivised by the underlying characteristics of each pair of countries. I show that these relative characteristics are able to partially explain the observed heterogeneity in cross-tax elasticities. First, countries with more similar consumption patterns have more substitutionary spillovers. Second, countries with more dissimilar labour skill endowments have more complementary spillovers. Third, while differences in corporate tax rates explain very little of this

[1] I measure spillovers at the intensive margin as this margin is directly observable. The reader might think of these as direct spillovers.

heterogeneity, tax reforms by tax havens generate more complementary spillovers.

The United States' high profile Tax Cuts and Jobs Act of 2017 sparked a debate on its expected spillover effects. Beer et al. (2018a) examine three types of spillovers from this tax reform: artificial spillovers, real spillovers, and policy spillovers. Artificial and real spillovers are forms of tax base spillovers, while policy spillovers are the resulting policy responses. These authors use a single homogeneous elasticity for all neighbouring countries, effectively assuming that all spillovers are substitutionary. In contrast, Boumans et al. (2019) survey German firms about their behavioural responses to the Tax Cuts and Jobs Act. Only a few firms surveyed derive at least 5% of their revenue from the United States. Of these, only 18% expect a change in the tax burden in the short run—with an increase to 25% in the long run. Only 14% intend to increase investment in the U.S., while 6% intend to reduce investment in the U.S. Further, only 26% of those firms who plan to increase investment in the United States will counterbalance that with a reduction in investment in Germany. The heterogeneity in their intended behavioural responses is striking, and makes clear the importance of accounting for such heterogeneity in calculating spillover effects.

This paper is related to a wide range of papers that measure various forms of fiscal spillover effects. The most well-known of this literature is the large number of papers which measure the impact of a home country tax change on the inflow of direct investment (reviewed in De Mooij and Ederveen, 2003, 2008 and Feld and Heckemeyer, 2011). This paper is also similar to works by Becker and Riedel (2012); Becker et al. (2012) and Davies et al. (2016) who examine the effects of tax changes on cross-border investment and profitability. This paper is also related to the line of literature begun by Feldstein (1995), who suggests that home and foreign investment are substitutes, and Desai et al. (2005), who suggests that they are complements. Using firm-level data, Goldbach et al. (2019) finds that home and foreign investment are complementary both at the intensive and extensive margin, in part due to opportunities for tax planning. Following the conceptual frameworks of Hines Jr and Rice (1994) and Huizinga and Laeven (2008), a number of works measure artificial profit spillovers as a function of tax differentials between affiliates (Heckemeyer and Overesch, 2017 and Beer et al., 2018b review this literature). A number of papers examine other margins of cross-border responses to taxation (reviewed in part by Riedel, 2018). Other papers examine cross-tax elasticities of various bases: Griffith et al. (2014) for the location of ownership of intellectual property; and Arulampalam et al. (2019) for the location of merger and acquisition targets. Egger et al. (2010b,a) pioneer the approach of matching foreign-owned affiliates to domestic firms—an approach recently exploited by Bilicka (2019) and which I use in this paper. This paper has a similar aim to works which estimate tax base spillovers using aggregate data, such as Crivelli et al. (2016) and IMF (2014). In a similar vein, Baker and Murphy (2019, 2021) propose a qualitative framework for assessing spillovers.

The most important contribution of this paper is explicitly examining heterogeneity in tax base spillovers. Assuming a single homogeneous cross-tax elasticity misleads us about how specific countries are affected and therefore about the aggregate effects of corporate tax reforms. I show that not only are tax base spillovers heterogeneous at the country-pair level, but also that this results in *aggregate* spillovers which can either be substitutionary or complementary. This finding challenges our prior beliefs about the corporate tax's international effects and has implications for our views of tax competition and of the optimal design of the international corporate tax system. The second contribution this paper makes to the literature is providing a clear and simple framework for measuring corporate tax base spillovers at the intensive margin. This framework provides governments with an approach to measuring the effects their tax reforms will have on neighbours. The third contribution this paper makes is that it advances our understanding of corporate tax base spillovers by providing a theoretical justification for this heterogeneity.

This paper is organised as follows. In Section 2, I present a measurement framework for corporate tax base spillovers. In Section 3, I provide three models of intensive margin spillovers that predict ambiguous fiscal spillovers. In Section 4, I describe the main dataset I use in this paper. Section 5 outlines my empirical strategy—including the use of the inverse hyperbolic sine to capture the full response of multinational firms. I provide the results of estimating country-specific and country-pair elasticities in Section 6. In Section 7, I use the theoretical predictions to help interpret the heterogeneity in elasticities. In Section 8, I estimate the country-pair corporate tax base of interest, and provide aggregate estimates of the size of corporate tax base spillovers in Europe. I conclude in Section 9.

2 Measurement Framework

In this section, I draw inspiration from Devereux et al. (2014) to provide a framework for measuring the welfare effects of tax reforms. To see how corporate tax base spillovers can be measured, consider a price-taking multinational firm that operates across countries $i = 1, \ldots, n$. Where corporate tax systems mainly operate under the source-based principle, the profits generated in country i are taxed in country i. This multinational firm chooses output in each country $\{y_1, ...y_n\}$ given tax rates $\{\tau_1, ..., \tau_n\}$, so as to maximise global profits:

$$\Pi = \sum_{i=1}^{n} y_i - c(y_i) - \tau_i[y_i - \alpha_i c(y_i)].$$

A firm's net profit in country i is revenue y_i minus the cost of production $c(y_i)$ and the corporate tax payable $\tau_i B_i$ to government i, where $B_i = y_i - \alpha_i c(y_i)$ is taxable income. I define global welfare narrowly as the sum of the multinational's global profits and all governments' tax revenues: $W = \Pi + \sum_{i=1}^{n} \tau_i B_i$. Consider the impact of a small change in country i's corporate tax rate on global welfare. Invoking the envelope theorem over the multinational firm's optimising behaviour:

$$\frac{dW}{d\tau_i} = \tau_i B_i e_{ii} + \sum_{j \neq i}^{N} \tau_j B_j e_{ij}, \tag{1}$$

where

$$e_{ij} = \frac{\partial B_j}{\partial \tau_i} \frac{1}{B_j}.$$

This elasticity e_{ij} is the main parameter of interest: it is the semi-elasticity of taxable income in country j with respect to the tax rate in country i. I describe this as the cross-tax elasticity. Where $j = i$, this is the common own-tax elasticity—estimated by Gruber and Rauh (2007), Dwenger and Steiner (2012), Devereux et al. (2014) and Coles et al. (2019) for different individual countries. Therefore the first term in equation 1 is the change in country' i's welfare resulting from its own corporate tax reform.

To isolate spillover effects, I focus on the second term in equation 1, which is the sum of cross-tax effects. Spillover effects are measured by the revenue $\tau_j B_j$ generated by multinational firms and the cross-tax elasticity. A critical proposition of this paper is that the tax base affected at the intensive margin by country i's tax rate change is only the portion of country j's tax base that is associated directly with economic activity in country i through the multinational group network. I can therefore more correctly write this tax base as B_{ij}. The aggregate spillover effects from country i's corporate tax reform on its neighbours it measured as:

$$\frac{dW_J}{d\tau_i} = \sum_{j \neq i}^{N} \tau_j B_{ij} e_{ij}.$$

For each country pair I estimate e_{ij} and B_{ij} to quantify the aggregate spillover effect dW_J for each country i's tax reform.

3 Multinational Intensive Margin Responses

There are two main ways in which multinational firms organise themselves across countries: horizontally and vertically. Horizontal multinational firms are so called because they duplicate economic activity across similar countries to gain market access while limiting trade costs. Vertical multinational firms are so called because they split their production processes across countries to take advantage of factor price differentials. There are two further ways in which intensive margin responses might be delineated: real responses and artificial responses. Real responses are changes in profit that result from changes in factors of production and in output. Artificial responses are changes in profit that do not result from changes in factors of production or in output, but that alter the location of profits to minimise the multinational firm's global tax liability. In this section, I present simple models of the spillovers that result from each of these organisational forms: real horizontal spillovers, real vertical spillovers, and artificial spillovers. The aim is to provide some guidance as to what e_{ij} might look like, given that the elasticity will be some combination of these three firm-level responses.

3.1 Horizontal multinationals

Consider a horizontal multinational firm of the standard type described by Markusen (1984), which replicates economic activity across countries to avoid trade barriers or transport costs arising from servicing a foreign market (Brainard, 1993). The multinational has productive capacity in two countries, neither of which might be the headquarter country. Output in country 1 is determined by the production function $f(k_1)$ and similarly $f(k_2)$ for country 2, where k is capital. The firm's production functions carry the standard assumption that $f'(k) > 0$ and $f''(k) < 0$. Production in countries 1 and 2 are linked by the firm's limited availability of total capital K, which it allocates between k_1 and k_2. The firm seeks to maximise its global profits by solving the problem:

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

This gives the optimality condition that the multinational should equalise net of tax marginal profit across the two countries: $(1-\tau_1)(f'(k_1)-r) = (1-\tau_2)(f'(k_2)-r)$. Using the implicit function theorem, I examine the effect of a change in the tax rate in country 2 on the optimal allocation of profits in country 1:

$$\frac{dk_1}{d\tau_2} = \frac{-(f'(k_2)-r)}{(1-\tau_1)f''(k_1)+(1-\tau_2)f''(k_2)} > 0. \tag{2}$$

The term $dk_1/d\tau_2$ is positive. If profits are increasing in capital, an increase in the corporate tax rate in one country will induce horizontal multinational firms to increase profits in affiliate countries. Horizontal firms' response to tax reform is therefore substitutionary. An increase in country 2's tax rate leads the multinational firm to substitute activity away from country 2 towards country 1. This is the standard substitutionary spillover that underpins the theory of tax competition (Keen and Konrad, 2014).

