

Home or away? Profit shifting with territorial taxation[☆]Dominika Langenmayr^a, Li Liu^{b,1}^a KU Eichstätt-Ingolstadt and CESifo, Ingolstadt School of Management, Auf der Schanz 49, 85049 Ingolstadt, Germany^b International Monetary Fund, 1900 Pennsylvania Avenue, Washington, DC 20009, United States

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ABSTRACT

In 2009, the United Kingdom abolished the taxation of profits earned abroad and introduced a territorial tax system. Under the territorial system, firms have strong incentives to shift profits abroad. Using a difference-in-differences research design, we show that the profitability of UK subsidiaries in low-tax countries increased after the reform compared to subsidiaries of non-UK multinationals in the same countries by an average of 2 percentage points. The shifted profits originate largely in the UK headquarters and its domestic affiliates, not in other high-tax affiliates.

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1. Introduction

Although it already was a top priority of the international tax policy agenda since the global financial crisis of 2008, tackling tax avoidance by multinational corporations has become ever more pressing for many governments with budgets strained after the COVID-19 crisis. At the forefront is the G20/OECD initiative on Base Erosion and Profit Shifting (BEPS), which now involves close to 140 countries under the umbrella of the Inclusive Framework.² It aims to develop approaches that limit the options for multinational corporations to shift profits to low-tax countries and thus to collect more tax revenue, recognizing that many aspects of the current tax system are outdated and can inadvertently facilitate BEPS.

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E-mail addresses: dominika.langenmayr@ku.de (D. Langenmayr), lliu@imf.org (L. Liu).

² OECD (2020a,b).

The unprecedented political effort to address profit shifting is paralleled by growing empirical research on this topic.³ The majority of this research focuses on differences in cross-border statutory corporate tax rates as the primary driver of profit shifting.⁴ We complement this literature by examining a more fundamental aspect of the tax system: the system of taxation for foreign earnings of multinational firms. Some countries tax the worldwide earnings of resident corporations (a *worldwide* tax system), whereas others exempt foreign earnings (a *territorial* tax system). Compared to the worldwide system, territorial taxation of multinationals is associated with greater incentives for outward profit shifting. Many countries have moved from a worldwide to a territorial tax system in the last two decades, the latest being the US with the 2017 Tax Cuts and Jobs Act (TCJA).⁵ All G7 countries (and most of the OECD countries) now tax their multinationals with a territorial approach. However, the global minimum tax, agreed on as part of the OECD BEPS initiative, can apply top-up taxes in the home countries of multinational firms

³ For recent surveys on the BEPS literature see, for example, Hines (2014), Riedel (2018), and Dharmapala (2019).

⁴ Other research has also explored cross-border differences in withholding tax rates that enable tax treaty shopping, as well as avoidance of residence country taxation under the worldwide system through tax deferral and corporate inversions and location of headquarters.

⁵ The US territorial regime comes with an important qualifier, however, as US companies face a 10.5% minimum tax on global intangible low-taxed income, defined as global profits above 10% of tangible capital.

up to a level of 15 %, thus partially reversing the global trend towards territorial taxation. Despite the significance of these reforms, there is little empirical research quantifying the impact of territorial taxation on BEPS.

We provide the first evidence on the causal effect of territorial taxation on the level of reported profits by multinationals, exploiting a 2009 policy reform in the United Kingdom (UK). Prior to the reform, foreign income of UK multinationals was liable to domestic taxation upon repatriation with a tax credit for foreign taxes (i.e. the UK had a worldwide tax system). The 2009 reform exempted foreign-source dividends received by UK multinationals from domestic taxable income, moving the UK to a territorial system. The reform generated greater incentives for outbound profit shifting for UK-based multinationals: under the former worldwide regime, profit shifting only deferred the tax payment until the income was repatriated. Under the current territorial tax system, profit shifting lowers the tax payment permanently.

To examine the implication of territorial taxation on profit shifting, we use data on more than 50,000 multinational affiliates in Europe and employ a difference-in-differences research design. The treatment group comprises affiliates of UK multinationals, and the control group affiliates of non-UK multinationals in the same country and year. If the UK affiliates are active in a country with a lower tax rate than the UK, we expect them to report a higher level of pre-tax profit after 2009. Our findings confirm this hypothesis, indicating that profitability (measured by earnings before tax relative to total assets) increased by 1.7–2.1 percentage points, or an 11% increase in pre-tax earnings. This is a large effect, equivalent to a seven percentage point increase in the statutory corporate income tax rate in the UK. Further analysis suggests that firms with high levels of intangible assets react especially strongly, given that costs associated with profit shifting via royalty payments on intellectual property are relatively low. To confirm that indeed profit shifting is driving the results, we conduct placebo tests with UK multinationals that have only affiliates in countries with a higher tax rate than the UK (where firms thus have no incentive to shift profits), and find no effect.

We also ask where the additional profits in low-tax countries originate. Using consolidated data on the global profitability of UK multinationals (with domestic UK companies as the control group), we find no effect of the reform, indicating that the effect found on the affiliate level does not arise because of higher profitability of UK multinationals in general. Returning to the affiliate-level data, we find little evidence that profits are shifted away from high-tax countries outside of the UK. Instead, most profits that are additionally shifted to low-tax countries originate in the UK headquarter and its domestic affiliates.

Our results have important implications for policymakers. For the reforming country, they highlight that countermeasures against profit shifting should accompany the introduction of a territorial tax system. Indeed, U.S. politicians cited concerns about outward profit shifting under a territorial tax system as the justification for the various anti-avoidance measures that accompanied the territorial tax reform. At the same time, the U.S. tax reform also decreased the federal corporate tax rate substantially, from 35% to 21%, which alleviates the incentives to shift profits abroad. For countries that aim to use their tax system to attract real investment or book profits, our results highlight the potentially intensified pressure on lowering their statutory tax rates. On a global scale, the empirical evidence lends support to the introduction of a minimum tax on outbound investments of multinational firms to alleviate profit shifting and tax competition.⁶

⁶ Although countering profit shifting and tax competition should also be carefully balanced against distortion to real tangible investment by multinationals.

Our paper contributes to several lines of literature on taxing multinational firms. First, we add to the literature that compares the territorial and worldwide tax systems in terms of economic efficiency. In a groundbreaking theoretical analysis, Peggy Musgrave (née Richman) suggested that worldwide taxation, when implemented in its pure form, achieves “capital export neutrality” (CEN): As the tax burden is independent of the location of earnings, it does not distort the allocation of capital across jurisdictions (Richman, 1963). However, CEN is not robust to deferral and inversion; and it is never fully achieved because there is no refund when foreign tax credits exceed home tax liabilities. Territoriality, by contrast, provides for “capital import neutrality” (CIN), meaning that all investments in a particular country face the same tax rate, regardless of their source. Desai and Hines (2003, 2004) have pointed out that a territorial tax system is optimal if foreign production takes place in addition to (and not instead of) domestic production.⁷ Becker and Fuest (2011) compare these arguments and highlight that higher compliance costs in a worldwide tax system may also pose an argument in favor of territorial taxation. More recently, Devereux et al. (2015) synthesize and extend the literature, showing that a cash-flow tax and a worldwide tax system ensure both the optimal allocation of mobile factors and efficient foreign investment. In practice, however, it is impossible to ensure all dimensions of tax neutrality without fully harmonized tax systems (IMF, 2019).

Empirical studies have analyzed the impact of a change in the international tax regime on various margins of firm behavior, including on dividend repatriation (Egger et al., 2015; Hasegawa and Kiyota, 2017), cash holding/dividend payout (Arena and Kutner, 2015), real investment (Liu, 2020), tax management (Kohlhase and Pierk, 2020) and mergers and acquisitions (Feld et al., 2016).⁸ Focusing on international transfer mispricing as a particular channel of profit shifting, Liu et al. (2020) find that the UK territorial tax reform reduced transfer prices on UK exports to low-tax countries by more than one third. Azémar and Dharmapala (2019) show that introducing a territorial tax system does not affect the value of tax sparing agreements (which prevent host country tax incentives from being nullified by home country taxes).⁹

We contribute to the more general literature on profit shifting by multinational companies, recently surveyed by Dharmapala (2014), Heckemeyer and Overesch (2017) and Beer et al. (2020). Studies have provided evidence for profit shifting using tax rate changes (e.g. Huizinga and Laeven, 2008; Weichenrieder, 2009; Buettner and Wamser, 2013) or firm-level earnings shocks (Dharmapala and Riedel, 2013) for identification. We use a more discrete change in profit shifting incentives that follow from abolishing the worldwide tax system.¹⁰ Clausing (2003, 2009) and Desai et al. (2006) provide evidence for profit shifting and deferral in coun-

⁷ “Capital ownership neutrality” (CON) is another important concept, meaning that taxes do not distort the ownership of capital. It is achieved either by global adoption of a territorial system or of a worldwide system with tax credits.

⁸ Before the 2009 tax regime changes in the UK and Japan, several studies attempted to infer the effects of the worldwide vs. territorial tax systems by comparing firm behavior in countries with a worldwide tax system with that in countries with a territorial tax system. Maffini (2012) and Markle (2016) show that there is less tax avoidance in a worldwide system. Differences between multinationals domiciled in territorial and worldwide countries have also been found along other dimensions, such as the location of foreign direct investment (Hines, 1996; Clausing and Shaviro, 2011), headquarter relocations (Voget, 2011), and subsidiary location choices (Barrios et al., 2012).

⁹ There is also a literature studying tax-repatriation holidays, which are similar to a temporary switch to a territorial tax system, see e.g. Dharmapala et al. (2011) on domestic investment and Flaaen (2017) on transfer mispricing.

