Where Does Multinational Profit Go with Territorial Taxation: Evidence from the UK*

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Abstract

In 2009, the United Kingdom abolished the taxation of profits earned abroad and introduced a territorial tax system. Under such a tax system, firms have strong incentives to shift profits abroad. Using a difference-in-differences research design, we show that profits of UK subsidiaries in low-tax countries increased after the reform compared to the subsidiaries of other multinational firms in the same countries. The effect corresponds to a 6% increase in the profitability of the median firm in the sample. The increase in profit shifting also leads to increases in measured productivity of the foreign affiliates of UK multinationals of between 5 and 9 percent.

Keywords: profit shifting, territorial tax system, multinational firms
JEL Classification: H25, H87, F23

1 Introduction

The U.S. tax reform of 2017 – known as the Tax Cuts and Jobs Act (TCJA) – may well prove a landmark event for the international tax system. Beyond the reduction in the statutory federal rate, from 35 to 21 percent, and a move towards full expensing of domestic investments, it also introduced a territorial tax system exempting U.S. multinationals' active business income earned abroad from being taxed in the U.S. (upon repatriation). Instead, they are taxed only once in the country where the affiliate is active. The move toward territoriality comes with an important qualification: the TCJA imposes a minimum tax on overseas income that is in excess of 10 percent of the return on tangible assets, in response to the concern that territorial taxation is associated with greater incentives for outward profit shifting.

How to tax foreign profits of multinationals is one of the most fundamental aspects of corporate taxation worldwide, especially with increasing prominence of multinationals in the global market. Despite its importance, only few empirical studies have considered the impact of the tax system on firm behavior. In particular, no previous paper analyzes how the introduction of a territorial tax system affects profit shifting and firm productivity.[1] This question is of particular importance as the incentives to shift profits abroad are stronger under a territorial tax system. Thus, an increase in profit shifting is often considered one of the main disadvantages of introducing a territorial tax system.

This paper provides first evidence on this question by studying the introduction of a territorial tax system in the United Kingdom in 2009. We use a difference-in-differences (DID) research design comparing affiliates of UK multinationals with affiliates of multinational firms headquartered in other countries. If these affiliates are active in a country with a lower tax rate than the UK, we expect that UK multinationals shifted more profits to their subsidiaries after 2009. Our findings confirm this hypothesis, indicating that profitability (measured by earnings before tax relative to total assets) increase by 0.021, which implies a 6 % increase in the profitability of the median firm in the sample. Further tests show that firms with high levels of intangible assets are reacting especially strongly. To show that

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[1]In a concurrent working paper, Liu et al. (2019) study a specific aspect of profit shifting, namely transfer mispricing.

indeed profit shifting (and not increases in investment or sales) are driving the results, we conduct placebo tests with affiliates in countries that have higher tax rates than the UK (and where firms thus have no incentive to shift profits), and find no effect.

Furthermore, we use consolidated accounts to study the global profitability of UK multinationals. In this setting, we use domestic companies in the UK as the control group. We find no effect of the reform on the overall profitability of UK multinationals, indicating that the effect found on the affiliate level arises because of profit shifting and not because of higher profitability of UK multinationals in general.

Profit shifting not only affects the distribution of tax revenue across countries, but can also distort the measurement of economic indicators such as productivity: for example, the manipulation of transfer prices would inflate reported productivity as it artificially increases turnover in low-tax countries. To gauge the importance of this mismeasurement, we study how the total factor productivity (TFP) of the affiliates of UK multinationals develops after the territorial tax reform. In low-tax countries, measured TFP increases by 5-9%. In high-tax countries, we find precisely estimated insignificant coefficients, indicating that there was no effect. 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 policymakers. For the reforming country, they highlight that measures 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 accompany the territorial tax reform in the Tax Cuts and Jobs Act.[2] At the same time, the U.S. tax reform also decreased the federal corporate tax rate substantially, from 35% to 21%, which should also decrease the incentives to shift profits abroad. For countries that aim to use their tax system to attract both real investment and paper profits, our results highlight the potentially intensified pressure on lowering their statutory tax rates.

Our paper contributes to two lines of literature on taxing the international income of MNCs. First, we add to the literature that compares the territorial and worldwide tax sys-

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[2]In particular, these are the Global Intangible Low-taxed Income (GILTI) provision, the Base Erosion and Anti-Abuse Tax (BEAT), and the foreign-derived intangible income (FDII) provisions.

tems. 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.[3] 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. However, as the International Monetary Fund (2019) recently pointed out, it is impossible to ensure all dimensions off tax neutrality (e.g. CEN, CIN and CON) without fully harmonized tax systems.

Empirical studies have analyzed the impact of a change in the international tax regime on various margins of firm behavior.[4] Also using the introduction of the territorial tax system in the UK, Liu (2019) studies real investment and finds that after the reform, UK multinationals invested more in countries with a lower corporate tax rate than the UK. Examining the same event, Egger et al. (2015) show that foreign affiliates of UK multinationals also paid more dividends to their owners. Similarly, but studying the introduction of a territorial tax system in Japan, Hasegawa and Kiyota (2017) find that foreign affiliates of Japanese firms with a

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[3] "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.

[4] 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).

large stock of retained earnings significantly increased divided payments to their parent firms. Analyzing both the UK and Japan, Arena and Kutner (2015) show that after the reforms firms accumulate less cash, pay out larger amounts through dividends and share repurchases, and invest less abroad. Feld et al. (2016) show that the number of acquisitions abroad by Japanese and British firms increased after the reform. Focusing on international transfer mispricing as a particular channel of profit shifting, Liu et al. (2019) 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 sparring agreements (which prevent host country tax incentives from being nullified by home country taxes).[5]

Second, we contribute to the more general literature on profit shifting by multinational companies, summarized by Dharmapala (2014) and Beer et al. (2019). Studies have provided direct 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. In a recent meta-study, Beer et al. (2019) find a tax semi-elasticity of subsidiary pre-tax profits of about 1.5. 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".[6] Clausing (2003, 2009) and Desai et al. (2006) provide evidence for profit shifting and deferral in countries with worldwide tax systems.[7] This paper also joins a growing empirical literature that examines the real effects of international tax avoidance on MNC investment and employment (Overesch, 2009; de Mooij and Liu, 2018; Suárez Serrato, 2018), and on country-level aggregate productivity growth (Guvenen et al., 2017).