3.2 Vertical multinationals

Vertical multinational firms split their supply chain across countries to take advantage of differences in factor prices, factor endowments, and technology across countries (Helpman, 1984). Consider a multinational firm that produces an intermediate good x in country 2. This intermediate good is needed for production of final output in country 1. Due to the existence of some fixed factor of production in both countries, 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. The price of the final output is normalised to 1. As before, the multinational firm is taxed in each country on the profits it generates in that countries. The firm's global profit function is:

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

To maximise global profits the multinational chooses x, which is the *output* in country 2 and the *input* in country 1. The firm's first-order condition for maximising global profit is:

$$(1-\tau_1)(f_1'(x)-w) + (1-\tau_2)(w-c_2'(x)) = 0.$$

Spillovers are measured by the change in country 1 profits in response to the change in country 2's tax rate. Before-tax profits in country 1 are defined as: $\pi_1(x) = f(x(\tau_1,\tau_2)) - w \cdot x(\tau_1,\tau_2)$.

Taking the derivative of profits in country 1 with respect to τ_2 gives:

$$\frac{\partial \pi_1(x)}{\partial \tau_2} = \frac{\partial x}{\partial \tau_2}\left(f_1'(x) - w\right).$$

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:

$$\frac{dx}{d\tau_2} = \frac{w - c_2'(x)}{(1-\tau_1)f_1''(x) - (1-\tau_2)c_2''(x)}. \tag{3}$$

Since $f_1''(x) < 0$ and $c_2''(x) > 0$, if marginal profit in country 2 is positive ($w - c_2'(x) > 0$), then $dx/d\tau_2$ is negative. An increase in the tax rate in country 2 reduces the production of the intermediate good x. If the firm is vertically fragmented such that x is needed for production in country 1 to take place, the firm reduces profit in country 1 in response to a tax increase in country 2. This represents an extreme version of the idea that imported inputs are needed for multinational production. This is the most intuitive way to think of vertically integrated or 'fragmented' multinationals. 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.

3.3 Profit shifting multinationals

Multinational firms can use tax devices to shift profit from high-tax to low-tax jurisdiction without altering the pattern of real economic activity. Consider a multinational firm which generates real profits in country 1. Real profits are those derived from actual economic value created within the country. The firm's real profits are fixed, but it can shift profits across borders. Real profits generated in country 1 are denoted π_1, while profits artificially shifted from country 1 to country 2 are denoted q_2. There is a cost attached to shifting profits from country 1 to country 2, denoted $z(q_2)$. Assume this cost is positive and increasing at an increasing rate in the level of profits shifted so that $z(q_2) > 0$, $z'(q_2) > 0$ and $z''(q_2) > 0$. 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). The firm's profit function is:

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

The firm's optimal choice of q_2 is determined by the condition: $\tau_1 - \tau_2 = z'(q_2)$. The change in profits shifted resulting from country 1's tax change is given by the implicit partial derivative:

$$\frac{dq_2}{d\tau_1} = \frac{1}{z''(q_2)} > 0. \tag{4}$$

An increase in the tax rate in country 1 will increase artificial profits booked in lower-tax countries. This is a substitutionary spillover, as an increase in country 1's tax rate increases profits in country 2. From the first order condition, it is easy to see that the opposite is true: an increase in country 2's tax rate leads to less profits shifted into country 2 and therefore an increase in profits booked in country 1.

3.4 Aggregating responses

These three models provide varying predictions of what direction and size corporate tax base spillovers might take at the intensive margin. In reality, the distinction between these models are blurred for a couple primary reasons. Firstly, it is difficult to differentiate between horizontal and vertical multinational firms—most multinationals bear characteristics of both organisational forms.[2] For example, horizontal multinationals do not duplicate all activities, but frequently rely on the home affiliate for headquarter services. Secondly, artificial profit shifting between non-haven countries is rarely of an economically significant magnitude (Davies et al., 2018). Combining these models, the central prediction is that the sign of e_{ij} is likely to be ambiguous. At the aggregate level, the resulting elasticity will be determined by which effects are most dominant. This aggregate effect is likely to be determined by the pattern of productive activity shared across two countries. In Section 7, I apply the theoretical predictions of these three models to help understand the heterogeneity in the empirically estimated cross-tax elasticities.

There is precedent for this ambiguity, even estimating aggregate responses. Becker et al. (2012) find that an increase in the tax rate not only reduces the level of foreign investment, but also the reported profitability of firms locating there. Using firm-level data, Becker and Riedel (2012) and Davies et al. (2016) examine the effect of tax changes on firm cross-border investment. Becker and Riedel (2012) find complementarity in cross-border investment at the firm level, but substitutionary effects when considering artificial profit shifting. Desai et al. (2005, 2009) find that outward foreign direct investment complements domestic American economic activity rather than substituting for American economic activity.

4 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 use Amadeus data on firms that have operating revenue greater than or equal to 1 million EUR, total assets greater than or equal to 2 million EUR, and 15 or more employees.

I clean the data as suggested by Kalemli-Ozcan et al. (2015). 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

[2] Works such as Davies and Markusen (2020) attempt to differentiate between the two.

[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.

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. 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.

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. 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, and also including Group S95.

Multinational affiliates are identified as corporations with an ultimate owner who is also the ultimate owner of affiliates located in other countries.[4] 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: 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. Data from Bureau van Dijk has the substantial benefit of capturing cross-border ownership structures, which is the main reason for using it in this study.

Combining data on the ownership and the financial statements is tricky, as financial statement data is presented in dynamic form while ownership data is static. I am only able to gather data on the most recent definition of the multinational group network. Therefore, the data at time t might suggest that a multinational group has an affiliate in country i at time t, but this does not tell me whether this affiliate existed in country i at time $t-k$. To reconcile this concern, I focus only on the affiliates of the multinational group that I am able to observe in the financial data at time $t-k$. I observe multinational groups with an average of 7.2 multinational affiliates, spanning an average of 3.4 of the 26 countries.

To measure the corporate tax rate, I use the top statutory corporate income tax rate from Eurostat, as at February 2020. Note that the corporate rax 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.

Table 1 presents a summary of the data. The first two columns display the number of

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

Table 1: Summary statistics by country

	Number of firms		Return on Assets (%)		Corporate tax rate (%)	
Country	Domestic	Multinational	Domestic	Multinational	Minimum	Maximum
Austria	4,724	4,172	6.00	8.62	25.00	25.00
Belgium	43,608	9,553	3.46	3.30	29.60	34.00
Bulgaria	29,695	2,036	4.61	4.86	10.00	15.00
Croatia	12,299	1,513	3.01	1.55	18.00	20.00
Czechia	29,441	6,176	4.56	7.27	19.00	24.00
Denmark	23,584	5,505	5.28	7.61	22.00	28.00
Estonia	8,646	1,750	6.43	6.11	20.00	23.00
Finland	23,028	3,807	5.10	6.99	20.00	26.00
France	147,333	29,989	4.34	5.19	34.40	44.40
Germany	53,853	14,454	5.42	6.30	29.40	38.40
Greece	13,411	946	1.69	2.81	20.00	35.00
Hungary	34,966	2,507	5.19	4.89	10.80	21.30
Ireland	5,036	3,932	2.88	6.40	12.50	12.50
Italy	249,897	18,545	2.76	3.73	27.80	37.30
Latvia	8,335	1,190	4.76	4.77	15.00	20.00
Lithuania	6,057	968	5.99	6.87	15.00	20.00
Luxembourg	4,550	4,655	5.12	5.65	26.00	29.60
Netherlands	5,815	4,207	4.84	6.28	25.00	29.60
Poland	60,464	9,559	5.14	5.92	19.00	19.00
Portugal	45,930	4,774	3.14	4.61	26.50	31.50
Romania	41,618	4,759	5.09	4.40	16.00	16.00
Slovakia	17,945	3,185	2.43	6.58	19.00	23.00
Slovenia	9,623	1,290	4.17	3.32	17.00	25.00
Spain	177,739	15,663	2.60	5.00	25.00	35.00
Sweden	56,831	12,218	5.44	6.77	22.00	28.00
United Kingdom	55,936	29,241	4.39	5.07	19.00	30.00

Note on Table 1: This table presents summary statistics of the cleaned dataset used to estimate cross-tax elasticities. The first two columns show the number of firms in each country by type. The next two columns show return on assets by firm type. Return on assets is measured as profit or loss before tax as a ratio of total assets. To summary statistic presented here is an average over the entire period, weighted by total real assets in 2015 euros. The final two columns present the minimum and maximum corporate tax rate over the sample period 2006 to 2018.

domestic and multinational firms in the estimating sample for each country. There is significant variation in the number of firms observed in each country, which is not directly correlated with country size. Multinational firms range from 6 percent to 47 percent of total firms in each country in this data. The next two columns highlight differences in the average return on assets both across countries and across firm types. Multinational firms are generally more profitable than domestic firms. The final two columns present the minimum and maximum corporate tax rate over the sample period 2006 to 2018. There are four countries which do not change their headline corporate tax rate in this period: Austria, Ireland, Poland, and Romania.

5 Empirical strategy for estimating cross-tax elasticities

This section describes the empirical strategy used to estimate country-specific and country-pair cross-tax elasticities. The variable of interest is profit or loss before taxes. Profit before tax most closely approximates the taxable income of the firm and is the tax base that matters to governments.