¹⁰ Multinational companies in countries with a worldwide tax system often postpone repatriation of foreign earnings to avoid paying home-country corporate income taxes – a practice known as “deferral”. As of 2015, US multinationals were estimated to have accumulated \$2.6 trillion in undistributed earnings overseas (JCT, 2015). In the UK, foreign earnings were often returned to multinationals’ parent companies as loans, but the US taxes these transactions as “constructive dividends”.

tries with worldwide tax systems.¹¹ Lastly, we briefly also consider the effects of profit shifting on total factor productivity, thus joining a growing empirical literature that examines the real effects of international tax avoidance on multinationals' investment and employment (Overesch, 2009; de Mooij and Liu, 2020; de Mooij and Liu, 2021; Suárez Serrato, 2018), and on country-level aggregate productivity growth (Guvenen et al., 2022).

This paper proceeds as follows. Section 2 provides some background information on the worldwide and territorial tax systems implemented in the UK before and after 2009 and a simple model to clarify the effects on profit shifting. Section 3 describes the data set and gives some descriptive evidence. Section 4 presents the empirical strategy, and Section 5 our results. Section 6 concludes.

2. Institutional background

2.1. Taxation of foreign earnings in the UK

Pre-2009 Worldwide Regime. Until 2009, the UK taxed the worldwide profits of firms headquartered in the UK with deferral. Under this *worldwide tax system*, foreign profits of UK multinationals were taxed at the domestic rate when repatriated as dividend payments to the parent company in the UK. British firms obtained a credit for taxes paid in foreign countries to avoid double taxation, and the amount of the foreign tax credit was capped at the UK tax liability on those earnings. Thus, in principle, firms' tax burden was determined by the UK tax rate and did not depend on the country where the profits were generated (as long as the foreign tax rate was lower than the UK tax rate). However, the UK deferred the taxation of foreign income until the firm repatriated the profits.

Post-2009 Territorial Regime. In 2009, the UK moved to a *territorial tax system*, which excludes profits that a British firm receives from foreign subsidiaries from domestic taxable income. Thus, all income earned abroad is exempted from UK profit taxes. Foreign affiliates of UK multinationals pay profit taxes only in the country where production takes place. The exemption is 100% for a wide range of foreign-source dividends, including profits accumulated before the introduction of the new legislation. Unlike the recent move in the US toward a more territorial system following the passage of the TCJA, the UK reform did not impose any deemed tax on unrepatriated profits or any minimum tax without deferral on profits earned abroad.¹²

The UK tightened its controlled foreign company (CFC) regime in response to the reform. However, the new CFC regime only took effect in January 2013 (after our period of analysis ends). Under the existing CFC regime at the time of territorial reform, both active and passive income were liable to UK taxation for subsidiaries deemed CFCs. However, there were a series of exemptions from being defined as a CFC, including an exemption for actively trading subsidiaries. One way to avoid UK taxes was to mix passive income with active income in a trading subsidiary so that the former went untaxed in the UK. The reformed CFC rule makes all passive income

liable to UK taxation, including all passive income in active subsidiaries. The reform of the CFC regime, however, was perceived as hurting the ability of the UK to attract multinational corporations and therefore only implemented in 2013.

Expected impact on profit shifting. Under the worldwide tax system, shifting profit abroad only defers the tax payment until the income is repatriated. Permanently avoiding taxation in the home country is only possible if there is a tax holiday, either temporarily or permanently (by switching to a territorial tax system). Thus, incentives to shift profits abroad should be stronger under a territorial tax system than under a worldwide tax system – a point we show more rigorously in the short model below. This insight holds both for shifting profits from home to a low-tax country, as well as for shifting profits from higher-tax to lower-tax subsidiaries. Tax payments on reported profits in high-tax countries become less valuable as they cannot offset additional UK taxes on repatriations from low-tax countries; and at the same time, some portion of tax savings that were (re)captured by the UK treasury now go to UK multinationals. All these considerations point to a higher reported profitability in low-tax countries, and a possibly lower reported profitability in high-tax countries.

A higher reported pre-tax profitability would capture stronger profit shifting through several main channels, of which the literature has established three. First, firms can manipulate prices on internal transactions so that low-tax affiliates make higher profits (transfer mispricing). Second, firms can relocate intellectual property to low-tax jurisdictions. When other subsidiaries use these technologies, they pay (potentially artificially increased) fees, again shifting profits there (relocation of intellectual property). Third, firms can borrow from low-tax affiliates, relocating profit to those affiliates via interest payments (debt shifting).

2.2. A simple model of profit shifting with tax regime change

This section develops a simple model that shows how a shift from a worldwide tax system to a territorial tax system increases incentives for profit shifting by multinational corporations (MNCs). We start from a modified version of the model based on Hines and Rice (1994) and Grubert (1998), and additionally model repatriation taxes.

Basic setup. Consider an MNC with headquarter in country h and affiliates in n countries. Let ρ_i present economic profits earned in each country by real factors located there. The MNC engages in profit shifting and allocates an additional amount π_i of profits from the headquarter to affiliates in country i , or vice versa.¹³ The cost of reporting a profit that is different from true profit rises quadratically in the degree of profit shifting:

$$C_i = \frac{\lambda}{2} \frac{(\pi_i)^2}{\rho_i},$$

where $\lambda > 0$ captures the strength of tax enforcement. These costs can be interpreted as various forms of real-world costs of profit shifting. They may stand for the real resource costs of tax lawyers and accountants, for expected fines and court costs arising from litigation with the tax authorities, or for the loss of efficiency that

¹¹ Worldwide taxation also makes countries less attractive as a place for locating headquarters and disadvantages their firms when bidding for foreign assets against firms from territorial countries. To escape home-country tax, multinational companies may "invert" – that is, reincorporate or seek acquisition by a company headquartered in a territorial country.

¹² The TCJA created a modified territorial tax system by introducing several provisions to reduce the extent of profit shifting under the new regime. The minimum tax on Global Intangible Low-Tax Income (GILTI) imposes a 10.5% minimum tax without deferral on foreign profits that exceed a firm's "normal" return (defined in the law as 10% on the adjusted basis in tangible property held abroad). The new base erosion and anti-abuse tax (BEAT) sets a minimum tax on otherwise deductible payments between a US corporation and a foreign affiliate. To transition to the new system, the TCJA also created a new deemed repatriation tax for previously accumulated and untaxed earnings of foreign affiliates of US firms, which is 15.5% for cash and 8% for illiquid assets.

¹³ Thus, by assumption, we exclude profit shifting among affiliates. If we set up the model so that there is profit shifting among affiliates (e.g. in a three-country version), predictions for the low-tax affiliates change little. However, the model would make different predictions for high-tax affiliates: Profits in these affiliates would then go down after introducing a territorial tax system, as their incentive to shift profits to the low-tax country increases. Under a worldwide tax system, it did not matter if the high-tax affiliate shifted profits to the UK or to the low-tax affiliate, because profits would be taxed at the UK tax rate later anyways. For simplicity, we present the model without profit shifting among affiliates. Its predictions also capture well the empirical results presented in Section 5.1.

results from setting up structures (e.g. new affiliates to administrate intellectual property) purely for tax reasons.

While MNCs can decide where to report their book profits, they can only pay out dividends to shareholders or reinvest at home if profits have been repatriated to the headquarter. Under the worldwide system, firms pay dividend taxes τ_h^{repat} on earnings repatriation. Foreign taxes are credited against this tax, so that the total tax burden on foreign profits is $\max(\tau_h^{\text{repat}}, \tau_i)$. The tax burden on foreign profits (τ_h^{repat}) may be lower than the profit tax rate at home (τ_h) also under a worldwide tax system, e.g. because the repatriation tax has to be paid only later, when profits are indeed repatriated. In a territorial system, there are no additional taxes on foreign repatriations, so $\tau_h^{\text{repat}} = 0$. Assume that profit shifting costs are not tax deductible.¹⁴ The after-tax profits for the MNC are given by:

$$\Pi = (1 - \tau_h) \left[\rho_h - \sum_{i=1}^n \pi_i \right] + \sum_{i=1}^n (1 - \max(\tau_h^{\text{repat}}, \tau_i)) [\rho_i + \pi_i] - \sum_{i=1}^n \frac{\lambda}{2} \frac{(\pi_i)^2}{\rho_i}. \quad (1)$$

Optimal Profits Shifted. Taking the first-order condition with respect to π_i , we derive:

$$\frac{\pi_i}{\rho_i} = \frac{\tau_h - \max(\tau_h^{\text{repat}}, \tau_i)}{\lambda}. \quad (2)$$

The optimal amount of profits shifted, in proportion to economic profit, depends on the tax differential between the two countries, as well as the strength of tax enforcement. The total profits reported in country i , i.e. $\rho_i + \pi_i$, relative to the true economic profits, is $1 + \frac{\pi_i}{\rho_i}$.

Proposition 1 (Optimal Reported Profitability). Relative to the economic profits ρ_i ,

- (i) under a territorial tax system, the optimal reported profits increase in the tax differential $\tau_h - \tau_i$,
- (ii) under a worldwide tax system, the optimal reported profits increase in the adjusted tax differential $\tau_h - \max(\tau_h^{\text{repat}}, \tau_i)$. If $\tau_h^{\text{repat}} = \tau_h > \tau_i$, no profit is shifted abroad.

Proof. Follows directly from Eq. (2).

Due to the repatriation tax, shifting profits abroad is less tax efficient for the MNC under worldwide taxation, as profit shifting only allows to defer the tax payment to the future (when profits are repatriated). Therefore, the difference in the statutory tax rates distorts reported profits less under worldwide taxation. A shift from a worldwide system with deferral to a territorial system therefore increases the incentive for profit shifting to low-tax countries.