This paper proceeds as follows. Section 2 provides some background information on the

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[5]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.

[6]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".

[7]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.

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 discusses the economic magnitude of our effects and the resulting policy implications, including the effect of profit shifting on measured TFP. Section 7 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 foreign 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 percent 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.[8] The UK also did not introduce any major changes to existing

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[8]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)

anti-tax avoidance rules to accompany the reform.[9]

Expected effects 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. 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.

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 MNCs. We start from a modified version of the model based on Hines and Rice (1994) and Grubert (1998). The key difference to the setup in Hines and Rice (1994) is a new parameter γ, which captures the feature that deferred profits abroad are worth less to an MNC than profits at home.

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imposes a 10.5 percent minimum tax without deferral on foreign profits that exceed a firm's "normal" return (defined in the law as 10 percent 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 percent for cash and 8 percent for illiquid assets.

[9]The UK government revised its controlled-foreign-corporation (CFC) rule four years later (in 2013). At the time of the reform, all profits of a CFC (active or passive), were liable to UK taxes on a current basis. However, there were a series of exemptions from the CFC rules, including an exemption for actively trading subsidiaries. The 2009 Finance Bill (which introduced dividend exemptions) only changed the CFC regime minimally in fear of hurting the UK's ability to attract multinational firms. A new CFC regime was enacted fully in January 2013. It focuses more narrowly on foreign profits artificially diverted from the UK by extending UK taxes to all passive income abroad. Thus, in contrast to the recent US reform, the UK took a more stepwise approach by strengthening its CFC rules four years after introducing the territorial tax system.

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 additional π_i of profits to affiliates in country i. 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.

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 on earnings repatriation. To capture this aspect, let γ be the relative value of a pound of after-tax profit in a low-tax country compared to a pound of after-tax profit at home. In a worldwide system with deferral, after-tax profits abroad are less valuable to the firm, because they are still taxed upon repatriation. and therefore $\gamma_W < 1$. In a territorial system, there are no additional taxes on foreign repatriations, so $\gamma_T = 1$.[10] Assume that penalties are paid at home and are not tax deductible. The after-tax profits for the MNC are given by:

$$\Pi = (1 - \tau_h)[\rho_h - \sum_{i=1}^{n} \pi_i] + \gamma \sum_{i=1}^{n} (1 - \tau_i)[\rho_i + \pi_i] - \sum_{i=1}^{n} \frac{\lambda}{2} \frac{(\pi_i)^2}{\rho_i}. \tag{1}$$

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

$$\frac{\pi_i}{\rho_i} = \frac{-(1 - \tau_h) + \gamma(1 - \tau_i)}{\lambda}. \tag{2}$$

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,*

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[10]Of course, there may still be some costs involved in moving profits back to the headquarters. The key point is that these costs should be strictly smaller under territorial taxation than under worldwide taxation — that is, $\gamma_W < \gamma_T$.

(i) *under a territorial tax system, the optimal reported profits increases in the tax differential $\tau_h - \tau_i$,*

(ii) *under a worldwide tax system, the optimal reported profits increases in the adjusted tax differential $\tau_h - \gamma_W \tau_i$.*

Proof.   *Follows directly from equation (2).*   ∎

Due to the repatriation tax, leaving profits abroad is less tax efficient for the MNC under worldwide taxation. Therefore, the difference in the statutory tax rates distorts reported profits less under worldwide taxation. This effect can easily be seen by noting that holding τ_h constant, the effect of τ_i on $\frac{\pi_i}{\rho_i}$ is smaller with a positive γ. A shift from a worldwide system with deferral to a territorial system therefore increases the incentive for profit shifting.

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: $\partial \frac{\pi_i}{\rho_i} / \partial \gamma = (1 - \tau_i)/\lambda > 0$.*

Proof.   *Follows directly from equation (2).*   ∎

3   Data and Descriptive Analysis

3.1   Data on UK Affiliates

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 all European countries (see Appendix Table A.1), as well as information on those ultimate parent companies in the UK. We include a subsidiary if at least 50 percent of its shares are (directly or indirectly) held by the ultimate owner company.

The initial sample consists of multinational companies in the EU-27 countries 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 negative value for assets or employees. Our final sample is an unbalanced panel with 346,933 firm-year observations and 66,134 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, Slovakia, 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, Denmark, France, Germany, Italy, Luxembourg, and Spain are considered "high-tax".[11]

Our main variables are firms' earnings before tax (EBT), earnings before interest and tax (EBIT), total assets, intangible assets, the number of workers, turnover and the investment rate. The investment rate is defined as gross investment (proxied by the yearly change in tangible and intangible assets, plus depreciation) divided by the sum of tangible and intangible assets at the start of the year. Table 1 provides some descriptive statistics. Low-tax firms in the sample have on average earnings before taxes of 821,486 Euro, total assets of 15 million Euro, sales of 19 million Euro and employ 94 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 percent and 99 percent level in the full sample (low-tax and high-tax combined).

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[11]The Amadeus database provides consistent information on a large number of firms in Europe, but it does not include any of the small tax haven countries. Therefore, our results have to be interpreted as a lower bound on profit shifting, as most tax avoidance occurs with tax haven counterparties (Davies et al., 2018). However, the sample is well-suited to study the effect of profit shifting on an indicator of real economic performance (in our case, TFP).