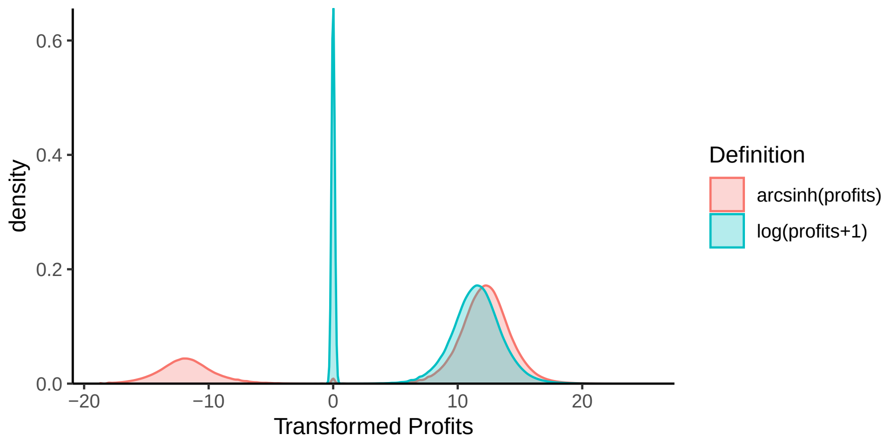
5.1 The inverse hyperbolic sine

The parameter of interest is the semi-elasticity of profits 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:

$$\text{arcsinh}(\pi_j) = \ln\left(\pi_j + \sqrt{\pi_j^2 + 1}\right). \tag{5}$$

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 firm profits.[5]

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

[5] 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.

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—so much so that I can describe profits and losses as a bimodal distribution. The difference between these distributions highlights the importance of taking an approach that allows losses to be an optimal response to tax changes.

5.2 Estimating country-specific spillovers

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 has an affiliate operating in country i. 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 interacted with a dummy D_{mi} that captures whether the firm has an affiliate in country. The estimated equation is:

$$\operatorname{arcsinh}(\pi_{mjt}) = \alpha_m + \gamma_{kt} + \sum_{i=1}^{N} e_i \cdot D_{mit} \cdot \tau_{it} + \varepsilon_{mt}, \tag{6}$$

where π_{mjt} and τ_{it} are profits in country j and the tax rate in country i. Note that m indexes the firm, j is the country being affected by the spillover, i is the country whose tax rate reform I am investigating, and k is a grouping variable. Firm fixed effects are included as α_m and group-specific time effects are included as γ_{kt}. The summation in equation 6 captures the interaction of the dummies and tax rates for all other countries. The coefficients e_i are the country-specific cross-tax semi-elasticities I am interested in estimating. 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.

5.3 Estimating country-pair spillovers

To estimate the spillover effect between a pair of countries, I extend Equation 6 by multiplying 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-pair spillover semi-elasticities is:

$$\text{arcsinh}(\pi_{mjt}) = \alpha_m + \gamma_{jkt} + \sum_{j\neq i}^{N}\sum_{i=1}^{N} e_{ij}\cdot D_{mit}\cdot D_j\cdot \tau_{it} + \varepsilon_{mt}. \tag{7}$$

This results in a matrix of semi-elasticities e_{ij} with $j \in N$ rows and $i \in N$ columns, where each entry 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 missing.

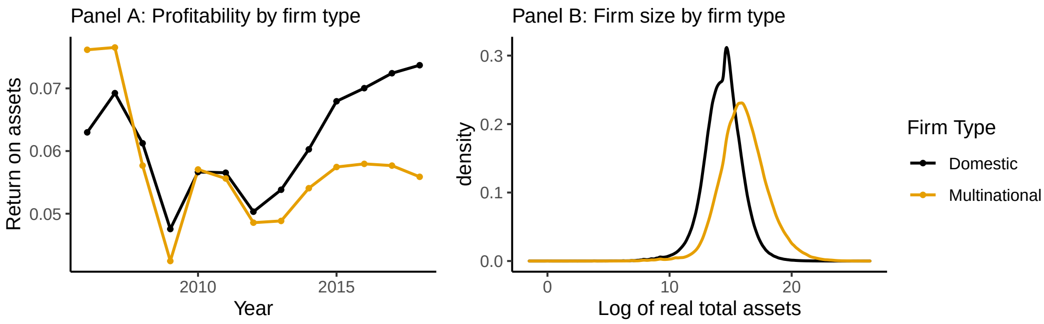
Random coefficients. While I can estimate this model directly by linear methods, I can extend our initial country-specific model to allow for random coefficients. That is, I assume that there is non-independence in the estimated country-pair coefficients for each country changing its tax rate. I assume 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 rather than 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 somethings in common. This approach is used by both Griffith et al. (2014) and Arulampalam et al. (2019) to estimate various cross-border responses.

5.4 Identification

One potential concern is the possibility that multinational firms are inherently different from domestic firms. Since I am interested in profits, I normalise each firm's profits to calculate their return on assets to see where differences lie. On average multinational firms have a *lower* return on asset than domestic firms in the data: 5.4% versus 6.4% respectively. I observe, as in Figure 2 that there is not a systematic difference between the return on assets of domestic firms and multinational firms over time, and they broadly move in similar directions. Only in the latter years of the sample do we see profitability trending in different directions—albeit opposite to what might be expected, with domestic firms generating higher profits. However, I observe that there is a systematic difference in firm size, measured by total assets: multinational firms are larger than domestic firms. The distributions are similarly shaped, but the distribution for multinational firms is shifted to the right in comparison to domestic firms.

It is comforting that multinational firms are not systematically different from domestic firms in terms of their profitability in this sample. However, the concern remains that multinational affiliates are systematically larger than domestic firms. To temper this concern I do two things. First, I use disaggregated time fixed effects, splitting firms into industry-size categories. Second, I consider a reweighting approach based on those industry-size. Note that since the systematic difference in size is a specific concern, I determine size categories based on the distribution of multinational firm's average real total assets in each industry category. 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.

Figure 2: Comparing the characteristics of multinational and domestic firms



Note on Figure 2: 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.

Comparison groups. Each firm is therefore placed into a country-industry-size bin, which represents its comparison group. To create these comparison groups I calculate size groupings within different industry grouping levels. From broadest to narrowest, I use the NACE Section level, the NACE 2-digit level, and the NACE 4-digit level as industry groupings within each country. I also consider estimates without an industry grouping, implying I calculate the size grouping based on all firms operating in a 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. A firm's size is defined by average real total assets over the period under investigation. These bins are used both as the level of disaggregation of time fixed effects, and to create covariate balance across multinational and domestic firms.

Disaggregated time fixed effects Goodman-Bacon (2018) shows that with disaggregated time fixed effects the estimated semi-elasticity will be a weighted average of the two-way fixed effects estimates for each grouping. Naturally, the weight each group receives in calculating the average depends on the number of firms in each group and the within-group variance. The choice of disaggregation in the time fixed effects determines the comparison groups on which the estimates are based.

Coarsened exact matching. 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:

$$w_{mkt}(\text{dom}) = \frac{N_{kt}(\text{mne})}{N_{kt}(\text{dom})} \times \frac{N(\text{dom})}{N(\text{mne})}. \tag{8}$$

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.

6 Results

In this section, I estimate cross-tax elasticities using the empirical strategy described above. First, I present estimates of average elasticities for 22 countries which change their tax rates between 2007 and 2018. Second, I present estimates of 550 country-pair elasticities. Third, I describe a number of robustness checks.

6.1 Average cross-tax elasticities

I begin by estimating average elasticities for each country, specified in equation 6. These elasticities are an average of the effect a country's tax reform has on all its neighbours. 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. All estimates include firm fixed effects and all standard errors are clustered at the firm level. All estimates are weighted by coarsened exact matching weights.

The estimated average elasticities are presented in Table 2. Each estimated elasticity e_i is effectively some weighted average of country-pair elasticities, e_{ij}. Each country's elasticity is interpreted as the 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 four models presented represent the four grouping levels considered: country-size, country-NACE Section-size, country-NACE 2-digit-size, and country-NACE 4-digit-size. As the grouping definition becomes progressively narrower some observations are dropped, either because domestic firms do not meet the size criteria within a narrower definition of the group, or because there are insufficient multinationals within a specific grouping to allow size-based stratification. The number of observations under analysis falls from 9.7 million in the broadest definition to 7.9 million in the narrowest definition. In each regression, the level of grouping is used both as an interaction with year fixed effects, and as the level of the bins for the coarsened exact matching weights defined in equation 8.

Table 2 presents evidence that disaggregating cross-tax elasticities from an aggregate across all countries to country-specific averages reveals significant heterogeneity. Estimated elasticities are both positive and significant, and negative and significant. The range of statistically significant elasticities ranges from -4.5 (s.e.=1.057) in Lithuania to +2.0 (s.e.=0.295) in Den-