Proposition 2 (Tax Reform and Reported Profitability, Main Prediction). There is more profit shifting under a territorial tax system than under a worldwide tax system: $\frac{\pi_i}{\rho_i}(\tau_h^{\text{repat}} > 0) < \frac{\pi_i}{\rho_i}(\tau_h^{\text{repat}} = 0)$.

Proof. Follows directly from Eq. (2).

¹⁴ Results are qualitatively the same when the profit shifting costs are instead tax deductible in one of the countries (see Appendix A.1).

3. Data and descriptive analysis

3.1. Affiliate-level data

Our empirical analysis uses affiliate-level information on the financial statements of multinational firms' and their subsidiaries from Bureau van Dijk's Amadeus database. This database includes unconsolidated balance sheet information and ownership data for a large sample of European firms. Our sample includes subsidiaries in most European Union countries (see Appendix Table A.2), as well as information on their ultimate parent companies. We include a subsidiary if at least 50% of its shares are (directly or indirectly) held by the ultimate owner company.

The Amadeus database provides consistent information on a large number of firms in Europe, but it does not include the zero-tax havens.¹⁵ Thus, our paper can only show that multinationals shift profits, but will underestimate the *magnitude* as most tax avoidance occurs with tax haven counterparties (Davies et al., 2018). Our results are also informative when one is interested in the magnitude of profit shifting among affiliates set up for non-tax purposes.

The initial sample consists of multinational companies from 2006 to 2012. We exclude companies from the finance industry and public utilities, as these firms are highly regulated and face different tax avoidance incentives and opportunities. Moreover, we drop observations if their industry classification is missing or if they have a zero or negative value for assets or employees.¹⁶ Our final sample is an unbalanced panel with 305,086 firm-year observations for 57,136 unique firms.

Our main sample of interest refers to firms that are active in a country with a lower tax rate than the UK in all years in which we observe the firm. We refer to these observations as "low-tax". As both the UK and other countries changed their tax rates during the sample period, we determine the "low-tax" status based on the individual affiliate. All observations from Austria, Bulgaria, Czech Republic, Estonia, Finland, Greece, Hungary, Ireland, Netherlands, Poland, Romania, Slovenia and Sweden are thus "low-tax", as well as some observations from Portugal (depending on how long they are in the sample). In placebo tests, we study firms that are active in a country with a higher tax rate than the UK in all years in which we observe it ("high-tax firms"). All observations from Belgium, France, Germany, Italy, Luxembourg, and Spain are considered "high-tax".

Our main variables are firms' earnings before tax (EBT), operating profit, total assets, intangible assets, the number of workers and turnover. Table 1 provides some descriptive statistics. Low-tax firms in the sample have on average EBT of 870,979 Euro, total assets of 16 million Euro, sales of 19 million Euro and employ 97 workers. For all these variables, the median lies substantially below the mean, indicating that the sample includes a substantial number of smaller affiliates. We winsorize all firm-level ratio variables at the 1% and 99% level in the full sample (low-tax and high-tax combined).

We now discuss our key dependent variables in more detail.

Pre-Tax Profitability. The literature has used different measures of pre-tax reported profitability, e.g. the ratio of EBT to total assets (EBT/Assets, see e.g. Schwarz, 2009; Loretz and Mokkas, 2015) and the natural logarithm of EBT (see e.g. Dharmapala and

¹⁵ Using the corresponding worldwide database by Bureau van Dijk, Orbis, would not solve this problem: Torslov et al. (2018) show that tax haven affiliates are systematically missing in Orbis.

¹⁶ We also rerun the analysis in a larger sample that does not require information on employment. The results (reported in Table A.4) are very similar to the main results. Note that the measurement of employment is not defined by standard accounting rules, so its definition follows other national legislation. For example, in the UK, the Company Act states that companies must disclose the average number of persons employed during the financial year.

Table 1
Summary statistics: affiliate-level.

	Obs.	Mean	Median	Std. Dev.	Min	Max
Low-Tax Observations						
EBT (Euro)	155,076	870,979	31,907	4,802,172	-12,329,598	46,736,000
Operating Profit (Euro)	155,076	889,759	49,091	4,149,189	-9,870,000	38,712,365
EBT/Total assets	155,076	0.04	0.04	2.56	-1.14	0.73
Total assets (Euro)	155,076	16,075,129	1,661,694	63,997,889	13,594	754,076,615
Intangible assets (Euro)	152,169	264,648	94	2,005,064	0	28,187,285
Workers	155,076	97	17	248	1	2,156
Turnover (Euro)	155,076	19,468,500	2,032,027	67,916,729	5,148	675,585,141
High-Tax Observations						
EBT (Euro)	150,010	1,622,421	144,026	7,044,888	-12,329,598	46,736,000
Operating Profit (Euro)	150,010	1,514,149	178,666	5,816,367	-9,870,000	38,712,365
EBT/Total assets	150,010	0.03	0.04	0.20	-1.14	0.73
Total assets (Euro)	150,010	39,501,772	6,692,006	111,567,582	13,594	754,076,615
Intangible assets (Euro)	148,473	1,039,982	12,589	4,074,373	0	28,187,285
Workers	150,010	121	30	287	1	2,156
Turnover (Euro)	150,010	41,859,669	9,015,245	103,072,763	5,148	675,585,141

Notes: Descriptive statistics for the main variables in the affiliate-level dataset used in the regressions. Low-tax (high-tax) observations are firms that are in countries which have a lower (higher) tax rate than the UK in all years in which we observe the firm. All variables are winsorized at the top and bottom 1% level. Data from Amadeus for 2006–2012.

Riedel, 2013; Dischinger et al., 2014).¹⁷ While we report results from both measures in Section 5, we use the former as our preferred measure of profitability. By taking the logarithm of EBT, we would exclude all affiliates with negative and zero EBT from our regressions, even though zero profit may reflect profit shifting in its most aggressive form.

Fig. 1 shows that as a simple feature of the data the distribution of pre-tax profitability has large dispersion and is centred around zero. Around 31% of observations in our data report negative or zero EBT. Despite the fact that accounting profits may be a noisy measure of taxable profit, there is clear evidence of bunching at zero, a phenomenon that has also been documented in other recent studies (Johannessen et al., 2019; Bilicka, 2019; Koethenbuerger et al., 2019; Hopland et al., 2018). In both the low-tax and the high-tax group, more than 5% of companies report a return to assets between 0 and 0.01%. If these are indeed the most tax-aggressive firms, excluding loss-making affiliates from the analysis would lead to downward bias in our results.

3.2. Data on UK parents

We combine the unconsolidated data with information on consolidated financial statements of UK-based corporations obtained from Thomson Reuters' Datastream database. We merge the two datasets based on the ultimate owner's ISIN number. We are able to successfully merge information on 595 ultimate owners (out of 1,883 parent companies). The matched dataset is an unbalanced panel from 2005 to 2014 with a total of 3,587 firm-year observations with non-missing information on the main regression variables. Due to missing information in Datastream, there are more

observations for more recent years. Table A.3 in the Appendix summarizes how the observations are distributed over time.

Table 2 presents summary statistics for the consolidated firms. On average, the consolidated balance sheets show total assets of 2.3 billion Euro, of which on average 19.6% are intangible assets. The average consolidated firm has 10,599 employees and pre-tax income of 228 million Euro. 43% of these firms have foreign assets, indicating that they are multinational firms.

3.3. Descriptive analysis

We begin our analysis by some simple comparisons of parent firms before and after the UK's change to a territorial tax system in 2009. If UK firms indeed shifted more profits abroad after 2009, we should see that their effective foreign tax burden decreased after 2009. Fig. 2 Panel A plots the density of effective foreign tax rates of UK multinationals. Before 2009, a large number of UK multinationals had an effective foreign tax rate close to the UK tax rate of 29% at the time, which they would have had to pay anyways upon repatriation. After 2009, this bunching partially diffuses. Thus, the distribution of effective foreign tax rates is now more even, with more firms having a lower effective foreign tax rate (at around 20%). While a gradual decline in the statutory CIT rates (Fig. 2 Panel B) may contribute to lower effective tax rate and shift their distribution to the left, the diffusion of bunching around the pre-reform UK tax rate is more clearly associated with the tax regime change.¹⁸

4. Empirical strategy

We have highlighted in Section 2 that our identification relies on the variation in the incentive for outward profit shifting arising from the UK's switch to a territorial tax system. Naturally, our main empirical strategy is a standard difference-in-differences (DiD) approach. We estimate the difference in the reported profitability before and after 2009, comparing affiliates of UK-based multina-

¹⁷ We use the pre-tax income reported in companies' financial statements as a proxy for their taxable income. Pre-tax income may deviate from the true taxable income due to the divergent reporting in financial and tax accounts (book-tax differences). While the book-tax difference adds noise to the measurement of true taxable income, we expect it to have a much smaller impact on the difference-in-differences estimation results as our identification exploits changes in the pre-tax income. Hence, the extent of book-tax difference in absolute level would have little impact on our results.

¹⁸ One may wonder why UK multinationals did not shift all profits to tax havens after the reform. First, most profit shifting strategies require some real activities in the location to which profits are shifted. It is therefore favorable to shift profits also to low-tax countries in which the multinational already had affiliates for non-tax reasons. In addition, firms may want to use the retained earnings obtained via profit shifting to finance investment in the subsidiaries.