Table 1. Summary Statistics: Affiliate-Level

	Obs.	Mean	Median	Std. Dev.	Min	Max
Low-Tax Observations						
EBT (Euro)	185,878	821,486	28,209	4,686,713	-12,329,598	46,736,000
EBIT (Euro)	185,878	842,036	43,763	4,056,221	-9,870,000	38,712,365
EBT/total assets	185,878	0.28	0.35	1.86	-364	427
Total assets (Euro)	185,878	15,432,239	1,528,966	63,014,459	13,576	754,761,405
Intangible assets (Euro)	182,762	252,463	15	1,968,139	0	28,155,804
Workers	185,878	94	15	245	1	2,161
Turnover (Euro)	185,878	18,619,874	1,867,193	66,393,776	5,133	676,070,607
Investment rate	131,888	15	0	1,360	-777	412,619
High-Tax Observations						
EBT (Euro)	160,396	1,595,448	138,015	6,996,460	-12,345,185	46,736,000
EBIT (Euro)	160,396	1,495,557	171,719	5,777,845	-9,877,536	38,712,365
EBT/total assets	160,396	0	0	1	-288	77
Total assets (Euro)	160,396	39,252,020	6626011	11,0746,446	13,594	754,076,615
Intangible assets (Euro)	158,758	1,033,027	12,618	4,060,116	0	28,217,179
Workers	160,396	119	29	284	1	2,156
Turnover (Euro)	160,396	41,895,305	8,866,134	103,432,040	5,148	675,730,274
Investment rate	125,732	96	0	19,652	-4	6,116,947

Descriptive statistics for the main variables in the affiliate-level dataset. Low-tax (high-tax) observations are firms that are in countries with a lower (higher) tax rate than the UK in all years in which we observe the firm. All ratio variables are winsorized at the 1 percent level. Data from Amadeus for 2006-2012.

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 1,239 parent companies). The matched dataset is an unbalanced panel with information from 2005 to 2014 with a total of 4,241 firm-year observations. Table A.2 in the Appendix summarizes how the observations are distributed over time. There are more observations for more recent years due to missing information in Datastream.

Table 2 presents summary statistics for the consolidated firms. On average, the consolidated balance sheets show total assets of 1.9 billion Euro, and on average 19.6 percent are intangible assets. The average consolidated firm has 9,567 employees and pre-tax income

of 195 million Euro. 41 percent of these firms have foreign assets, indicating that they are multinational firms.

Table 2. Summary Statistics: Consolidated Firms

|	Obs.	Mean	Median	Std. Dev.	Min	Max
Total assets (thous. Euro)	4,241	1,930,426	70,460	12,874,206	2	285,302,595
Intangible assets (thous. Euro)	4,232	378,958	9,743	1,634,212	0	22,357,000
Foreign assets (thous. Euro)	1,726	75,664	1,729	1,005,159	0	40,876,316
Pre-tax income (thous. Euro)	4,240	195,241	2,475	1,686,696	-2,261,516	39,823,617
EBIT (thous. Euro)	4,167	215,027	3,296	1,739,056	-2,112,087	40,265,783
Debt (thous. Euro)	4,241	415,886	4,326	2,062,853	0	37,661,580
Employees	4,034	9,567	455	44,212	0	648,254

Descriptive statistics for the main variables in the consolidated-firm-level dataset. Data from Datastream for 2005-2014.

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. Figure 1 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%, which they would have had to pay anyways upon repatriation. After 2009, the distribution of effective foreign tax rates is more even, with more firms having a lower effective foreign tax rates (at around 20%). While gradual decline in the statutory CIT rates (Figure 1 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.[12]

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[12]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.

Figure 1. Density of Parent Firms' Effective Foreign Tax Rate Before and After 2009

A. Effective Foreign Tax Rates

B. Statutory Foreign CIT Rates
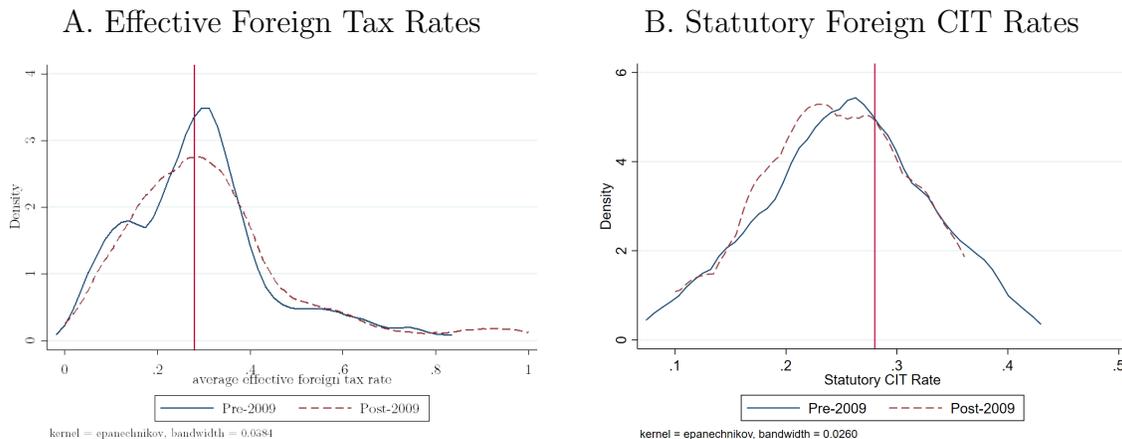
Panel A: Kernel density of parent firms' effective foreign tax rates pre-2009 (blue line) and post-2009 (dashed red line). Data from Datastream for 2005-2014. Panel B: Kernel density of statutory CIT rates in EU-28, pre-2009 (blue line) and post-2009 (dashed red line). Vertical line marks the UK tax rate of 29%. Data from OUCBT Tax Database for 2005-2012.

4 Empirical Strategy

4.1 Estimating Profit Shifting

We have highlighted in Section 2 that our identification relies on the variation in the incentive for outward profit shifting due to a UK-specific tax reform. Naturally, our main empirical strategy is the standard difference-in-differences (DiD) approach. We estimate the difference in the reported profitability before and after 2009, comparing affiliates of UK-based multinationals with affiliates of non-UK multinationals in the same country. Following the discussions in Section 2, in low-tax countries there are stronger incentives for outward profit shifting for the UK multinationals after the switch to a territorial tax system, whereas incentives for other non-UK-owned multinationals should remain the same. We thus expect a positive effect of the DiD estimator on reported profitability in low-tax countries.

Formally, we test the following regression specification:

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

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 $\text{UK-Parent}_i \times \text{Post}_t$, where UK-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). We also control for time-varying input factor proxies X_{ikt}, namely the natural logarithms of the number of employees and of fixed tangible assets. Given that firms in the sample do not change their location, firm fixed effects subsume host-country fixed effects. We include year dummies (d_t) to capture the effect of aggregate macroeconomic shocks that are common to all companies. In our preferred specifications, we include time-varying country- and industry-trends 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 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. Finally, ϵ_{ikt} is the error term.

Pre-reform 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 for 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 an event-time specification by estimating the following model:

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

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.