Table 2: Average cross-tax elasticity by tax reform country

	Country	NACE Section	NACE 2-Digit	NACE 4-Digit
	(1)	(2)	(3)	(4)
Belgium	0.652**	0.528*	0.524*	0.616*
	(0.282)	(0.295)	(0.295)	(0.315)
Bulgaria	−1.725	−0.838	−1.355	−1.298
	(1.296)	(1.371)	(1.634)	(1.796)
Croatia	0.241	−0.642	−0.294	−0.729
	(0.534)	(0.549)	(0.566)	(0.625)
Czechia	−0.143	0.244	0.147	0.245
	(0.508)	(0.521)	(0.529)	(0.571)
Denmark	1.038***	1.917***	2.014***	1.948***
	(0.271)	(0.297)	(0.295)	(0.310)
Estonia	−0.714	−0.860	−0.412	−0.504
	(0.735)	(0.770)	(0.825)	(0.904)
Finland	1.836	1.924	1.339	0.614
	(1.208)	(1.333)	(1.353)	(1.412)
France	0.558***	0.797***	0.742***	0.540**
	(0.194)	(0.201)	(0.203)	(0.215)
Germany	0.815***	0.942***	0.974***	1.205***
	(0.256)	(0.262)	(0.266)	(0.285)
Greece	−0.587	−0.871	−1.375	−1.203
	(0.893)	(0.938)	(0.983)	(1.072)
Hungary	−0.808**	−0.992**	−1.122**	−0.627
	(0.412)	(0.434)	(0.439)	(0.474)
Italy	0.616**	0.569*	0.656**	0.677**
	(0.292)	(0.303)	(0.306)	(0.328)
Latvia	0.566	1.038	1.524	1.811*
	(0.934)	(0.965)	(0.990)	(1.079)
Lithuania	−4.538***	−3.921***	−3.731***	−3.972***
	(1.057)	(1.083)	(1.109)	(1.230)
Luxembourg	0.785*	1.000**	1.381***	0.777*
	(0.404)	(0.416)	(0.441)	(0.463)
Netherlands	0.302	0.061	−0.161	−0.286
	(0.307)	(0.310)	(0.314)	(0.336)
Portugal	0.907***	0.678**	0.569*	0.739**
	(0.314)	(0.321)	(0.326)	(0.351)
Slovakia	0.603	0.961**	1.104**	0.598
	(0.457)	(0.467)	(0.482)	(0.528)
Slovenia	0.664	0.271	0.504	0.012
	(0.616)	(0.631)	(0.657)	(0.708)
Spain	0.059	0.004	−0.046	0.032
	(0.292)	(0.300)	(0.308)	(0.327)
Sweden	−0.172	−0.436	−0.399	−0.142
	(0.417)	(0.442)	(0.439)	(0.472)
United Kingdom	−3.337***	−3.846***	−4.522***	−3.947***
	(0.926)	(1.062)	(1.076)	(1.098)
Observations	9,789,350	9,714,557	9,408,629	7,987,614
R^2	0.524	0.536	0.550	0.577

Notes on Table 2: Coefficients are interpreted as the average percentage change in multinational profits in neighbouring countries resulting from a one percentage point increase in the named country's corporate tax rate. Column titles represent the level at which level interactions with size are calculated. These interactions are used for country-size-year fixed effects, country-industry-size-year fixed effects,country-NACE 2-digit-size-year fixed effects, and country-NACE 4-digit-size-year fixed effects respectively. For each regresions, the grouping used in the year fixed effects are also used to calculate weights according to Equation 8. All models include firm fixed effects. The model includes a dummy for the change in the tax system in the United Kingdom, and dummies for changes in transfer pricing regulations in Finland, Greece, and Luxembourg. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

mark. My preferred estimate is presented in column 3, where there is a balance between the level of disaggregation (NACE 2-digit-size) and the number of observations retained (9.4 million). In this specification, the majority of statistically significant estimates are positive for Belgium(0.524, s.e.=0.295), Denmark (2.014, s.e.=0.295), France (0.742, s.e.=0.203), Germany (0.974, s.e.=0.266), Italy (0.656, s.e.=0.306), Luxembourg (1.381, s.e.=0.441), Portugal (0.569, s.e.=0.326), and Slovakia (1.104, s.e.=0.482). These encompass three of the four largest European economies—Germany, France, Italy. Elasticities which are negative and significant are fewer: Hungary(−1.122, s.e.=0.439), Lithuania (−3.731, s.e.=1.109), and the United Kingdom (−4.522, s.e.=1.076).

Notice that if we were to take an average across all countries, we might find a single aggregate elasticity that is close to zero and positive. This aggregate number is uninformative, since we can have an average of, for example +0.5 that is driven by two very different sets of underlying country-specific numbers: first, all estimates might be exactly equal to 0.5; second, estimates might be very heterogeneous, as is the case here. As we will explore in the following subsection, even these country-specific elasticities hide significant heterogeneity.

These elasticities are robust across various levels of disaggregation of the comparison groups. The narrowest comparison group (column 4) explains the largest proportion of variance. Across all specifications, there are some average elasticities which are statistically indistinguishable from zero. The robustness of these results across comparison groups increases the likelihood that the observed heterogeneity reflects significant differences across countries in how multinational firms respond.

6.2 Country-pair cross-tax elasticities

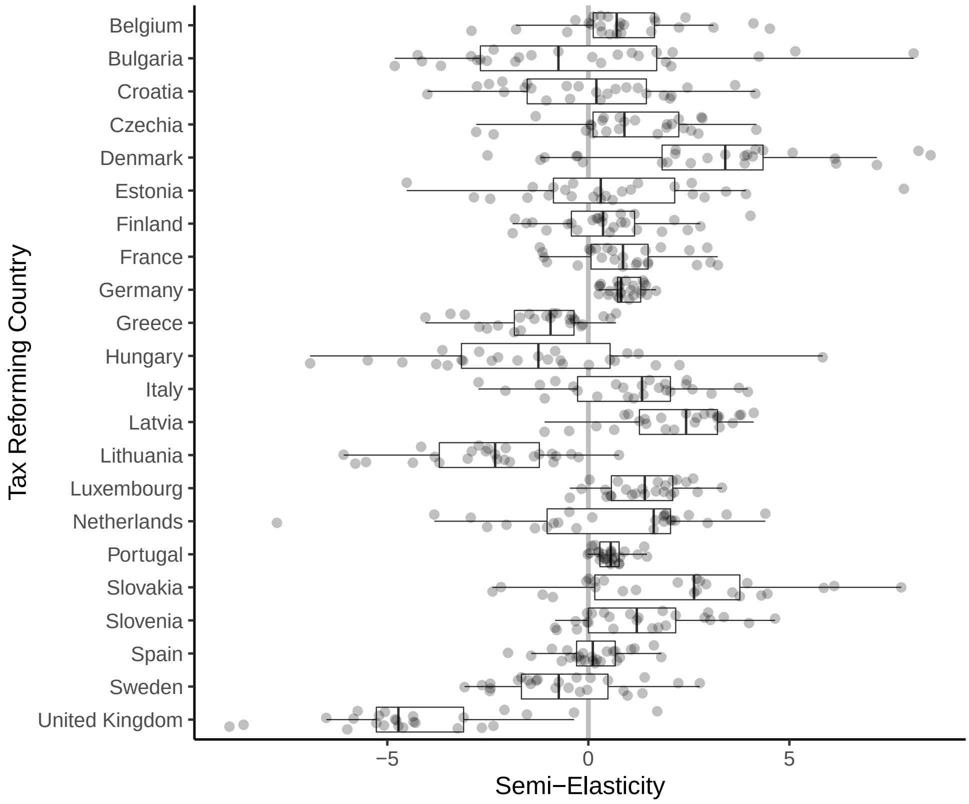
I now allow the elasticities to vary by country-pair. I estimate equation 7. These elasticities are the most important results in this paper, as they allow us to calculate corporate tax base spillovers. In this section I use the baseline NACE 2-digit-size grouping. However, estimates for all groupings are included in the appendix.

The estimated country-pair elasticities (e_{ij}) are presented graphically in Figure 3, grouped by the country changing its corporate tax rate.[6] This figure displays significant heterogeneity in the estimated country-pair elasticities. This heterogeneity is most distinct for countries such as Estonia or Lithuania which have almost the same number of positive elasticities as negative elasticities. Despite the heterogeneity of country-pair elasticities, these countries would have a median elasticity 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. 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. Once again, this finding helps to explain the substitutionary effects that are often observed on average after aggregating across a wide range of countries.

[6] The full matrix of country-pair cross-tax elasticities is included in the appendix.

Figure 3: Country-pair cross-tax elasticities by country



Note on Figure 3: 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.

The heterogeneity in cross-tax elasticities is stark and economically significant. Heterogeneity exists not just across countries, but within countries. It is no longer clear that a single average elasticity provides 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*. In Section 7, I attempt to put some structure on this heterogeneity to help make sense of country-pair relationships.

6.3 Robustness

I estimate a range of alternative specifications, which are included in the appendix. I re-estimate the model without assuming dependence among elasticities arising from a single country's tax reforms. This gives larger estimated elasticities since the regularization effect is removed. Of interest is the specification using the log of profits, where profits are truncated at zero and one is added to all values. These results show that truncating profits results in significantly smaller estimated elasticites. I re-estimate the average cross-tax elasticities without coarsened exact matching weights. I re-estimate the model of country-pair spillovers using all four types of grouping-size-year fixed effects. These estimates suggest the results are robust to the specifications of these fixed effects.

7 Understanding the heterogeneity in cross-tax elasticities

Each of the three theoretical models in Section 3 provides a different prediction about cross-tax elasticities. Each model is based on a different organisation form of the multinational group. At the country-pair level, we are likely to observe a mixture of these organisational forms. The composition of horizontal, vertical, and profit shifting multinationals in the aggregate country-pair relationship is therefore likely to determine the observed country-pair elasticity.

The choice of whether to set up a horizontal, vertical or profit-shifting multinational between two countries depends on the incentives created by the relative characteristics of that pair of countries. Each of the three theoretical models provide predictions about what characteristics of a pair of countries is likely to give rise to horizontal, vertical, or profit shifting multinational firms. Combining these predictions about how country characteristics lead to different organisational forms with predictions about the directions of cross-tax elasticities under those organisational forms, I provide some theoretical predictions about how elasticities are expected to vary across country pairs. These predictions about how elasticities vary depend on the relative characteristics of each country pair.

Horizontal multinationals. 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). Horizontal multinational firms are expected to generate substitutionary spillovers.

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

Vertical multinationals. Vertical multinationals arise so that firms can take advantage of differences in factor prices across countries—effectively specialising separate parts of the production process (Helpman, 1984). Vertical multinational firms are likely to be more dominant the larger is the difference in factor endowment. Vertical multinational firms are expected to generate complementary spillovers.