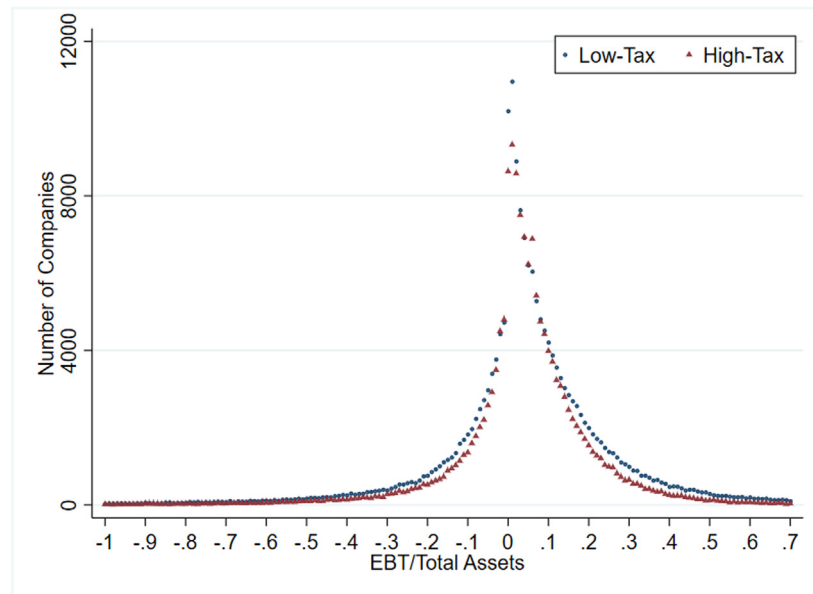


Fig. 1. Distribution of Pre-Tax Profitability.

Notes: Distribution of pre-tax profitability (measured by EBT/total assets) in low-tax and high-tax countries. Data from Amadeus for 2006–2012.

Table 2

Summary statistics: consolidated firms.

	Obs.	Mean	Median	Std. Dev.	Min	Max
Total assets (thous. Euro)	3,587	2,258,277	92,301	13,972,717	13	285,302,595
Intangible assets (thous. Euro)	3,585	442,404	12,713	1,766,721	0	22,357,000
Foreign assets (thous. Euro)	1,544	84,396	3,014	1,062,445	0	40,876,316
Pre-tax income (thous. Euro)	3,587	227,639	3,800	1,831,377	-2,261,516	39,823,617
EBIT (thous. Euro)	3,537	252,244	5,108	1,885,164	-2,112,087	40,265,783
Total Debt (thous. Euro)	3,587	487,068	6,729	2,235,239	0	37,661,580
Employees	3,587	10,599	526	46,760	1	648,254

Notes: Descriptive statistics for the main variables in the consolidated-firm-level dataset for regression analysis. Data from Datastream for 2005–2014.

tionals with affiliates of non-UK-owned multinationals in the same country. Following the discussions in Section 2, UK multinationals in low-tax countries have stronger incentives for outward profit shifting after the reform, whereas profit shifting incentives for non-UK multinationals should remain the same.¹⁹ We thus expect a positive coefficient on the DiD estimator on reported profitability in low-tax countries.

Formally, we test the following regression specification:

$$y_{ikt} = \beta_1 \text{UK} - \text{Parent}_i \times \text{Post}_t + \beta_x X_{ikt} + \beta_z Z_{kt} + \alpha_i + d_t + \epsilon_{ikt}, \quad (3)$$

where y_{ikt} is a measure of profitability of subsidiary i in country k in year t . The key variable of interest is the interaction term $\text{UK} - \text{Parent}_i \times \text{Post}_t$, where $\text{UK} - \text{Parent}_i$ is a dummy indicator that takes the value of one for a UK-owned multinational affiliate, and zero otherwise, and Post_t is a dummy indicator that takes the value of one for all years after 2009. To control for time-invariant subsidiary and parent characteristics, we include a full set of firm-fixed effects (α_i).²⁰ We also control for time-varying input factor

¹⁹ Although all firms in the control group have ultimate owners outside the UK, some of these groups may include holding companies in the UK, as the UK is an attractive location for such firms (van 't Riet and Lejour, 2018). If the reform also increased the outbound profit shifting by UK holding companies (of foreign MNCs), then our identified impact would be a lower bound of the overall impact of introducing territorial taxation on profit shifting.

²⁰ Given that the ownership information in our sample is time invariant, firm fixed effects also subsume host-country fixed effects.

proxies X_{ikt} . In most specifications, these are the natural logarithm of the number of workers and (in the specifications where it is not part of the dependent variable) fixed assets.²¹ We include year dummies (d_t) to capture the effect of aggregate macroeconomic shocks that are common to all companies. In many specifications, we replace the year dummies with time-varying country and industry fixed effects to control for such shocks in a more flexible way.

The firms in our sample have parent companies in different countries. We thus control for some characteristics of these countries, which would, for example, capture aggregate shocks (such as the global financial crisis) that hit parent countries to a differing extent. These home-country control variables Z_{kt} are the inflation rate, GDP per capita, the long-term unemployment rate, and GDP growth. ϵ_{ikt} is the error term.

Common Trends. Our identifying assumption is that in the absence of the territorial tax reform the control firms would have similar trends in reported profitability to the treated firms. While we cannot directly test this assumption, we check whether reported profitability trended similarly in the control and treated firms in the pre-reform period. To validate the empirical design, we extend the DiD analysis to a dynamic specification by estimating the following model:

²¹ We therefore control for the main real factors of production, labor and capital, to identify the impact of taxes on reported profits on top of any changes related to real production. In doing so, we follow a large literature on profit shifting going back to Hines and Rice (1994) and summarized by Dharmapala (2014).

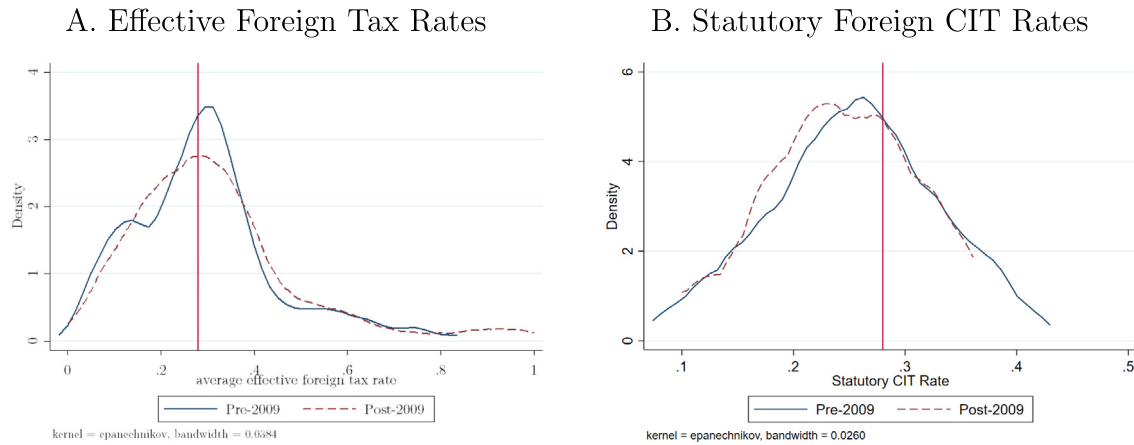


Fig. 2. Density of Parent Firms' Effective Foreign Tax Rate Before and After 2009.

Notes: Panel A: Kernel density of parent firms' effective foreign tax rates pre-2009 (blue line) and post-2009 (dashed red line). Data from Datastream for 2005–2014. Panel B: Kernel density of statutory CIT rates in EU-28, pre-2009 (blue line) and post-2009 (dashed red line). Vertical line marks the UK tax rate of 29%.

$$y_{ikt} = \sum_{\theta=-3}^3 \delta_t \mathbb{1}[t = \theta] \times \text{UK} - \text{Parent}_i + \beta_x X_{ikt} + \beta_z Z_{kt} + \alpha_i + d_t + \epsilon_{ikt}, \quad (4)$$

where $\mathbb{1}[t = \theta]$ is a series of year dummies that equal one when the territorial tax reform is θ years away. Each coefficient δ_t measures the change in profitability for treated firms relative to control firms in the θ -th year before or after the reform became effective in 2009. The omitted time category is $\theta = -1$, so that the estimated effects δ_t are relative to the period prior to the start of the reform. By focusing on the lead variables (i.e., the year dummies leading up to the reform), this specification allows us to check whether there is any evidence of pre-existing trends. In addition, the lag variables (i.e., the year dummies after the reform) illustrate the potential dynamic effects of the reform.

Potential Group-Level Effects. As a step further, we test whether changes in the profitability at the affiliate level are indeed due to profit shifting or merely reflect changes in the overall profitability of UK multinational groups after reform (e.g. because of lower cost of capital due to the lower tax rate, or simply because they were more resilient to the financial crisis). We use the consolidated data and compare UK multinationals with domestic companies in the UK. We estimate the following equation:

$$y_{jt} = \gamma_1 \text{MNC}_j \times \text{Post}_t + \gamma_x X_{jt} + \eta_j + d_t + \epsilon_{jt}, \quad (5)$$

where y is the profitability of the consolidated firm j in year t . In this specification, the main variable of interest is the interaction term $\text{MNC}_j \times \text{Post}_t$, where MNC_j is a dummy variable that is one if the UK company group has foreign affiliates, and Post_t is again a dummy variable that is one for the years after 2009. We add consolidated-firm fixed effects η_j to control for time-constant firm characteristics, and firm-level variables X_{jt} . We also add year dummies d_t to control for overall shocks to the UK economy. With consolidated data capturing the overall profitability of the company group, which should be invariant to inter-company profit shifting, we should not find a significant coefficient for γ_1 in this specification.

5. Results

5.1. Baseline results

Table 3 presents the results of our baseline specification (3), starting by using EBT/Assets as the dependent variable. In Column (1), we estimate a regression by including only firm labor inputs to

control for the remaining real factor of production. We find a positive and highly significant coefficient on the interaction term of 0.019, indicating that UK multinationals indeed shifted more profits to low-tax affiliates after the introduction of the territorial tax system. Column (2) further controls for the scale of output by including the natural logarithm of firm turnover, which leads to a slightly smaller coefficient on the interaction term. By conditioning on the scale of output, the estimation in Column (2) excludes transfer mispricing in goods and services.