Common Trends across Company Groups As a step further, we test whether it is indeed profit shifting we look at or whether UK multinationals became more profitable overall 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:

$$y_{jt} \;\; = \gamma_1 \mathrm{MNC}_j \times \mathrm{Post}_t + \gamma_x X_{jt} + \eta_j + d_t + \epsilon_{jt}, \tag{5}$$

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 $\mathrm{MNC}_j \times \mathrm{Post}_t$, 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 control for several time-varying firm characteristics, X_{jt}, including the natural logarithms of workers and fixed assets, as well as turnover growth. 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.

4.2 Variables

Pre-tax profitability The literature has used different measures of pre-tax reported profitability, e.g. the ratio of earnings before tax to total assets (EBT/Assets, see e.g. Schwarz, 2009; Loretz and Mokkas, 2015) and the natural logarithm of earnings before tax (ln (EBT), see e.g. Dharmapala and Riedel, 2013; Dischinger et al., 2014). 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 earnings before tax from our regressions, even though zero profit (or loss making) may reflect profit shifting in the most aggressive form. Shifting to a loss-making affiliate saves taxes efficiently, it does not induce any positive taxes in the host country (Simone et al., 2017; Hopland et al., 2018). Therefore, excluding loss-making affiliates from the analysis may lead to downward bias in our results. Indeed, when decomposing the overall measure of profitability (EBT/Assets) into an extensive margin (whether reporting losses) and an intensive margin (as captured by ln (EBT)), we find that both margins respond significantly to the territorial reform.

While we defer discussing the implication of using different profitability measures to Section 5.2, Figure 2 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 percent 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 (Johannesen et al., 2019; Habu, 2017; Hopland et al., 2018; Koethenbuerger et al., 2019). In both the low-tax and the high-tax group, more than five percent of companies report a return to assets between 0 and 0.01 percent.

Total Factor Productivity The primary measurement of firm productivity (i.e., TFP) is based on the Levinsohn and Petrin (2003) approach. To illustrate, consider a standard logarithmized Cobb–Douglas production function in the form of

$$\ln Y_{jt}^k = \beta_0 + \beta_K \ln K_{jt}^k + \beta_L \ln L_{jt}^k + \beta_M \ln M_{jt}^k + v_{jt} + \epsilon_{jt}, \tag{6}$$

Figure 2. Distribution of Pre-Tax Profitability
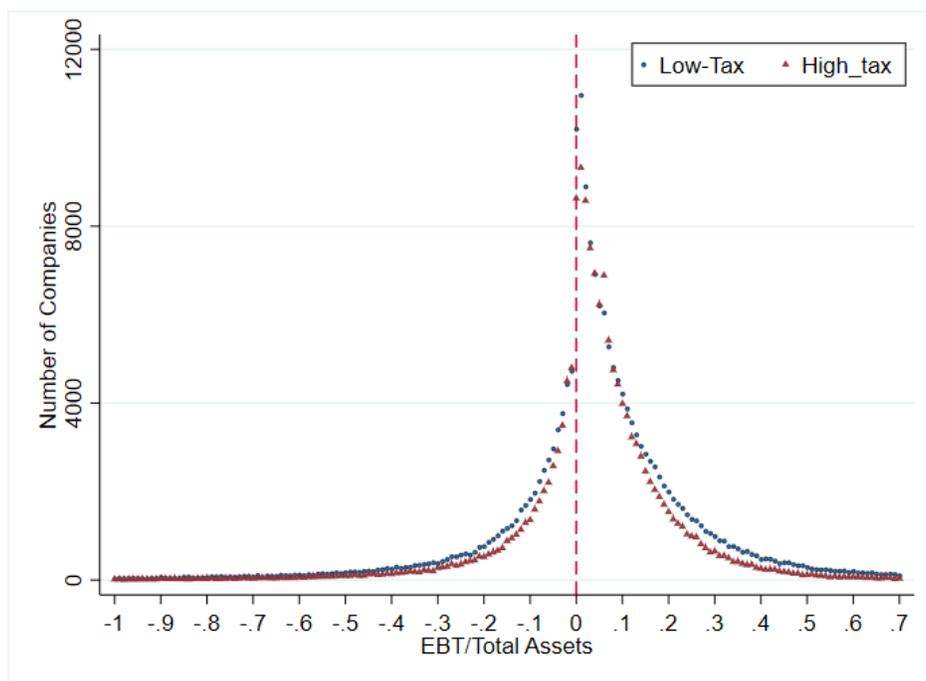
Distribution of pre-tax profitability (measured by EBT/total assets) in low-tax and high-tax countries. Data from Amadeus for 2006-2012.

where Y_{jt}^k, K_{jt}^k, L_{jt}^k, and M_{jt}^k refer to firm j's output (measured by total turnover), capital stock, labor, and materials in industry k in year t, respectively, and $\omega_{jt} = \beta_0 + v_{jt}$ presents the firm-level productivity. Traditionally, the simplest benchmark of TFP is the Solow residual from the ordinary least square (OLS) regression for specification (6), which is usually run industry-by-industry and based on firm-level data. That is,

$$\ln \text{TFP}_{jt}^k = \ln Y_{jt}^k - \ln \hat{Y}_{jt}^k.$$

However, the OLS estimates of specification (6) are likely to be inconsistent and biased, largely due to endogeneity of input choices and selection biases. The "endogeneity of inputs" or simultaneity bias 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.

To address these biases, Olley and Pakes (1996) propose a semi-parametric approach, using the firm's investment to proxy for unobserved productivity shocks and addressing the selection issues by explicitly incorporating an exit rule into the estimation. However, by requiring that investment is strictly increasing in productivity, the Olley and Pakes (1996)-approach uses only observations with positive investment and may result in a significant loss in efficiency. Moreover, later evidence from firm-level datasets suggests that investment is lumpy with a large number of zero investment. Thus, investment may not be a good proxy for unobserved productivity. Levinsohn and Petrin (2003) (hereby the LP approach) overcome this limitation by using intermediate inputs (such as raw materials, electricity, or fuels) rather than investment as a proxy for the unobserved productivity shocks. In light of the relative advantages of both approaches, we employ the LP approach as the primary measure of firms' TFP. To check the robustness of the TFP measure, we also use a factor share approach that calculates the parameters from cost share data in equation (6) for each firm. By imposing constant returns to scale in equation (6), the factor share approach of the log TFP is:

$$\ln \text{TFP}_{jt} = \ln \left(\frac{Y_{jt}^k}{L_{jt}} \right) - \beta_k \ln \left(\frac{K_{jt}^k}{L_{jt}} \right). \tag{7}$$

where the cost share of capital is calculated separately for each country–industry pair, as the mean value of one minus the share of labour costs in value added for firms in that country and industry.