Prediction 2 *The more different are factor endowments, the more complementary are the spillovers.*

Profit shifting multinationals. Profit shifting behaviour exists due to significant differences in corporate tax rates. Without this differential, there is no incentive to artificially shift profits. Alternatively, some countries have special vehicles that provide multinational firms with significantly lower liability than the top corporate tax rate would imply—these countries can broadly be defined as tax havens. Profit shifting multinational firms are expected to generate substitutionary spillovers.

Prediction 3 *The larger the difference in corporate tax rates, the more substitutionary are the spillovers.*

Substitutionary spillovers are defined by a positive cross-tax elasticity, while complementary spillovers are defined by a negative cross-tax elasticity.

To test these predictions against the estimated elasticities, I collect aggregate data for each country from Eurostat and organise them into country-pair differentials. For each measure, I use the average of all data available from 2006 onward.

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. Second, I use the share of total consumption accounted for by each of 47 consumption categories to measure the difference in consumption patterns. To do so, I use the log of the Euclidean distance between each pair of countries' vectors of consumption shares. The first measure captures the overall level of consumption, assuming that countries at similar levels of consumption consume similar types of commodities. The second measure captures the pattern of consumption more directly by identifying what share is spent on each type of commodity, even if the overall level of consumption is very different.

To measure the difference in factor endowments, I use two measures: a measure of labour cost and a measure of labour skill endowments (Yeaple, 2003). To measure labour cost, I use the compensation of employees plus taxes minus subsidies in the business economy (NACE Section B to N), measured in euros. As before, I take the log of the absolute difference between each pair of countries' labour costs. To measure labour skill endowment, I measure the difference between the amount of persons with tertiary education and/or employed in science and technology as a share of total active workers.

To measure the difference in corporate income tax rates, I use the average corporate tax rate from 2006 to 2018. In addition, I consider whether tax havens might have an influence. I include separate dummies 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.

The results of four specifications are presented in Table 3. To give greater emphasis to more precisely estimated elasticities, the estimates in this table are weighted by the value of the t-statistic originally calculated for each estimated elasticity. A positive coefficient on a covariate implies that a higher value of that covariate is associated with a more subsitutionary spillover.

First, a smaller difference in aggregate consumption and in consumption patterns implies a more positive value of the cross-tax elasticity. This fits well with the theory, implying that countries with more similar consumption patterns are more likely to play host to horizontal multinationals with substitutionary spillovers being dominant. These results conform to the findings of Brainard (1997) and Yeaple (2003) who find horizontal multinational firms more likely to arise when consumption patterns are similar.

Second, I observe that the greater is the difference in skill endowments between two countries, the more complementary is the spillover. This is the result predicted by the theory of vertical multinational firms. This result backs up the findings of Yeaple (2003), who suggests that the

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

	(1)	(2)	(3)
Log difference in labour cost	0.215	0.390***	0.404***
	(0.133)	(0.147)	(0.147)
Difference in education/sci-tech		−0.065**	−0.065**
		(0.028)	(0.028)
Log difference in aggregate consumption	−0.618***	−0.592***	−0.617***
	(0.090)	(0.089)	(0.091)
Log difference in consumption patterns		−1.332**	−1.458***
		(0.531)	(0.536)
Difference in corporate tax rates	−0.006	0.005	0.008
	(0.030)	(0.030)	(0.030)
Is tax haven (reform country)			−0.692*
			(0.369)
Is tax haven (affected country)			−0.144
			(0.373)
Constant	7.543***	10.360***	11.056***
	(1.095)	(1.472)	(1.534)
Observations	550	550	550
R^2	0.085	0.109	0.115

Note on Table 3: The dependent variable in this model is the set of semi-elasticities estimated in Figure 3. 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 * $p < 0.1$.

skill endowments of the workforce matters for vertical multinationals. In contrast, I find that the greater the difference in wages, the more substitutionary is the spillover. This is counter to the predictions of theory. While measuring labour cost is theoretically appropriate, it is likely to measure labour supply effects as well: greater similarity in labour costs might imply greater similarity of incomes, potentially being instead a measure of similarity of consumption patterns.

Third, I observe no linear relationship between corporate tax rate differentials and the cross-tax elasticity. Davies et al. (2018) also find no evidence of tax avoidance between French multinational firms and non-haven countries. Accounting for tax havens, I find—counter to predictions—that being exposed to a reform from a tax haven countries actually induces a more *complementary* spillover than for a non-haven country. This might suggest that tax havens reduce the distortionary effect of the corporate tax, increasing the firm's ability to invest in non-haven countries, as per the 'positive view' of havens (Dharmapala, 2008). This is similar to the recent results of Suárez Serrato (2018), Schwab and Todtenhaupt (2019) and Albertus (2019) who find that access to tax havens allows multinational to reduce their cost of capital or their average tax burden, and therefore increase economic activity in non-haven countries. Theoretical work to also helps to rationalise this finding (Desai et al., 2006; Johannesen, 2010; Hong and Smart, 2010; Klemm and Liu, 2019).

In summary, I find that the heterogeneity in estimated cross-tax elasticities fits well with the theoretical predictions of horizontal and multinational firms: greater similarity in consumption patterns leads to more substitutionary spillovers, while greater differences in factor endowments leads to more complementary spillovers. I do not observe an impact of corporate tax rate differentials on elasticities, but countries which have more business-friendly tax regimes generate complementarities for their neighbours. These results help us to understand the heterogeneity in the estimated cross-tax elasticities. That is—they are not heterogeneous simply due to noise in the data, but rather due to underlying differences in the relative characteristics of country pairs.

8 Measuring Corporate Tax Base Spillovers

8.1 Measuring the tax base

In this section, I measure corporate tax base spillovers at the intensive margin. To do so, I need an estimate of B_{ij}, which is the tax base in country j affiliated with a multinational firm that has productive activity in country i. Calculating B_{ij} using foreign direct investment data is inadequate since it measures only links directly from country i to country j and vice versa. To be captured in foreign direct investment data, the multinational firm would likely have to maintain its headquarters in either country i or country j. In reality, a multinational firm with affiliates in both countries i and j might be headquartered in country k, implying that we would be unable to observe this as a link between countries i and j.

I therefore rely on the Amadeus database's ownership data to calculate B_{ij}. For each country-pair, I aggregate the total profits of firms located in j which have affiliates in i. To standardise this measure across countries, I express this as a ratio of total profits in country j: $s_{ij} = B_{ij}/B_j$. This allows me to express the change in revenue resulting from corporate tax base spillovers as a percentage change in total revenue.

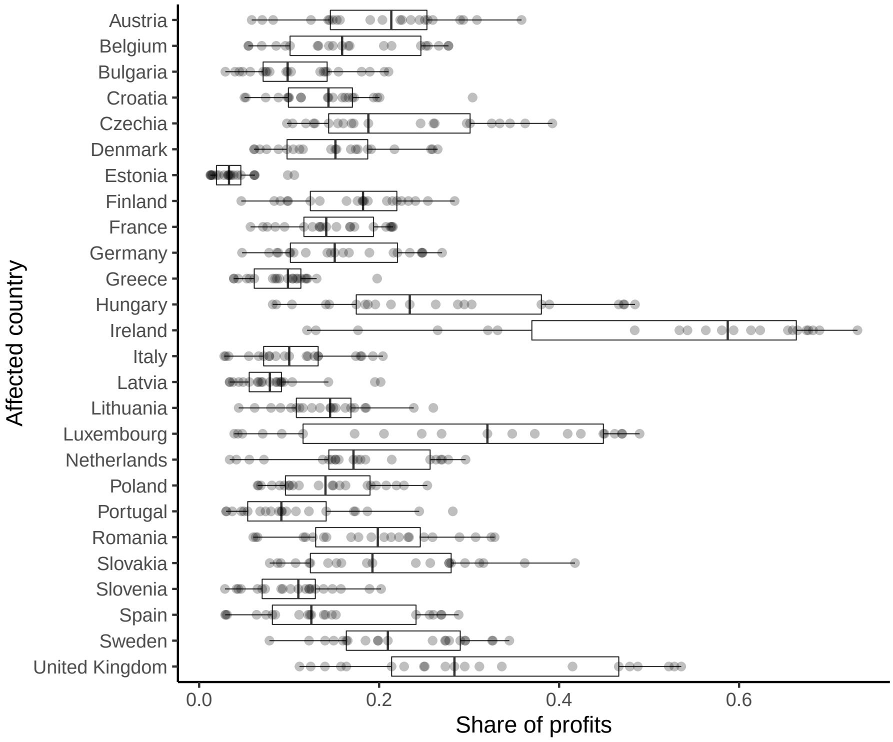
However, Amadeus provides only a sample of firms located in each country j, which might not be representative of the total population of firms. To correct for this bias, I adjust the aggregated Amadeus data to match Eurostat's Structural Business Statistics.[7] Specifically, I calculate gross operating surplus generated by foreign controlled enterprises in each country as a ratio of that country's total gross operating surplus. I match this to the share of profits generated by foreign-owned firms in each country in the Amadeus database. I do this for each year from 2014 to 2018. I calculate an adjustment factor based on these two ratios for each country. This adjustment factor is an estimate of the incompleteness of the Amadeus database which affect the measured tax base being affected by the spillovers. For each country j, the adjustment factor is applied to each B_{ij}. For most country-year observations, the Amadeus database overestimates the share of total profits being generated by foreign-owned firms, and so the shares s_{ij} are mainly adjusted downward. This is unsurprising given that I use firm-level data that excludes firms with less than 1 million euros in operating revenue or 2 million euros in total assets. These excluded smaller firms are more likely to be domestic firms, biasing the share of multinational profits in the data upwards.