In Columns (3) and (4), we add time-varying host country and time-varying industry fixed effects, which also effectively control for the effect of statutory corporate tax rate changes in the host country on profit shifting. The DiD coefficients are almost unaffected, with an estimated value of 0.021 without controlling for turnover, and of 0.017 when controlling for turnover.²² In Column (5), we do not control for employment, to ensure that the correlation between employment and assets is not affecting our results.²³ Doing so does not affect the estimated coefficient relative to the corresponding specification in Column (3).²⁴

Column (6) uses operating profit relative to assets as an alternative dependent variable, to address the possibility that profits of indirectly owned affiliates are duplicated in the pre-tax profits reported by their direct owners. Blouin and Robinson (2019) show that the use of the equity method of accounting leads to double counting of profits by US multinationals in U.S. BEA data, and has cautioned researchers that the same accounting error may lead to biased estimates in other datasets as well, including the financial data from Bureau van Dijk. Indeed, as Bureau van Dijk uses statutory reporting from different countries, whether profits are double counted depends on the accounting rules used in the respective country. In countries that use the same equity method of accounting, reported profits by MNCs with several layers of affiliates would be inflated, especially for those in the upper tier of the ownership chain. As some countries (e.g. Germany) allow for a mix of methods, there is – to our knowledge – no direct way of correcting for this double counting. We thus turn to operating profit, which does not include financial income and any downstream

²² We now also include controls for several characteristics of the MNC parent's home country, including inflation, GDP per capita, long-run unemployment rate, and GDP growth rate.

²³ Note that the correlation between the number of workers and assets is only 0.12.

²⁴ To provide further robustness that controlling for employment does not drive our results, Table A.4 in the appendix replicates Table 3 without this control in a larger sample (which also includes observations with missing data on employment). Results are similar to those in Table 3.

Table 3
Profit shifting after territorial reform: baseline results.

Sample:	Low-Tax								High-Tax
Dependent variable:	EBT/Assets					Operating Profit/Assets	EBT/Assets	ln (EBT)	EBT/Assets
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
UK-Parent \times Post	0.019*** (0.007)	0.017*** (0.006)	0.021*** (0.007)	0.017** (0.007)	0.021*** (0.007)	0.022*** (0.007)	0.012 (0.008)	0.111** (0.045)	0.002 (0.006)
\times High Intangibles							0.019** (0.009)		
ln (Workers)	0.016*** (0.002)	-0.035*** (0.002)	0.016*** (0.002)	-0.035*** (0.002)		0.015*** (0.002)	0.016*** (0.002)	0.309*** (0.014)	0.009*** (0.002)
ln (Turnover)		0.071*** (0.002)		0.070*** (0.002)					
ln (Fixed Assets)								0.092*** (0.007)	
Add. Controls	-	-	✓	✓	✓	✓	✓	✓	✓
Affiliate FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	-	-	-	-	-	-	-
Host Country-Year FE	-	-	✓	✓	✓	✓	✓	✓	✓
Industry-Year FE	-	-	✓	✓	✓	✓	✓	✓	✓
N	155,076	155,076	155,076	155,076	155,076	155,076	155,076	97,357	150,010
R ²	0.491	0.526	0.495	0.529	0.494	0.485	0.495	0.851	0.591

Notes: Data from Amadeus for 2006–2012. Specification (3) to (9) include the following characteristics of the multinational firm's home country: inflation, GDP per capita, long-run unemployment rate, and GDP growth. Standard errors in parentheses are clustered by parent. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

profits. At the same time, operating profit also excludes financial income and financial expenses and therefore all profit shifted via internal debt. The results in Column (6) show that the DiD coefficient is almost unaffected at 0.022, and thus remains robust to the potential double counting of profits for some affiliates in our dataset.²⁵ Note that this result also indicates that profit shifting via internal debt is of minor importance.²⁶

Next, we interact our main coefficient of interest with an indicator variable that is one if the multinational firm has above-median intangible assets to see which firms react the strongest. Column (7) shows that firms with high levels of intangibles reacted more strongly, consistent with the notion that firms with high intangible assets have more leeway to shift profits because it is difficult to find comparable prices. We explore the heterogeneity of results further in Appendix A.2.

We next focus on profitable affiliates. To do so, we use the natural logarithm of earnings before tax ($\ln(EBT)$) as the dependent variable. This specification allows interpreting the estimated coefficient as a tax semi-elasticity and facilitates comparison with the wider literature on profit shifting. Column (8) reports the results, showing that among affiliates with positive pre-tax earnings, on average their EBT increases by 11% following the territorial tax reform. In comparison, the estimated coefficient in column (3) suggests that on average the pre-tax EBT (scaled by total assets, with a pre-reform mean of 0.06 for UK-owned firms) increases by 35% for the full sample, an effect that is three times larger than when only focusing on the profitable affiliates.

Placebo Tests. The validity of our main results in Table 3 relies on the assumption that there were no differential trends from the treated and control firms in the pre-reform period. To verify this

assumption, we carry out a dynamic DiD and estimate Eq. (4). We use the specification from Table 3, Column (3), as it allows for profit shifting through a broad range of channels while controlling for country-specific and industry-specific time-varying shocks.

Fig. 3 plots the estimated coefficients on these dummies and shows the 90% confidence intervals. The coefficients can be interpreted as the differential changes in pre-tax profits reported by UK-owned multinational affiliates, relative to the non-UK affiliates, as compared to the last year prior to the implementation of the territorial reform. As the graph shows, the parallel pre-trend on pre-tax profitability between the treated and control firms is satisfied, as the coefficient estimates are close to zero prior to the reform. Moreover, positive and statistically significant coefficients from 2009 onward indicate that the territorial tax reform induced the low-tax affiliates of UK multinationals to report more profits. The gradual increase in the profitability after the reform is consistent with somewhat delayed responses due to adjustment costs associated with the different channels of profit shifting.²⁷

As an alternative test, we run the specification in Column (3) of Table 3 for affiliates in high-tax countries. In particular, the treatment group only includes high-tax affiliates that are part of a UK MNC group that has no affiliates in low-tax countries. The reported profits of these firms should not be affected by any changes in profit shifting incentives towards low-tax affiliates. Column (9) of Table 3 presents the results. The coefficient of the interaction term is statistically insignificant and close to zero (0.002). This zero result is relatively precisely estimated; its standard error is similar to the other regressions. We can interpret this test as a placebo test, as there is no incentive to shift profits from the UK to high-tax countries.

5.2. Where is the shifted profit coming from?

To investigate this question, we first turn to the results with the consolidated data and compare UK multinationals to UK domestic firms. These tests also allow us to rule out that the increase in profit shifting to low-tax countries is not an artifact of higher overall profitability of UK multinationals after the territorial tax reform.

²⁷ Some caution needs to be taken with this interpretation, since the post-reform coefficient estimates are not statistically different from each other.

²⁵ It is also important to note that the Blouin-Robinson critique is most relevant when calculating the absolute amount of profit shifted abroad, which we do not attempt in our analysis. As our identification strategy uses changes in profits in response to changes in tax incentives, double counting of profits would only affect our results if there is more double counting after the UK reform. In our view, the only channel by which this could take place is if UK-owned MNCs shift more profits from the UK to their second-tier affiliates, which is then newly double counted (in the second tier affiliate and the affiliate in between). We address this concern in the robustness section.

²⁶ Note that while mean EBT to assets in the low-tax sample is 0.038, mean operating profits to assets is 0.052. Thus, while the estimated coefficient on operating profits to assets is (slightly) larger in absolute terms, it implies a smaller elasticity.

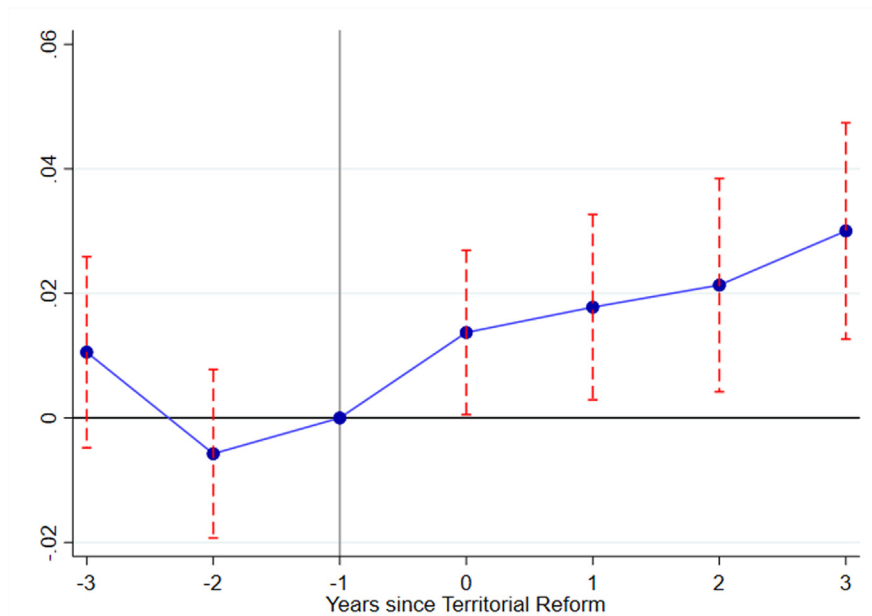


Fig. 3. Profit Shifting after Territorial: Dynamic DiD.

Notes: Regression coefficients from estimating Eq. (4). Specification includes country-level controls, host country-year and industry-year fixed effects. Bars depict 90% confidence intervals. Data from Amadeus for 2006–2012.

Table 4 presents the result. In column (1), we estimate eq. (5). We find an insignificant and small coefficient of 0.003. Thus, the profitability of the consolidated accounts of UK MNCs remains approximately constant after the reform, indicating that the effects found on EBT at the affiliate level indeed arise because of profit shifting.