5 Evidence on Profit Shifting

5.1 Graphical Evidence

We start by presenting graphical evidence on the effect of the switch to a territorial tax system in the UK in 2009 on profitability. Figure 3 plots the time trends in profitability (EBT divided by assets) for the affiliates of UK multinationals (the treated group) and for the affiliates of multinational firms from other countries (the control group). Given the discussion in Section 4, we expect an effect only for affiliates in countries with a lower tax rate than the UK. Figure 3 thus shows two separate plots, one for low-tax and one for high-tax affiliates.

Figure 3. Profitability before and after the reform
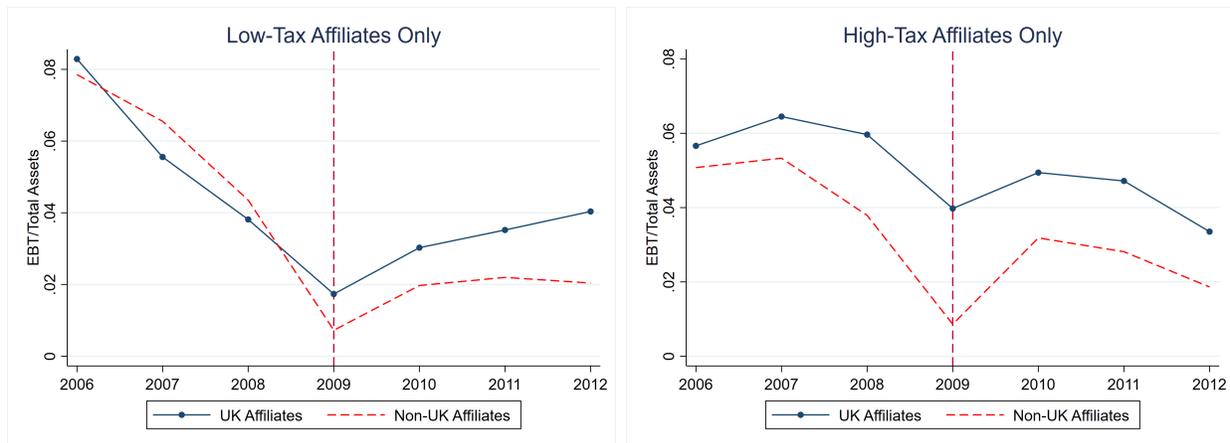
Graphs show time trends in EBT/Assets for low-tax affiliates (left panel) and high-tax affiliates (right panel). The blue line shows affiliates of companies headquartered in the UK, the red dashed line shows affiliates of companies headquartered in other countries. Data from Amadeus for 2006-2012.

In both groups, profitability developed similarly before the reform. As expected, for the high-tax affiliates the parallel development for both groups continues after the reform.

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For the low-tax affiliates, we observe that profitability increases substantially relative to the control group after the UK introduced the territorial tax system.

Table 3. Profit Shifting after Territorial: Baseline Results

Sample:	Low-Tax							High-Tax
Dependent variable:	EBT/Assets					Loss Making	ln (EBT)	EBT/Assets
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UK-Parent × Post	0.020***	0.019***	0.021***	0.017**		-0.021*	0.111**	0.002
	(0.007)	(0.006)	(0.007)	(0.007)		(0.011)	(0.045)	(0.006)
UK-Parent × Post × Wholly-Owned					0.031***			
					(0.009)			
UK-Parent × Post × Majority-Owned					0.011			
					(0.009)			
ln (Workers)	0.014***	-0.032***	0.016***	-0.035***	0.016***	-0.046***	0.309***	0.009***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.014)	(0.002)
ln (Turnover)		0.068***		0.070***				
		(0.001)		(0.002)				
ln (Fixed Assets)						0.003**	0.092***	
						(0.001)	(0.007)	
Home Country Charact.	-	-	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	-	-	-	-	-	-
Affiliate FEs	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FEs	-	-	Y	Y	Y	Y	Y	Y
Host Country-Year FEs	-	-	Y	Y	Y	Y	Y	Y
N	186,468	186,468	155,076	155,076	155,076	174,761	97,357	150,010
R^2	0.487	0.521	0.495	0.529	0.495	0.474	0.851	0.591

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.

5.2 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 baseline regression by controlling only firm labor inputs. We find a positive and highly significant coefficient on the interaction term of 0.02, indicating that UK multinationals indeed shifted more profits to low-tax affiliates after the UK introduced 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 via goods and services.

In Columns (3) and (4), we add time-varying host country and time-varying industry trends, which also effectively controls for the effect of statuary 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.[13] Our preferred specification is Column (3), which allows for profit shifting through a broad range of channels while controlling for country-specific and industry-specific time-varying shocks. Lastly, in Column (5), we differentiate between wholly-owned and majority-owned subsidiaries. It is more attractive to shift profits to a wholly-owned subsidiary, as otherwise minority shareholders profit from the profit shifting activities as well. Correspondingly, we find that profit is only shifted to the wholly-owned subsidiaries.

Extensive vs. intensive margin. The next two columns in Table 3 decompose the overall behavioral response of pre-tax profitability into two margins: (1) the propensity of an affiliate to report a loss or zero profit, which is captured by a discrete dummy indicator that takes the value of one for negative or zero pre-tax EBT (*Loss*), and (2) the level of reported profits for those with positive earnings, as captured by the natural logarithm of earnings before tax ($\ln(EBT)$). Column (6) reports the results concerning the extensive margin from a regression that uses the *Loss* indicator as the dependent variable. The results suggest that the probability of reported losses by UK affiliates in low-tax countries is 2.1 percentage point lower following the reform. Thus, UK multinationals shifted profits to previously loss-making affiliates in low-tax countries so that they became profitable after the reform. Focusing on the intensive margin, Column (7) shows that among affiliates with positive pre-tax earnings, on average their EBT increases by 11 percent 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 firms) increases by 34 percent for the full sample, an effect that is three time larger than when only focusing on the profitable affiliates.