The estimated values of s_{ij} are shown in Figure 4, which groups them by country j (the country being affected by the fiscal spillover). The measure of s_{ij} is an important source of heterogeneity in fiscal spillovers. For example, even with a single homogenous cross-tax elasticity, the fiscal spillover will vary from country to country simply depending on the degree to which a country is *exposed* to a neighbouring country's tax rate reform.[8] I observe heterogeneity both

[7]This database covers the business economy as is done in this paper, which implies covering NACE Rev. 2 sections B to N and division S95.

[8]Note that Beer et al. (2018b) create heterogeneity in their fiscal spillover estimates by identifying a measure

Figure 4: Measuring country-pair tax base by country



Note on Figure 4: This figure plots the calculated shares of a country's profits that are affiliated with a multinational firm affiliate in another country. Each dot represents a share $s_{ij} = B_{ij}/B_j$, where the observations are grouped by country j. 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.

within and across countries. Some countries such as Ireland are, in general, highly exposed by effectively linking a large portion of their tax base to other countries. Other countries such as Estonia have very limited exposure to fiscal spillovers. Many countries have significant variation in their exposed tax base across neighbouring countries. For example, Luxembourg, Hungary, and the United Kingdom are highly exposed to some countries but carry little exposure to others. This variation—both within and across countries—is economically significant.

8.2 Measuring fiscal spillovers

I combine the estimated country-pair elasticities and country-pair tax bases to estimate corporate tax base spillovers across countries. I calculate the percentage change in a country j's revenue resulting from a one percentage point decrease in a neighbour i's corporate tax rate as:

$$\%\Delta R_{ij} = -0.01 \times \frac{\tau_j B_{ij}}{\tau_j B_j} e_{ij}, \tag{9}$$

of heterogeneity in the exposed tax base. They adjust a homogeneous substitutionary elasticity by the number of multinational links between the U.S. and the neighbouring country. While this does imply heterogeneity in the spillovers, the spillovers are still all substitutionary and does not allow for complementarity in fiscal spillovers.

where I can simply express the term in fractions as s_{ij}. Because e_{ij} is a semi-elasticity, I multiply the expression by $d\tau_i = -0.01$ to capture the effect of a one percentage point decrease.

Table 4: Country-aggregated fiscal spillovers from 1 p.p. tax cuts

Country	Spillover from neighbours (%)	Spillover to neighbours (%)
Austria	0.31	
Belgium	2.04	-0.11
Bulgaria	-1.04	0.24
Czechia	-3.95	-0.00
Germany	2.69	-0.25
Denmark	0.78	-0.15
Estonia	-0.11	-0.01
Spain	0.60	-0.15
Finland	-1.31	-0.12
France	1.16	-0.08
United Kingdom	-1.38	1.01
Greece	-1.44	0.36
Croatia	-0.89	0.01
Hungary	-2.03	0.20
Ireland	-7.30	
Italy	-0.47	-0.24
Lithuania	-3.12	0.24
Luxembourg	0.45	-0.17
Latvia	-0.23	-0.15
Netherlands	-0.77	0.07
Poland	-0.69	
Portugal	0.07	-0.10
Romania	-4.15	
Sweden	0.13	-0.04
Slovenia	-1.41	-0.12
Slovakia	-0.42	-0.09

Note on Table 4: This table presents percentage changes in the corporate tax base spillovers by country. For each country listed in column 1, the second column calculates the total percentage change in that country's corporate tax revenue resulting from a 1 percentage point reduction in the corporate tax rate of all neighbours. Conversely, the third column calculates the total percentage change in neighbours' corporate tax revenue resulting from a 1 percentage point reduction in the corporate tax rate of the country listed in column 1.

To contextualise the estimated spillovers, I consider two thought experiments. First, what is the total effect on a country j's corporate tax revenue if all neighbours ($\forall i \neq j$) uniformly reduced their tax rate by one percentage point? To calculate this measure of the tax base spillover, I simply sum the percentage change given by equation 9 across all i: $\sum_{i \neq j} \%\Delta R_{ij}$. Second, what is the total effect on the revenue of all countries ($\forall j \neq i$) if a country i reduced its corporate tax rate by one percentage point? To calculate this measure of the tax base spillover, I calculate the average percentage change given by equation 9 for all countries j, weighted by each country j's share of total revenue (excluding country i): $\sum_{j \neq i}(\omega_j \times \%\Delta R_{ij})$. I calculate these weights using aggregate data on general government taxes on the income or profits of corporations including holding gains from Eurostat for the period 2014 to 2018.

The estimated fiscal spillovers from these two thought experiments are presented in Table 4. The full matrix of spillovers are included in the appendix. The second column provides the estimated change in a country's corporate tax revenue resulting from a one percentage point reduction in all neighbours' tax rate. The third column presents the estimated change in neighbouring countries' corporate tax revenue resulting from a one percentage point reduction in a country's tax rate. Most of the aggregated spillover effects are substitutionary—a reduction in neighbours' tax rates tends to lead to a decline in a country's tax revenue, while a country's tax cut will reduce neighbours' tax revenue. There are a few exceptions. Belgium, Germany and France experience significant positive fiscal spillovers when neighbouring countries cut their corporate tax rates. Conversely, the United Kingdom's corporate tax cut significantly benefits its neighbours. While on average, we expect a country to be negatively affected by a simultaneous reduction in its neighbours' tax rates, this is apparently not true for all countries. Further, not all countries' tax cuts are expected to reduce corporate tax in neighbouring countries. Fiscal spillovers are also not symmetric—some countries are negatively affected by a tax cut in neighbouring countries, but their own tax cut will positively affect neighbours' revenue.

The magnitudes of spillovers can be potentially economically large. To see this, consider the effect of a 10 percentage point decrease in a corporate tax rate. For Germany, for example, this can reduce corporate tax revenues across its European neighbours by 2.5 percent in total.

The heterogeneity in fiscal spillovers is significant. Even at the aggregate level, countries are affected in very different ways by a uniform reduction in their neighbours' tax rates. Each country has a different place in the international production system, and is therefore uniquely affected by fiscal spillovers. More importantly, the fact that there are aggregate complementarities for some countries suggest that traditionally competitive tax rate cuts are not necessarily harmful to all neighbours, neither are they necessarily an optimal response to neighbours' tax cuts.

9 Conclusion

In this paper, I estimate fiscal spillovers at the intensive margin resulting from corporate tax rate changes in Europe. I quantify the size and heterogeneity of these spillovers. Heterogeneity in fiscal spillovers results both from heterogeneity in the cross-tax elasticity of taxable income across country pairs, and from heterogeneity in the corporate tax base linked between two countries through multinational groups. Heterogeneity in the cross-tax elasticities implies heterogeneity in both the magnitude and direction of fiscal spillovers. Heterogeneity in the linked corporate tax base implies heterogeneity only in the magnitude of fiscal spillovers.

My preferred estimates of the cross-tax semi-elasticity between country pairs range from -8.9 to +8.5, while the share of the tax base exposed between country pairs range from 0% to 73%. I find that a one percentage point reduction in all neighbouring countries' tax rates can induce changes in a country's tax revenue anywhere from a 7% decrease to a 3% increase. A one percentage point reduction in one country's tax rate might be expected to change its neighbours' aggregate revenue anywhere between -0.25% to +1%.

It is easy to think that corporate tax base spillovers must be substitutionary. Neither theory nor the results presented in the paper suggests this holds at the intensive margin. Instead, I observe that corporate tax base spillovers operate along a continuum from complementary to substitutionary. Where spillovers fall on this continuum is determined by the nature of the relationship between each pair of countries. In particular: country pairs with more similar consumption patterns have more 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 recommend caution when drawing conclusions about the expected spillover effects from a country's corporate tax rate reform. The results further recommend caution in how we redesign the international corporate tax system to stem substitutionary spillovers.

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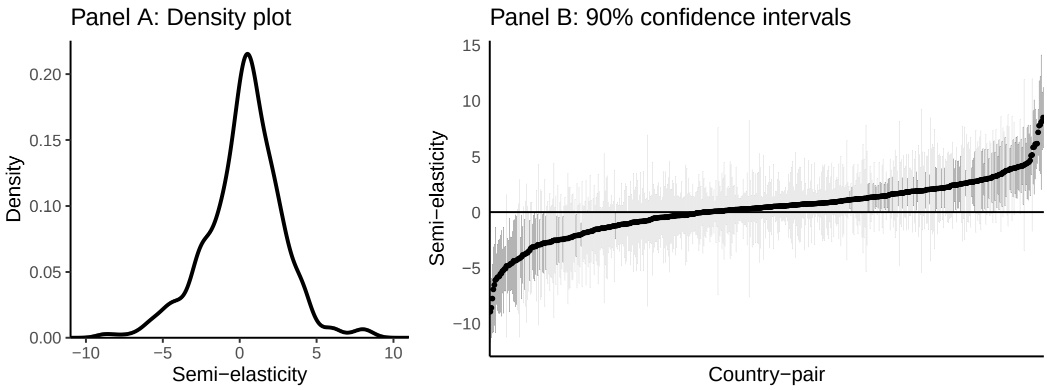
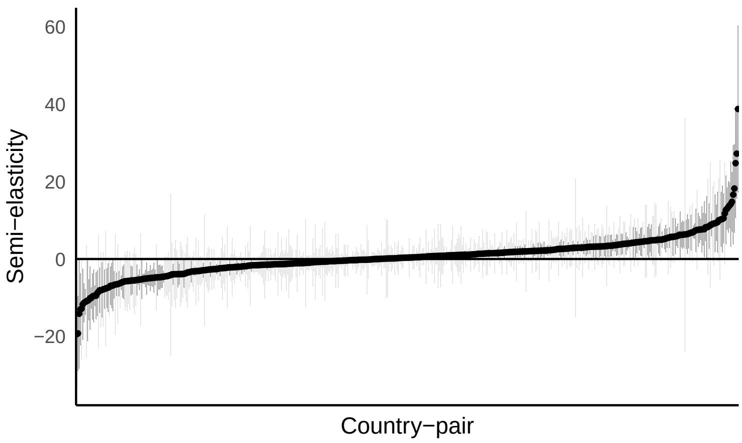
A Appendix