Next we turn to UK-owned affiliates in high-tax countries that are part of a UK multinational group that has affiliates also in low-tax countries. If profits are relocated from high- to low-tax

countries, then these affiliates would on average report a lower profit after the reform compared to their non-UK-owned counterparts. Column (2) of Table 4 examines this possibility, and reports a DiD coefficient of -0.003, though insignificant at any conventional level. We interpret the finding as suggesting that at the margin, some profits may be relocated from high- to low-tax countries by UK multinationals after the reform. However, the effect is too small to explain most of the additional profits in low-tax affiliates.

We therefore turn to domestic affiliates of UK multinational groups to see whether they report lower profit after the reform. Such evidence would be consistent with the hypothesis that profits are shifted out of the UK to low-tax countries. The last column of Table 4 examines this possibility, using a sample of multinational affiliates in the UK. The control group consists of UK affiliates of non-UK-owned MNCs. The estimated DiD coefficient is -0.01, significant at the 5% level. This finding is consistent with the notion that profits are shifted out of the UK to low-tax countries after the territorial reform.

Table 4
Where is the shifted profit coming from?

Sample:	Parent Level		Affiliate Level	
			High tax	UK
			EBT/Assets	
Dependent variable:	(1)	(2)	(3)	
MNC × Post	0.003 (0.014)			
UK-Parent × Post		-0.003 (0.010)		-0.011** (0.005)
ln (Workers)	-0.011 (0.020)	0.009*** (0.002)		-0.007* (0.004)
Add. Controls	-	✓		✓
Affiliate FE	-	✓		✓
Parent FE	✓	-		-
Year FE	✓	✓		✓
Host Country-Year FE	-	✓		-
Industry-Year FE	-	✓		✓
N	3,587	142,319		68,548
R ²	0.01	0.592		0.578

Notes: Column (1) shows result for consolidated data, comparing UK multinationals with UK domestic firms. Column (2) shows the main treatment effect for affiliates of UK MNCs in high-tax countries, including only MNCs that also have affiliates in low-tax countries. Column (3) compares UK affiliates of UK MNCs to UK affiliates of foreign MNCs. Column (1) uses data from Datastream for 2005–2014; Columns (2)–(3) data from Amadeus for 2006–2012. Robust standard errors in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

5.3. Robustness

We conduct several robustness tests based on the specification (3) of Table 3. First, we define “low-tax” countries according to an alternative approach, namely those with statutory corporate tax rates always below the UK rate during 2005–2012. Results are basically unchanged (Table 5, row (1)). Second, we address the concern that treated and control affiliates might not have similar observable characteristics (and that these differences explain different trends in reported profitability over time) by matching a subsample of firms (using Mahalanobis distance matching) with similar pre-reform turnover, fixed assets, and employment. As row (2) shows, the resulting estimate has a wider confidence interval due to fewer observations, but remains positive and significant at the 5% level. The results in row (3), where we expand the low-tax sample to include observations in Switzerland (which features a low tax rate and strong privacy laws, but is not a member of the European Union) are again very similar.

Table 5
Profit shifting after territorial reform: robustness results.

	Est. Coefficient UK-Parent \times Post	N	R ²
(1) Altern. Definition Low-Tax Countries	0.020*** (0.007)	165,360	0.494
(2) Matched Sample	0.029** (0.014)	11,658	0.510
(3) Adding Switzerland as Low-Tax Country	0.019*** (0.007)	185,878	0.491
(4) Without Indirect Affiliates	0.039** (0.016)	47,959	0.479
(5) Without 2009 and 2010	0.024*** (0.009)	104,460	0.523
(6) Without M&A Participants	0.021*** (0.007)	155,027	0.495
(7) Without German MNCs in Control Group	0.022*** (0.007)	124,200	0.494

Notes: The dependent variable is earnings before taxes divided by total assets. All specifications control for $\ln(\text{Workers})$ and characteristics of the multinational firm's home country (inflation, GDP per capita, long-run unemployment rate, GDP growth), as in Column (3) of Table 3. Data from Amadeus for 2006–2012. Standard errors in parentheses are clustered by parent. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

We next take a different approach to address the potential issue of double counting of profits by excluding all indirect affiliates from the sample. Row (4) shows a highly significant coefficient of 0.039.²⁸ Row (5) confirms that our results are robust to any potential anticipation effects by dropping observations in 2009 and 2010. Row (6) tests whether the results are robust to potential mismeasurement of ownership, as the ownership information in Amadeus is a snapshot at the end of the sample. We thus drop observations that changed ownership as part of an M&A, based on information from the Zephyr database (also provided by Bureau van Dijk). The DiD coefficient is unaffected (0.021).²⁹ Lastly, in row (7), we confirm that observations from Germany (which undertook a large-scale tax reform in 2008 that might have led to less profit-shifting by German MNEs after 2008) are not driving our results by dropping all German-owned affiliates from the control group.³⁰

6. Policy implications and conclusion

In this paper, we have used the introduction of a territorial tax system in the UK to study its impact on the intensity of profit shifting by multinationals. The 2009 reform switched the UK from a worldwide to a territorial tax system and, as such, lowered the taxation of repatriated earnings from countries with tax rates lower than the UK's corporate tax rate, increasing the tax incentives to shift profits to these countries.

²⁸ As our identification strategy is based on a DiD design with firm fixed effects, it uses changes in profits in response to changes in tax incentives. Therefore, double counting of profits would only affect our results if there is more double counting after the UK reform, and if UK MNCs shift more profits to second-tier affiliates which are then newly double counted (in the second-tier affiliate and the direct affiliate). Note that profits may nevertheless be (partially) allocated to the “wrong” country, but if they are actually shifted elsewhere with a lower tax rate, this misallocation will bias our estimates towards zero. In addition, Clausing (2020) argues that profits should largely be allocated to the holding country to measure profit shifting correctly, and if so, these estimates should be correct.

²⁹ In other tests to check the robustness of our results with respect to firm entry and exit, we run several regressions by restricting the sample to firms that we observe for a significant time span before and after the reform. These additional tests include: (1) dropping all firms that were observed only before or only after the reform; (2) using only firms that we observe at least in the two years before and the two years after the change; and (3) using only firms we observe for the full sample period. Table A.5 in the appendix reports the results. They are similar to those reported in the baseline table (although less precisely estimated in the sample where we require observations for the full period).

³⁰ We also confirm that no single host country is driving our results by dropping each host country individually from the sample. The resulting coefficients range between 0.017 and 0.025 and are all highly significant.

Our main findings provide strong evidence that UK multinationals reported more profits in low-tax countries after the territorial tax reform. On average, profits of UK subsidiaries in low-tax countries increased by about two percentage points compared to subsidiaries of non-UK multinationals in the same country. Among profitable firms, the reform increases the reported profitability by 11%.

To put these results in perspective, we use the consensus semi-elasticity of reported profits to the corporate tax rate differential of 1.5 from a recent meta-analysis (Beer et al., 2020), which suggests that for every one percentage point lower corporate tax rate (everything else equal), there is a 1.5% increase in the pre-tax profit reported by multinational affiliates. The benchmark specification of the meta-analysis uses the logarithm of reported profit before taxation as dependent variable, which is comparable to our results from Column (8) of Table 3. On average, we find that for profit-making UK affiliates, there is an 11% increase in their pre-tax earnings following the reform. The increase in pre-tax profits is thus equivalent to a seven percentage points reduction in the statutory corporate income tax rate in the UK ($= 11/1.5$). Evaluated at the mean asset value for UK affiliates in low-tax countries, our results imply an increase of EUR 0.06 million in pre-tax profits for the median firm and EUR 0.65 million on average.

It is important to note that our results may underestimate the total effect of the reform on profit shifting. As shown in Liu (2020), the territorial reform implies – everything else equal – a lower cost of capital for UK affiliates in low-tax countries. As firms re-optimize, the marginal return to capital and thus break-even profitability should drop, too. If “true” profitability (in the absence of profit shifting) is lower after the territorial tax reform, our results underestimate the true magnitude of profit shifting. In addition, profit shifting not only affects the distribution of tax revenue across countries, but can also distort the measurement of economic indicators such as firm-level productivity: for example, the manipulation of transfer prices would inflate reported productivity as it artificially increases turnover in low-tax countries. We gauge the importance of this mismeasurement by analyzing how the total factor productivity (TFP) of UK-owned affiliates develops after the territorial tax reform (see Appendix A.3). In low-tax countries, measured TFP of UK-owned affiliates increases by 5–9%. In high-tax countries, we find precisely estimated insignificant coefficients. Thus, the change in the low-tax countries likely results from profit shifting, and does not reflect real changes in productivity.