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[13]We now also include controls for several characteristics of the MNC parent's home country.

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 conduct an event study by estimating specification (4) replacing the reform dummy in Column (3) of Table 3 with a series of year dummies for a window of three years around the territorial tax reform. Figure 4 plots the estimated coefficients on these dummies and shows the 90 percent level confidence intervals. These are 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 after the year 2009 indicate that the territorial tax reform induced the 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.[14]

As an alternative test, we run the regression in Column (3) of Table 3 for high-tax affiliates. The results are reported in Column (8) of the same table. The coefficient of the interaction term is statistically insignificant and close to zero. 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.

This test also shows that the profits shifted to low-tax countries do not originate in affiliates in high-tax countries (which would be consistent with a negative coefficient). Thus, multinationals seem to shift profits from the UK headquarter to the low-taxed affiliates after the reform.

Tests with consolidated data. To investigate this question, we now 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

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

Figure 4. Profit Shifting after Territorial: Placebo Results
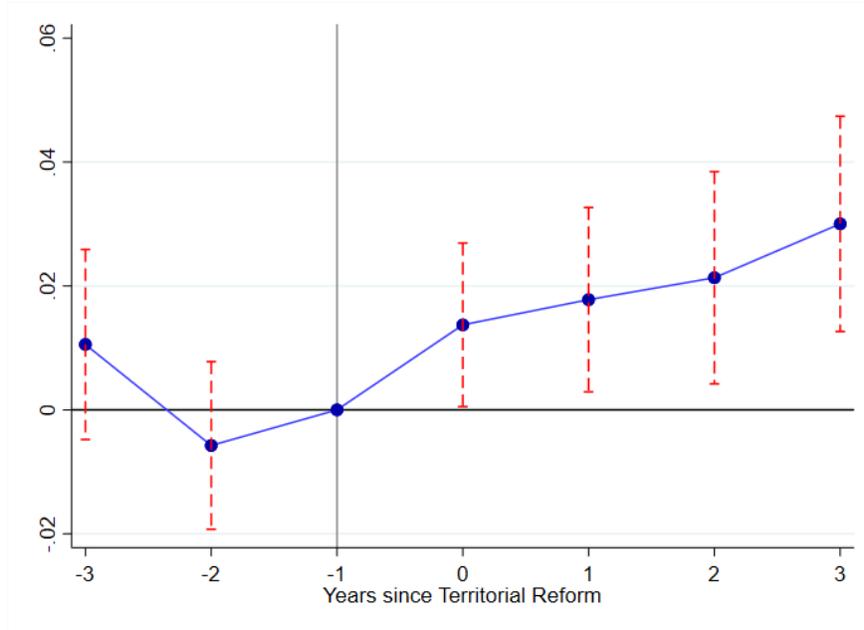
Regression coefficients from estimating eq. (4), replacing the reform dummy with year dummies for the three years before and after the reform. Bars depict 90 percent confidence intervals. Data from Amadeus for 2006-2012.

artifact of higher overall profitability of UK multinationals after the territorial tax reform.

Table 4 presents these results. In column (1), we estimate eq. (5) without control variables. We find that UK MNCs are 15 percent more profitable after the reform, compared to domestic firms. This effect could be driven by increased investment after the reform (see Liu, 2019). Indeed, when we include control variables in column (2), this effect disappears. This finding remains unchanged when using the ratio of earnings before taxes relative to total assets as the dependent variable in column (3). Thus, the profitability of the consolidated accounts of UK MNCs remains constant after the reform, indicating that the effects found on earnings before taxes on the affiliate level indeed arise because of profit shifting. As the profitability of high-tax affiliates does not change, the shifted profits must originate in the UK headquarter.

Robustness checks. To test for the robustness of the basic results, we conduct sensitivity analysis along three dimensions. First, we define "low-tax" and "high-tax" countries using

Table 4. DiD Tests with Consolidated Data

Sample:	Consolidated Accounts		
Dependent variable:	ln(EBT)		EBT/Assets
	(1)	(2)	(3)
MNC × Post	0.150*	0.068	0.003
	(0.090)	(0.103)	(0.014)
ln (Fixed Assets)		0.542***	
		(0.083)	
ln (Workers)		0.113	-0.011
		(0.078)	(0.020)
Sales growth rate		0.002	
		(0.001)	
Year FEs	Y	Y	Y
Firm FEs	Y	Y	Y
N	2,814	2,431	3,587
R^2	0.04	0.12	0.01

The dependent variable are the natural logarithms of earnings before taxes (in columns 1 and 2), earnings before taxes relative to total assets (in column 3), and the natural logarithms of interest payments (in columns 3 and 4). Data from Datastream for 2005-2014. Robust standard errors in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

an alternative approach, where a country is considered as low-tax (high-tax) if its statutory corporate tax rate is always below (above) the UK rate during 2005-2012. Table 5 Column (1) reports the results using this alternative definition of low-tax countries. Results are basically unchanged compared to the baseline findings. Second, we create a subsample of matched firms to address the concern that companies in the treated UK and control affiliates may not have similar observable characteristics, and that these differences may explain different trends in reported profitability over time. The sample is matched from a Mahalanobis distance matching procedure based on pre-reform firm-level turnover, fixed assets, and employment. Column (2) replicates the DiD analysis on this matched sample in low-tax countries. The resulting estimate has a wider confidence interval due to fewer observations, but nevertheless, remains positive and significant at the 5% level. Column (3) expands the low-tax sample to include observations in Switzerland, and the results remain very similar. [**Can we add a sentence explaining why we add Switzerland? I don't remember**] Panel (B) of Table 5 reports the results concerning the high-tax countries, where the estimated impact of the reform remains small and insignificant with alternative definition of high-tax countries, a matched sample based on similar turnover, fixed assets, and employment, and a smaller sample excluding observations from Luxembourg (which has a high nominal tax rate, but is often considered a tax haven due to numerous special tax rules).