Figure 5: Summary of country-pair elasticities



Note on Figure 5: The estimated elasticities presented in this figure are from the baseline model in Section 6. 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 6: Country-pair elasticities estimated as independent coefficients



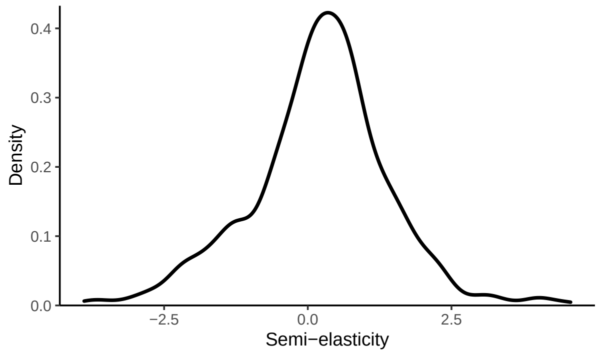
Note on Figure 6: This figure re-estimates the main model assuming all country-pair elasticities to be independent. The model includes NACE 2-digit-size-year fixed effects, and are reweighted using coarsened exact matching weights. This figure plots the estimated semi-elasticities for each country pair 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.

Table 5: Re-estimating average cross-tax elasticity without re-weighting

	Country	NACE Section	NACE 2-Digit	NACE 4-Digit
	(1)	(2)	(3)	(4)
Belgium	0.663**	0.626**	0.560**	0.637**
	(0.274)	(0.273)	(0.274)	(0.286)
Bulgaria	−1.134	−0.803	−0.862	−0.338
	(1.258)	(1.260)	(1.270)	(1.335)
Croatia	0.166	−0.379	−0.426	−0.155
	(0.527)	(0.527)	(0.533)	(0.565)
Czechia	−0.162	0.116	0.093	0.079
	(0.500)	(0.501)	(0.501)	(0.528)
Denmark	1.104***	1.624***	1.738***	1.749***
	(0.258)	(0.260)	(0.261)	(0.274)
Estonia	−1.112	−1.163	−1.052	−1.021
	(0.721)	(0.724)	(0.727)	(0.773)
Finland	1.759	1.127	0.674	0.600
	(1.161)	(1.170)	(1.179)	(1.236)
France	0.674***	0.803***	0.780***	0.614***
	(0.188)	(0.189)	(0.190)	(0.199)
Germany	0.758***	0.821***	0.804***	1.023***
	(0.254)	(0.253)	(0.253)	(0.265)
Greece	−0.335	−0.930	−1.276	−1.102
	(0.866)	(0.871)	(0.879)	(0.925)
Hungary	−0.701*	−1.063***	−1.055***	−0.764*
	(0.399)	(0.400)	(0.403)	(0.425)
Italy	1.221***	1.109***	1.148***	1.034***
	(0.281)	(0.280)	(0.281)	(0.295)
Latvia	0.656	1.000	0.943	0.598
	(0.924)	(0.923)	(0.931)	(0.976)
Lithuania	−4.738***	−4.093***	−3.869***	−3.617***
	(1.047)	(1.045)	(1.043)	(1.113)
Luxembourg	0.709*	1.029***	1.035***	0.641*
	(0.367)	(0.367)	(0.369)	(0.388)
Netherlands	0.173	−0.018	−0.176	−0.170
	(0.300)	(0.299)	(0.299)	(0.313)
Portugal	1.165***	0.998***	0.899***	0.961***
	(0.307)	(0.307)	(0.307)	(0.322)
Slovakia	0.538	0.862*	0.870*	0.503
	(0.450)	(0.451)	(0.452)	(0.478)
Slovenia	0.614	0.271	0.633	0.672
	(0.603)	(0.604)	(0.608)	(0.637)
Spain	0.081	0.082	0.001	0.071
	(0.283)	(0.283)	(0.283)	(0.297)
Sweden	−0.144	−0.003	−0.161	−0.082
	(0.401)	(0.401)	(0.402)	(0.421)
United Kingdom	−3.324***	−4.405***	−4.966***	−4.735***
	(0.773)	(0.779)	(0.787)	(0.829)
Observations	9,789,350	9,714,557	9,408,629	7,987,614
R^2	0.489	0.494	0.499	0.517

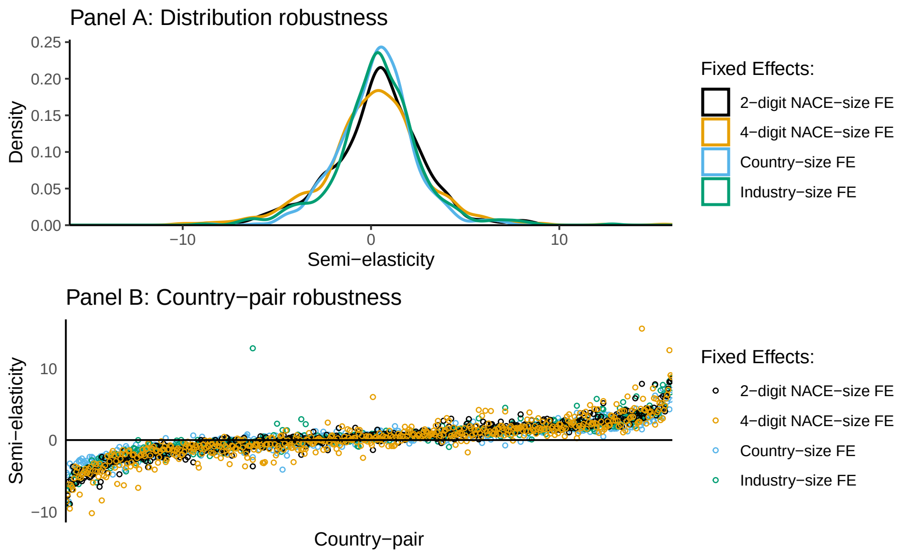
Notes on Table 5: This model re-estimates Table 2 without coarsened exact matching weights. The results are very similar to the model with weights. As before, column titles represent the level at which level interactions with size are calculated: country-size-year fixed effects, country-industry-size-year fixed effects, country-NACE 2-digit-size-year fixed effects, and country-NACE 4-digit-size-year fixed effects. All models include firm fixed effects. The model includes a dummy for the change in the tax system in the United Kingdom, and dummies for changes in transfer pricing regulations in Finland, Greece, and Luxembourg. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Figure 7: Distribution of country-pair elasticities using log profits as dependent variable



Note on Figure 7: 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 8: Summary of country-pair elasticities



Note on Figure 8: This panel extends the estimated semi-elasticities to all four types of year fixed effects estimated at the country average level in Table 2. 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 6: 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