Our results have important implications for other countries switching to a territorial tax system. In particular, the US intro-

duced a territorial tax system as part of its tax reform in December 2017. It is likely that the US will also see an increase in profit shifting, counteracted by the newly-introduced anti-tax avoidance rules. Our results point out that this response may be somewhat delayed, as the UK multinationals responded more strongly about two years after the reform. Moreover, as the territorial tax reform removes the additional tax in the home country, it makes the source country tax rate most relevant for MNCs in terms of investment and profit shifting decisions. This consideration may in turn exacerbate the downward trend in statutory corporate tax rates worldwide. At the same time, it also highlights the importance of global coordination in imposing some sort of minimum taxes on outbound MNC investment, to alleviate competition in attracting book profits among low and zero-tax jurisdictions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Appendix

A.1. Model with tax-deductible costs

In the main part of the paper, we have assumed (for clarity of exposition) that the profit shifting costs are not tax deductible. However, some of these costs (e.g. for lawyers and accountants) may be tax deductible in one of the countries. Let us assume that a share α of costs is deductible in the high-tax country, and a share β in the affiliate country, with $\alpha + \beta \leq 1$ and $\alpha, \beta \geq 0$. This model nests the cases where all costs are tax-deductible in the high-tax country ($\alpha = 1, \beta = 0$), or where all costs are deductible in the affiliate country ($\alpha = 0, \beta = 1$), or the model from the main part of the paper ($\alpha = 0, \beta = 0$). Then, after-tax profits of the MNE are given by

$$\begin{aligned} \Pi = (1 - \tau_h) & \left[\rho_h - \sum_{i=1}^n \pi_i - \alpha \sum_{i=1}^n \frac{\lambda}{2} \frac{(\pi_i)^2}{\rho_i} \right] \\ & + \sum_{i=1}^n (1 - \max(\tau_h^{\text{repat}}, \tau_i)) \left[\rho_i + \pi_i - \beta \frac{\lambda}{2} \frac{(\pi_i)^2}{\rho_i} \right] \\ & - (1 - \alpha - \beta) \sum_{i=1}^n \frac{\lambda}{2} \frac{(\pi_i)^2}{\rho_i}. \end{aligned} \quad (\text{A.1})$$

The optimal share of profits shifted becomes

$$\frac{\pi_i}{\rho_i} = \frac{\tau_h - \max(\tau_h^{\text{repat}}, \tau_i)}{\lambda[(1 - \alpha - \beta) + (1 - \tau_h)\alpha + (1 - \max(\tau_h^{\text{repat}}, \tau_i))\beta]}. \quad (\text{A.2})$$

Now compare profit shifted under a territorial tax system with profit shifted under a worldwide tax system:

$$\begin{aligned} \left(\frac{\pi_i}{\rho_i} \right)^{\text{Territorial}} &= \frac{\tau_h - \tau_i}{\lambda[1 - \tau_h\alpha - \tau_i\beta]} \\ \left(\frac{\pi_i}{\rho_i} \right)^{\text{Worldwide}} &= \frac{\tau_h - \tau_h^{\text{repat}}}{\lambda[1 - \tau_h\alpha - \tau_h^{\text{repat}}\beta]}. \end{aligned} \quad (\text{A.3})$$

As long as there is any additional tax due upon repatriation ($\tau_h^{\text{repat}} > \tau_i$), there is more profit shifting under the territorial tax system than under the worldwide tax system. For $\tau_h^{\text{repat}} \rightarrow \tau_h$, profit shifted under the worldwide tax system goes to zero.

A.2. Heterogeneity analysis

Recent literature has uncovered effect heterogeneity in the profit shifting behavior of multinational entities. For example, profit shifting is concentrated in large multinationals (Wier and Reynolds, 2018), is stronger in R&D intensive firms (Liu et al., 2020) and to countries that impose low or no taxes on corporate profits (Dowd et al., 2017; Davies et al., 2018; Tørsløv et al., 2018). To explore the extent to which the impact of territorial tax reform may vary across these characteristics, we divide firms in the low-tax sample into quintiles (for each firm characteristic), and estimate the effect of the tax reform by interacting the policy variable with the quintile indicators. Thus, we estimate

$$\begin{aligned} y_{ikt} = \sum_{j=1}^5 \beta_{\text{Quintile}_j} \text{UK} - \text{Parent}_i \times \text{Post}_t \times \mathbb{1}\{i \in \text{Quintile}_j\} \\ + \beta_x X_{ikt} + \beta_z Z_{kt} + \alpha_i + d_t + \epsilon_{ikt}, \end{aligned} \quad (\text{A.4})$$

where $\mathbb{1}\{i \in \text{Quintile}_j\}$ is the j th quintile indicator defined above, and all other variables are as previously defined. We implement d_t with host country-year and industry-year fixed effects.

Panel A of Fig. A.1 plots the results across firm sizes measured by fixed assets. It shows that only medium-to-large UK affiliates significantly increased their reported profitability in response to the 2009 reform. Panel B shows a stronger pattern across size measured by employment.

Next, we confirm that firms with high intangible assets indeed have larger opportunities to shift profits to low-tax affiliates (Panel C of Fig. A.1). The evidence shows that the effect of the reform on reported profits is larger in firms with relatively high levels of intangibles.

Lastly, we test whether the effect differs in the level of statutory tax rate in the host country (Panel D of Fig. A.1). Surprisingly, there is no evidence that profit shifting increases with the tax rate differential.³¹ One reason for this finding may be that our sample does not include zero-tax havens (see p. 11); the average tax rate in the first bin is only eight percentage points lower than that of the last bin. Our results capture the tax-optimized setting of e.g. transfer prices and financing structures among producing affiliates, not the purely artificial shifting of book profits to zero-tax havens. A second reason for this finding may be that statutory tax rates do not capture profit shifting incentives well, for example because our sample includes a large number of loss-making affiliates (see Simone et al., 2017; Hopland et al., 2018; Gamm et al., 2018). Moreover, host country may offer specific tax incentives, including company-specific advance pricing agreements or country-specific double tax treaty networks, which are not reflected in the statutory tax rate. Countries differ also in their anti-avoidance regulations. Lastly, the opportunity cost of non-repatriation of profits varies across firms and countries.

A.3. Effects of profit shifting on total factor productivity

Measuring Total Factor Productivity. The starting point for the TFP calculation is a logarithmized Cobb–Douglas production function in the form of

$$\ln Y_{it}^k = \beta_0 + \beta_K \ln K_{it}^k + \beta_L \ln L_{it}^k + \beta_M \ln M_{it}^k + v_{it} + \epsilon_{it}, \quad (\text{A.5})$$

where Y_{it}^k , K_{it}^k , L_{it}^k , and M_{it}^k refer to firm i 's output (measured by total turnover), capital stock, labor, and materials in industry k in year t , and $\omega_{it} = \beta_0 + v_{it}$ presents the firm-level productivity.

³¹ When imposing restriction that shifting increases linearly with the tax rate differential, the coefficient on the interaction term $\text{UK} - \text{parent}_i \times \text{Post}_t \times \delta \tau_{it}$ is also insignificant.

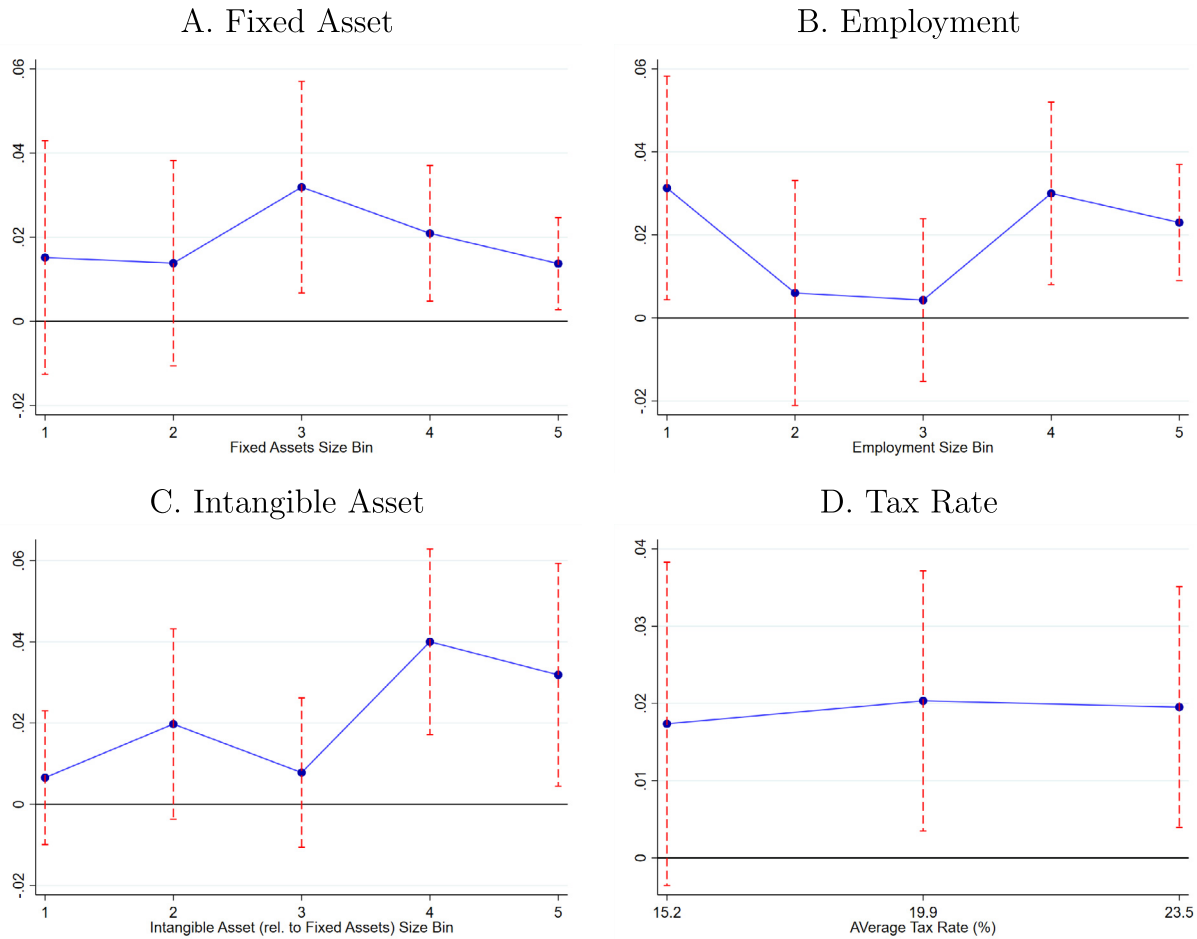


Fig. A.1. Effect Heterogeneity in Low-Tax Countries.