5.3   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., 2019) and to countries that impose low or no tax 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

Table 5. Profit Shifting after Territorial: Robustness Results

	Panel A. Low-Tax Countries		
	Alternative Definition of Low-Tax Countries	Matched Sample	Adding Switzerland
	(1)	(2)	(3)
UK-Parent × Post	0.020***	0.029**	0.019***
	(0.007)	(0.014)	(0.007)
N	165,360	11,658	185,878
R^2	0.494	0.51	0.491
	Panel B. High-Tax Countries		
	Alternative Definition of High-Tax Countries	Matched Sample	Excluding Luxembourg
	(1)	(2)	(3)
UK-Parent × Post	0.002	0.004	0.004
	(0.006)	(0.009)	(0.006)
N	149,970	19,015	159,975
R^2	0.591	0.599	0.59

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

with the quintile indicators:

$$y_{ikt} = \sum_{j=1}^{5} \beta_{Quintile_j} \text{UK-Parent}_i \times \text{Post}_t \times \mathbb{1}\{i \in Quintile_j\} + \beta_x X_{ikt} + \beta_z Z_{kt} + \alpha_i + d_t + \epsilon_{ikt}, \quad (8)$$

where $\mathbb{1}\{i \in Quintile_j\}$ is the jth quintile indicator defined above, and all other variables are as previously defined. Figure 5 summarizes the main results concerning the effect heterogeneity of the territorial tax reform, reporting the coefficient estimates $\beta_{Quintile}$ and the 95 percent confidence interval across each firm or country characteristic.

Firm size Panel A of Figure 5 plots the results across firm sizes measured by fixed assets. It shows that only medium-to-large UK affiliates in the upper quintiles of the fixed-asset distribution significantly increased their reported profitability in response to the 2009 reform. Panel B shows a stronger pattern across the size measured by employment. The evidence shows the effect of the reform on reported profits is concentrated in larger firms.

Intensity of intangibles Next, we test whether firms with intangible assets indeed have larger opportunities to shift profits to low-tax affiliates. Panel C of Figure 5 plots the results across the ratio of intangible assets. The evidence shows that the effect of the reform on reported profits is concentrated in firms with lots of intangibles.

Level of host-country tax rate Lastly, we test whether the effect differs in the level of statutory tax rate in the host country. Panel D of Figure 5 plots the results in countries with relatively low, medium, and high tax rates within the low-tax country sample. Surprising, there is no evidence that profit shifting increases with the tax rate differential.[15] As our sample includes a large number of loss-making affiliates, the statutory tax rate does not capture the underlying profit shifting incentives well (see Simone et al., 2017; Hopland et al., 2018; Gamm et al., 2018). In addition, some additional benefits from profit shifting due to specific regimes or advance pricing agreements (APAs) are not reflected in the statutory tax rate.

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

Figure 5. Effect Heterogeneity in Low-Tax Countries
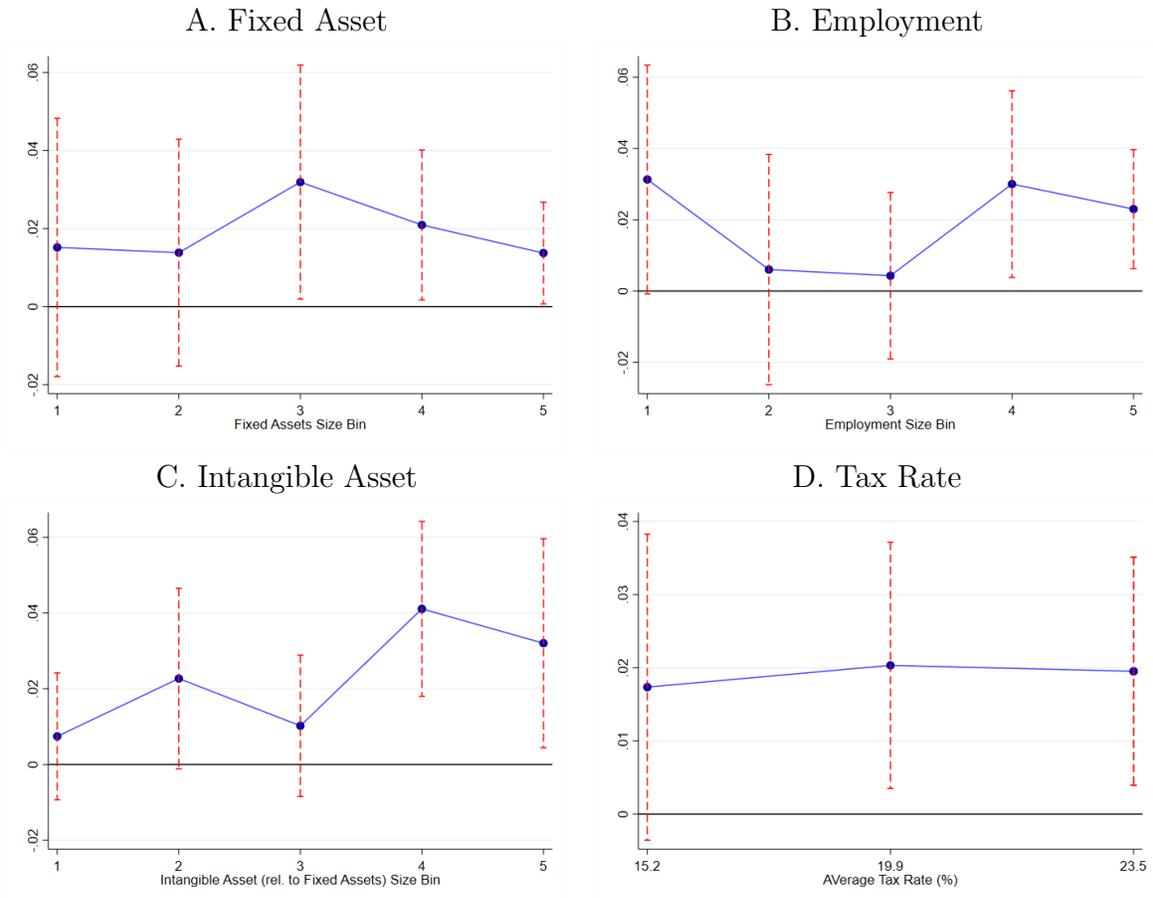
Estimated coefficients from specification (8) for quintiles, including 95% confindence intervals across firm size (measured by fixed assets in Panel A and employment in Panel B), intensity of intangibles (Panel C), and host-country tax rate (Panel D). Data from Amadeus 2006-2012.