Table 7: Share of total profits with affiliates in partner country (partner 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	0.23	0.00	0.14	0.26	0.22	0.17	0.04	0.15	0.21	0.21	0.48	0.11	0.14	0.26	0.66	0.13	0.15	0.42	0.07	0.26	0.16	0.12	0.21	0.27	0.10	0.26
BG	0.20	0.10	0.00	0.19	0.10	0.07	0.02	0.12	0.10	0.12	0.21	0.10	0.17	0.14	0.32	0.09	0.10	0.12	0.07	0.14	0.09	0.05	0.21	0.17	0.09	0.12
HR	0.14	0.10	0.08	0.13	0.10	0.10	0.01	0.07	0.09	0.08	0.16	0.06	0.00	0.18	0.33	0.07	0.08	0.07	0.03	0.07	0.08	0.05	0.14	0.14	0.20	0.12
CZ	0.29	0.21	0.15	0.00	0.19	0.17	0.03	0.12	0.18	0.17	0.34	0.09	0.16	0.38	0.62	0.12	0.15	0.37	0.10	0.18	0.22	0.09	0.29	0.26	0.15	0.42
DK	0.12	0.13	0.04	0.17	0.14	0.00	0.03	0.08	0.18	0.13	0.25	0.08	0.10	0.20	0.53	0.07	0.13	0.25	0.09	0.16	0.10	0.07	0.12	0.28	0.06	0.16
EE	0.06	0.05	0.03	0.10	0.08	0.10	0.00	0.03	0.19	0.08	0.14	0.04	0.05	0.08	0.13	0.03	0.24	0.09	0.20	0.03	0.06	0.03	0.06	0.20	0.04	0.08
FI	0.15	0.14	0.10	0.15	0.15	0.15	0.06	0.08	0.00	0.13	0.28	0.08	0.10	0.19	0.58	0.08	0.11	0.21	0.08	0.15	0.11	0.07	0.13	0.33	0.07	0.19
FR	0.26	0.28	0.14	0.30	0.25	0.19	0.04	0.26	0.23	0.00	0.53	0.11	0.17	0.39	0.69	0.18	0.17	0.47	0.09	0.27	0.20	0.19	0.23	0.30	0.12	0.28
DE	0.36	0.27	0.18	0.39	0.00	0.26	0.04	0.24	0.24	0.21	0.52	0.12	0.20	0.47	0.68	0.18	0.19	0.46	0.09	0.28	0.25	0.14	0.32	0.33	0.19	0.32
GR	0.15	0.13	0.06	0.13	0.10	0.11	0.01	0.14	0.10	0.13	0.27	0.00	0.10	0.14	0.56	0.13	0.04	0.27	0.04	0.18	0.09	0.09	0.14	0.15	0.07	0.15
HU	0.24	0.17	0.10	0.30	0.17	0.15	0.03	0.14	0.18	0.15	0.30	0.09	0.11	0.00	0.48	0.10	0.13	0.32	0.06	0.21	0.15	0.11	0.26	0.21	0.12	0.28
IT	0.31	0.25	0.19	0.35	0.25	0.19	0.03	0.27	0.21	0.21	0.47	0.13	0.20	0.47	0.67	0.00	0.16	0.45	0.06	0.27	0.23	0.17	0.33	0.29	0.16	0.31
LV	0.08	0.05	0.05	0.10	0.09	0.09	0.11	0.03	0.16	0.06	0.12	0.04	0.05	0.10	0.12	0.03	0.26	0.05	0.00	0.04	0.07	0.03	0.06	0.20	0.04	0.09
LT	0.07	0.07	0.04	0.12	0.05	0.06	0.10	0.03	0.18	0.07	0.11	0.04	0.07	0.09	0.18	0.03	0.00	0.04	0.20	0.06	0.10	0.04	0.06	0.16	0.03	0.09
LU	0.14	0.17	0.07	0.16	0.12	0.06	0.01	0.12	0.05	0.14	0.25	0.06	0.09	0.23	0.54	0.08	0.09	0.00	0.05	0.15	0.10	0.10	0.12	0.12	0.05	0.11
NL	0.25	0.25	0.21	0.33	0.25	0.22	0.05	0.27	0.22	0.19	0.54	0.12	0.16	0.47	0.68	0.17	0.17	0.47	0.09	0.00	0.19	0.24	0.25	0.30	0.12	0.36
PT	0.19	0.16	0.08	0.17	0.16	0.15	0.02	0.26	0.13	0.17	0.31	0.11	0.15	0.21	0.61	0.13	0.11	0.35	0.04	0.14	0.13	0.00	0.17	0.18	0.09	0.19
SK	0.25	0.15	0.13	0.36	0.15	0.12	0.02	0.11	0.12	0.14	0.23	0.10	0.17	0.29	0.59	0.09	0.12	0.17	0.09	0.15	0.15	0.08	0.23	0.16	0.12	0.00
SI	0.16	0.09	0.07	0.14	0.09	0.07	0.01	0.06	0.08	0.09	0.16	0.05	0.30	0.17	0.27	0.06	0.06	0.04	0.03	0.17	0.07	0.05	0.18	0.08	0.00	0.14
ES	0.24	0.25	0.14	0.26	0.23	0.18	0.03	0.00	0.22	0.21	0.49	0.12	0.11	0.30	0.66	0.19	0.15	0.45	0.07	0.26	0.19	0.28	0.22	0.27	0.13	0.28
SE	0.22	0.21	0.10	0.25	0.22	0.26	0.06	0.15	0.28	0.17	0.41	0.10	0.14	0.29	0.65	0.12	0.18	0.41	0.14	0.18	0.16	0.09	0.19	0.00	0.11	0.24
GB	0.29	0.28	0.21	0.33	0.27	0.27	0.06	0.29	0.25	0.22	0.00	0.20	0.19	0.48	0.73	0.20	0.15	0.49	0.09	0.30	0.21	0.17	0.31	0.34	0.14	0.30

Table 8: Percent change in corporate tax revenue resulting from a 1 percentage point reduction in tax rate (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	-0.07		-0.34	0.08	-0.07	-0.14	-0.00	-0.24	-0.36	-0.11	-0.03	-0.49	-0.02	0.76	-2.05	-0.04	-0.10	-0.21	-0.15	0.46	-0.13	-0.09	-0.88	-0.24	-0.17	0.13
BG	0.51	0.28		-0.39	0.18	0.05	-0.00	0.52	-0.50	-0.09	0.57	-0.13	0.50	-0.29	1.18	0.16	-0.03	0.48	-0.29	0.66	-0.10	-0.08	-1.66	0.39	-0.18	0.17
CZ	-0.65	0.57	-0.02		0.25	-0.34	-0.03	-0.33	-0.21	0.01	-0.03	-0.23	-0.67	-1.08	-0.22	-0.23	-0.31	-0.14	-0.08	0.44	-0.20	-0.16	-0.69	-0.01	-0.42	-0.19
DE	-0.11	-0.21	-0.25	-0.54		-0.29	-0.03	-0.12	-0.07	-0.24	-0.39	-0.10	-0.27	-0.34	-0.99	-0.10	-0.19	-0.49	-0.07	-0.22	-0.07	-0.20	-0.55	-0.08	-0.25	-0.30
DK	-0.23	-0.28	-0.16	-0.66	0.15		-0.11	-0.41	-0.79	0.02	-0.49	-0.67	-0.84	-0.76	1.34	-0.30	0.04	-0.63	-0.28	0.18	-0.64	-0.30	-0.83	0.07	-0.14	-0.97
EE	-0.23	0.13	0.02	0.10	-0.08	0.04		-0.01	-0.05	0.34	-0.08	0.06	-0.13	-0.04	-1.02	0.01	-0.29	-0.24	0.28	-0.00	-0.14	0.03	-0.17	-0.17	-0.14	0.22
ES	0.06	-0.02	-0.02	-0.42	-0.42	-0.08	-0.02		-0.02	0.42	-0.56	0.11	0.07	0.14	-0.45	-0.15	0.08	0.64	-0.01	0.04	-0.20	0.04	0.07	-0.08	-0.08	0.02
FI	0.04	-0.08	0.13	0.29	0.08	-0.27	0.03	0.13		-0.16	-0.07	-0.08	0.10	-0.40	-1.62	-0.01	-0.04	-0.24	-0.05	-0.61	-0.09	0.12	-0.03	-0.81	-0.06	-0.07
FR	0.30	-0.09	-0.01	-0.80	0.26	-0.04	-0.06	-0.22	-0.00		-0.32	-0.36	-0.08	-0.46	0.18	-0.27	-0.21	0.52	-0.16	-0.18	-0.28	-0.55	-0.58	0.36	-0.11	-0.85
GB	0.10	1.28	1.37	1.56	1.42	0.86	0.27	1.47	0.79	0.45		1.13	1.01	2.83	1.12	1.03	0.72	1.16	0.40	-0.51	1.25	1.47	2.74	1.65	0.59	0.78
GR	0.07	0.18	0.02	0.23	0.15	0.25	0.01	0.02	0.17	0.23	1.11		0.25	0.02	1.93	0.10	-0.03	0.12	-0.01	0.54	-0.05	0.04	0.13	0.05	0.07	0.41
HR	0.30	-0.07	-0.04	0.36	0.14	0.02	0.02	0.16	0.09	0.21	-0.15	-0.13		-0.67	-0.62	-0.27	-0.02	0.28	0.02	-0.18	-0.02	0.07	-0.28	0.08	-0.25	-0.18
HU	0.56	0.11	0.56	0.30	0.11	0.41	0.10	0.17	-0.30	-0.15	0.92	0.19	0.78		-2.82	-0.00	-0.08	1.12	0.05	0.81	0.69	-0.06	-0.59	-0.26	0.37	0.49
IT	0.84	0.30	-0.16	-0.66	0.07	-0.57	-0.08	-0.41	0.43	-0.20	-0.53	-0.17	-0.40	0.18	-2.68		-0.31	-1.09	-0.04	-0.66	0.19	-0.31	-0.07	0.31	-0.22	-1.17
LT	0.43	0.27	0.13	-0.09	0.26	0.08	0.20	0.13	0.04	0.41	0.30	0.08	0.31	0.20	0.65	0.01		0.11	0.41	0.05	0.09	0.03	0.14	0.42	0.08	0.12
LU	-0.16	-0.44	-0.16	-0.28	-0.05	-0.20	-0.03	-0.07	0.01	-0.06	-0.48	-0.12	-0.06	0.11	-0.02	-0.11	-0.15		-0.13	-0.20	-0.12	-0.20	-0.29	-0.23	-0.04	-0.06
LV	-0.08	-0.20	-0.20	-0.09	-0.12	-0.17	-0.32	-0.10	0.18	-0.08	-0.40	-0.12	-0.16	-0.07	-0.26	-0.09	-0.98	-0.13		-0.10	-0.12	-0.12	-0.19	0.10	-0.06	-0.02
NL	-0.87	0.19	-0.91	-0.54	0.12	1.68	-0.08	0.23	0.46	0.26	0.16	-0.24	-0.31	-0.89	-0.07	-0.33	-0.50	-1.01	-0.18		-0.48	0.25	0.96	-0.57	0.31	1.06
PT	-0.05	0.00	-0.03	-0.06	-0.07	-0.08	-0.01	-0.36	-0.05	-0.14	-0.03	-0.13	-0.09	-0.16	-0.10	-0.19	-0.06	-0.23	-0.02	-0.04	-0.12		-0.09	-0.05	-0.05	-0.01
SE	0.11	-0.01	0.15	-0.33	0.31	-0.23	0.10	0.11	-0.64	0.05	-0.58	0.32	0.38	0.50	-1.81	0.15	-0.18	0.01	0.35	-0.09	0.38	0.22	0.25		0.02	0.20
SI	-0.53	-0.01	-0.09	-0.44	0.00	-0.16	-0.01	0.05	-0.15	0.03	-0.29	0.00	-0.59	-0.81	-0.28	0.04	-0.03	0.01	-0.00	-0.51	-0.20	-0.06	-0.11	-0.31		-0.23
SK	-0.04	0.13	-1.05	-1.56	0.01	-0.04	-0.06	-0.13	-0.33	-0.03	-0.00	-0.35	-0.67	-0.79	1.29	0.10	-0.43	0.41	-0.24	-0.66	-0.33	-0.07	-1.43	-0.47	-0.72	