Notes: Estimated coefficients $\beta_{Quintile}$ from estimating eq. (A.4), including 90% confidence intervals across firm size (measured by fixed assets in Panel A and employment in Panel B), intensity of intangibles (Panel C), and host-country tax rate (Panel D). Data from Amadeus 2006–2012.

However, OLS estimates of specification (A.5) are likely to be inconsistent and biased, largely due to endogeneity of input choices and selection biases.³² To address these biases, we follow Levinsohn and Petrin (2003) and use costs of goods sold as a proxy for the unobserved productivity shocks (hereby the LP approach). To check the robustness of the TFP measure, we also use a factor share approach that calculates the parameters from cost share data in Eq. (A.5) for each firm. By imposing constant returns to scale in Eq. (A.5), the factor share approach yields $\ln TFP_{it} = \ln(\frac{y_{it}}{L_{it}}) - \beta_k \ln(\frac{K_{it}}{L_{it}})$, where the cost share of capital is calculated separately for each country–industry pair, as the mean value of one minus the share of labor costs in value added for firms in that country and industry.

Effects on TFP. How profit shifting affects measured productivity depends on the specific channels through which profit shifting takes place. The manipulation of transfer prices may inflate reported productivity in low-tax countries as sales would be over-recorded and costs of intermediate inputs would be under-recorded (the reverse holds for high-tax countries). Tax-motivated relocation of intellectual property would affect measured productivity in low-tax countries by inflating both turnover

(via fee payments for the use of the intellectual property) as well as capital (the intellectual property itself).³³

To test this, we estimate a DiD regression based on eq. (3), where the dependent variable is the natural logarithm of TFP. Table A.1 summarizes the results. Focusing on low-tax countries first, Columns (1) and (2) provide results with affiliate and fixed effects only for the factor-share and LP TFP measures, respectively, as dependent variables. Both columns report a positive and significant coefficient on the interaction term, suggesting an increase in the measured TFP of between 5% and 9% for low-tax UK affiliates after the introduction of the territorial tax system. The results are in line with our baseline findings on profit shifting: Assuming that 70–80% of profit shifting is through non-financial transactions (Heckemeyer and Overesch, 2017) and thus captured in the firm

³² The “endogeneity of inputs” is caused by correlation between the level of inputs chosen and unobserved productivity shocks (De Loecker, 2011). In addition, firms with low productivity are more likely to exit from the market, leading to a selection bias in the sample.

³³ Profit shifting via internal financing should not affect productivity measures as long as it does not change the level of reported operating profit or turnover. As Heckemeyer and Overesch (2017) show that firms’ non-financial inter-company transactions (including tax-motivated transfer pricing and licensing) are the dominant profit-shifting strategies, accounting for about 70–80% of the response to taxation, we expect that stronger profit shifting following the territorial tax reform would exacerbate the mis-measurement of the productivity of UK multinationals in foreign countries. In the longer term, if low-tax affiliates use inbound shifted profits to invest in R&D, profit shifting may also lead to an increase in the real TFP. However, given the considerable time lag and uncertainty between innovation input and output, we would expect the real impact of profit shifting on TFP to show up with significant delay rather than immediate following the territorial reform.

Table A.1

Profit shifting after territorial: effects on TFP.

Sample: Dependent variable:	Low-Tax						High-tax	
	$\ln(TFP_{FS})$	$\ln(TFP_{LP})$	$\ln(TFP_{FS})$	$\ln(TFP_{LP})$	$\ln(TFP_{FS})$	$\ln(TFP_{LP})$	$\ln(TFP_{FS})$	$\ln(TFP_{LP})$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UK-Parent \times Post	0.093** (0.046)	0.046* (0.027)	0.093** (0.044)	0.049* (0.029)	0.030 (0.049)	0.023 (0.035)	0.003 (0.021)	0.005 (0.013)
\times High Intangibles					0.141** (0.066)	0.057 (0.041)		
Controls	–	–	✓	✓	✓	✓	✓	✓
Affiliate FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	–	–	–	–	–	–
Host Country–Year FE	–	–	✓	✓	✓	✓	✓	✓
Industry–Year FE	–	–	✓	✓	✓	✓	✓	✓
N	65,698	66,074	65,696	66,072	65,696	66,072	90,681	92,431
R ²	0.989	0.731	0.989	0.735	0.989	0.735	0.989	0.773

Notes: Data from Amadeus for 2006–2012. Specifications (3) to (8) include the following characteristics of the multinational firm's home country: inflation, GDP per capita, long-run unemployment rate, and GDP growth. Standard errors in parentheses are clustered by firm. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

output variables used to calculate TFP, we would expect that on average, the measured TFP would increase by about 8–9% (given that the overall increase in the level of pre-tax profits is 11%).

Columns (3) and (4) replace the year fixed effects with host country–year and industry–year fixed effects, and the results remain very similar. Columns (5) and (6) confirm that the effect is driven by firms with high intangible assets, consistent with the previous finding that increased profit shifting is also concentrated

in these firms. Columns (7) and (8) repeat the main DiD test for high-tax affiliates, and show that there is no similar increase in observed TFP for UK affiliates.

A.4. Additional tables

see [Tables A.2,A.3,A.4,A.5](#).

Table A.2

Affiliate-level data.

Panel A: Observations by Country				
	Low-Tax Affiliates of		High-Tax Affiliates of	
	UK MNCs	Non-UK MNCs	UK MNCs	Non-UK MNCs
Austria	283	3,591		
Belgium			1,783	20,491
Bulgaria	435	7,486		
Czech Republic	1,823	29,697		
Estonia	371	7,795		
Finland	329	4,927		
France			3,800	32,660
Germany			2,197	17,893
Greece	453	4,283		
Hungary	281	4,563		
Ireland	1,163	1,910		
Italy			3,509	31,220
Luxembourg			54	337
Netherlands	699	3,057		
Poland	1,156	18,607		
Portugal	50	411	4	36
Romania	1,673	55,430		
Slovenia	130	3,653		
Spain			3565	32,461
Sweden	109	711		
Total	8,955	146,121	14,912	135,098
	155,076		150,010	

Notes: Observations by country in the affiliate-level dataset. Low-tax (high-tax) observations are affiliates that are in countries with a lower (higher) tax rate than the UK in all years in which we observe the firm. Data from Amadeus for 2006–2012.

Panel B: Top 20 Home Countries					
	Country	# of HQs		Country	# of HQs
1	Germany	4,861	11	Turkey	906
2	Italy	3,256	12	Spain	875
3	Netherlands	2,199	13	Sweden	773
4	United Kingdom	1,883	14	Hungary	665

(continued on next page)

Table A.2 (continued)

Panel B: Top 20 Home Countries					
	Country	# of HQs		Country	# of HQs
5	Switzerland	1,684	15	Finland	533
6	Luxembourg	1,540	16	Denmark	519
7	France	1,499	17	Greece	486
8	Austria	1,380	18	Russia	326
9	Cyprus	1,271	19	Portugal	321
10	Belgium	976	20	Canada	296

Notes: Observations by country in the affiliate-level dataset. Low-tax (high-tax) observations are affiliates that are in countries with a lower (higher) tax rate than the UK in all years in which we observe the firm. Data from Amadeus for 2006–2012.

Table A.3

Observations by year (consolidated data).

	# Obs.	% of sample
2005	93	2.59
2006	95	2.65
2007	175	4.88
2008	197	5.49
2009	503	14.02
2010	523	14.58
2011	520	14.50
2012	510	14.22
2013	487	13.58
2014	484	13.49
Total	3,587	100

Notes: Observations by year in the consolidated data. Data from Datastream for 2005–2014.

Table A.4

Profit shifting after territorial: regression results for full sample without employment control.

Sample: Dependent variable:	Low-Tax							High-Tax
	EBT/Assets				Op. Profit/Assets	EBT/Assets	ln (EBT)	EBT/Assets
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UK-Parent \times Post	0.018*** (0.006)	0.019*** (0.005)	0.019*** (0.007)	0.018*** (0.007)	0.022*** (0.007)		0.056 (0.043)	0.005 (0.005)
\times High Intangibles						0.024*** (0.008)		
ln (Turnover)		0.048*** (0.001)		0.048*** (0.001)				
ln (Fixed Assets)							0.144*** (0.007)	
Add. Controls	–	–	✓	✓	✓	✓	✓	✓
Affiliate FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	–	–	–	–	–	–
Host Country-Year FE	–	–	✓	✓	✓	✓	✓	✓
Industry-Year FE	–	–	✓	✓	✓	✓	✓	✓
N	206,004	206,004	206,004	206,004	206,004	206,004	122,726	212,961
R ²	0.450	0.477	0.454	0.480	0.443	0.454	0.846	0.540

Notes: The sample includes observations with missing information on employment. Data from Amadeus for 2006–2012. Specification (3) to (8) include the following characteristics of the multinational firm's home country: inflation, GDP per capita, long-run unemployment rate, and GDP growth. Standard errors in parentheses are clustered by parent. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

Table A.5

Profit shifting after territorial: robustness regarding firm entry & exit.

	Dropping firms observed only		Only firms observed	
	before reform	after reform	≥2y before/after	all 6 years
	(1)	(2)	(3)	(4)
UK-Parent × Post	0.022*** (0.007)	0.020*** (0.007)	0.022*** (0.007)	0.012 (0.008)
ln (Workers)	0.016*** (0.002)	0.016*** (0.002)	0.015*** (0.002)	0.010*** (0.002)
Add. Controls	✓	✓	✓	✓
Affiliate FE	✓	✓	✓	✓
Host Country-Year FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓
N	146,470	148,779	123,965	89,461
R ²	0.482	0.488	0.467	0.459

Notes: The dependent variable is earnings before taxes divided by total assets. Data on low-tax countries from Amadeus for 2006–2012. Standard errors in parentheses are clustered by parent. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

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