6 Economic Magnitude and Policy Implication

6.1 Economic magnitude

Our preferred results based on Column 3 of Table 3 suggest that there is a 2.1 percentage-point increase in the overall pre-tax profitability of UK affiliates, which can be decomposed into two effects. First, the reform reduces the likelihood of reporting losses by 2.1 percentage point for UK affiliates that report loss making prior to the reform.[**Not for full sample?**] At the same time, the reform increases the reported profitability of UK affiliates with positive earnings by 11 percent.

To put these results in perspective, we use the consensus semi-elasticity of reported profits to corporate tax rate differential of 1.5 in a recent meta-analysis (Beer et al., 2019), which suggests that for every one percentage point lower corporate tax rate (everything else equal), there is a 1.5 percent increase in the pre-tax profit reported by multinationals. The benchmark specification of the meta-analysis uses the logarithm of reported profit before taxation as dependent variable, which is comparable to our results focusing on the intensive response margin to the territorial tax reform. On average we find that for profit-making UK affiliates, there is an eleven percent increase in their pre-tax earnings following the reform. The extent of increase in pre-tax profits is thus equivalent to a seven percentage point reduction in the statutory corporate income tax rate in the UK ($= 11/1.5$).

In terms of economic magnitude, overall the reported pre-tax profitability for UK affiliates in low-tax countries in our sample increases by 2.1 percentage point following the reform. Evaluated at the mean asset value for UK affiliates in the low-tax countries, the result implies an increase of EUR 2.9 mil for the median firm and of EUR 41.6 mil on average.

6.2 The effect of profit shifting on measured TFP

By altering the allocation of reported profits across countries, profit shifting by multinational firms not only changes the distribution of tax revenue among the countries involved. It also has implications on real economies in these countries as it affects the investment and other behaviors of multinational companies. Profit shifting may also distort the measurement of

aggregate outcomes such as productivity or the trade balance.

Whether profit shifting affects measured productivity depends on the profit shifting channel. In particular, 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. In addition, the relocation of intellectual property affects 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). Profit shifting via internal financing should not affect productivity measures.

As Heckemeyer and Overesch (2017) show that transfer pricing and licensing are the dominant profit-shifting strategies (accounting for about 80% of the response to taxation). Thus, we expect that stronger profit shifting following the territorial tax reform exacerbated the mis-measurement of the productivity of UK multinationals in foreign countries.

To test this hypothesis, we use two alternative measures of TFP, including one based on the factor share approach and one estimated following the LP algorithm. We run a similar DD regression based on Eq. (3), where the dependent variable is the natural logarithm of TFP. Consistent with increased profit shifting into low-tax countries by UK affiliates, we expect a corresponding increase in the measured TFP for UK affiliates and hence a positive coefficient for β_1.

Table 6 summarizes the regression results. Columns (1) and (2) focus on the low-tax countries, respectively using the factor-share TFP and LP TFP measure as the dependent variable. Both columns report a positive and significant coefficient on the interaction term, suggesting an increase in the measured TFP of between 5 and 9 percent for low-tax UK affiliates after the territorial tax system. As a placebo test, Columns (3)-(4) report the results for high-tax countries. The estimated effect of the territorial tax reform is much smaller and insignificant in both specifications.

Table 6. Profit Shifting after Territorial: Effects on TFP

Sample:	Low-Tax		High-Tax	
Dependent variable:	$\ln(TFP_{FS})$	$\ln(TFP_{LP})$	$\ln(TFP_{FS})$	$\ln(TFP_{LP})$
	(1)	(2)	(3)	(4)
UK-Parent × Post	0.085***	0.049*	0.016	0.005
	(0.038)	(0.029)	(0.021)	(0.013)
Affiliate FEs	Y	Y	Y	Y
Industry-Year FEs	Y	Y	Y	Y
Host Country-Year FEs	Y	Y	Y	Y
N	132,068	66,072	107,727	92,431
R^2	0.974	0.735	0.986	0.773

The dependent variable is natural logarithm of total factor productivity (TFP). Data from Amadeus for 2006-2012. Standard errors in parentheses are clustered by firm. ***, ** and * indicate significance at the 1%, 5% and 10% levels.

7 Conclusion

In this paper, we have used the introduction of a territorial tax system in the UK to study the difference in profit shifting under a worldwide and a territorial tax system. Using a DiD research design comparing the foreign subsidiaries of UK parents with subsidiaries from other multinationals in the same country, we found that UK multinationals shifted significantly more profits to low-tax countries after the UK introduced the territorial tax system. In placebo tests considering high-tax countries, we have found no effect. In further analyses, our paper confirmed that firms with high shares of intangible assets are more responsive to profit shifting incentives. We also find that increased profit shifting following the territorial tax reform has a significant and positive impact on measured TFP of UK affiliates in low-tax countries.

Our results have important implications for other countries switching to a territorial tax system. In particular, the US introduced 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 most strongly about

two years after the reform. As many US multinationals hold large amounts of intellectual property, their response may be even larger than our estimates for the UK.

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8 Appendix

Table A.1. Observations by Country

	Low-Tax	High-Tax	Total
Austria	4,008	0	4,008
Belgium	0	23,177	23,177
Bulgaria	9,553	0	9,553
Czech Republic	33,414	0	33,414
Denmark	659	0	659
Estonia	8,686	0	8,686
Finland	5,747	0	5,747
France	0	39,383	39,383
Germany	0	21,514	21,514
Greece	5,057	0	5,057
Hungary	4,981	0	4,981
Ireland	3,370	0	3,370
Italy	0	37,627	37,627
Luxembourg	0	421	421
Netherlands	4,271	0	4,271
Poland	20,590	0	20,590
Portugal	543	42	585
Romania	63,794	0	63,794
Spain	0	38,232	38,232
Sweden	830	0	830
Slovenia	3,915	0	3,915
Slovakia	17,119	0	17,119
Total	186,537	160,396	346,933

Observations by country in the affiliate-level dataset.
Low-tax (high-tax) observations are firms 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.2. Observations by Year (Consolidated Data)

	# Obs.	% of sample
2005	100	2.358
2006	166	3.914
2007	196	4.622
2008	547	12.90
2009	519	12.24
2010	539	12.71
2011	539	12.71
2012	535	12.61
2013	544	12.83
2014	556	13.11
Total	4,241	100