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How aggressive are foreign multinational companies in reducing their corporation tax liability?*

Evidence from UK confidential corporate tax returns.

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Abstract

In this paper, I use confidential UK corporate tax returns dataset from Her Majesty's Revenue and Customs (HMRC) to explore whether there are systematic differences in the amount of taxable profits that multinational and domestic companies report. I estimate, using propensity score matching, that the ratio of taxable profits to total assets reported by foreign multinational subsidiaries is 12.8 percentage points lower than that of comparable domestic standalones, which report their ratio of taxable profits to total assets to be 25.2 percent. If we assume that all of the difference can be attributed to profit shifting, foreign multinational subsidiaries shift over half of their taxable profits out of the UK. The difference is almost entirely attributable to the fact that a higher proportion of foreign multinational subsidiaries report zero taxable profits (59.2 percent) than domestic standalones (27.5 percent), suggesting a very aggressive form of profit shifting. Comparison of propensity score matching results using accounting and taxable profits data reveals that the extent of profit shifting estimated using accounting data is much smaller than that estimated using tax returns data.

JEL: H25, H32, Key words: tax payments, UK tax revenues, multinational companies

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1 Introduction

Following the financial crisis, the issues of aggressive tax avoidance and profit shifting by corporations became more prominent in policy debates as authorities around the world saw combatting tax avoidance as one of the important means of recovering from the fiscal consequences of the crisis. For example, the United Kingdom has introduced the Diverted Profits Tax in April 2015 aimed at taxing profits shifted abroad by multinational companies.[1] UK also announced limits to interest deductibility—one of many ways in which corporations minimize their tax payments—from April 2017.[2] More generally, in 2015 the OECD countries have agreed to jointly reduce the extent of profit shifting via the Base Erosion and Profit Shifting (BEPS) project.[3] The media has also shown increased appetite for 'naming and shaming' many familiar multinational companies, such as Starbucks and Amazon, for paying too little tax.

The question remains as to whether it is only the very large multinationals that avoid paying corporation tax, or even whether it is only those for which we have public information available, or do all multinational do so. In this paper, I analyze a universe of confidential corporate tax returns to consider the taxable profits that companies reported to Her Majesty's Revenue & Customs (HMRC) during the period 2000 to 2011. In particular, I focus on whether there are systematic differences in the amount of taxable profits that UK subsidiaries of foreign multinational companies (foreign multinational subsidiaries) and standalone UK companies (domestic standalones) report.

This is the first study to use the new administrative data, rather than accounting data, to analyze the profit shifting practices of multinational companies residing in the UK. Further, the availability of tax returns data allows me to explore a new phenomenon - companies reporting zero taxable profits. I find large bunching at zero taxable profits for foreign multinational subsidiaries relative to domestic standalones, which is not observed to the same extent in the accounting data.[4]

In this paper I focus on the differences in the ratio of reported taxable profits to total assets between foreign multinational subsidiaries and comparable domestic standalones. These two ownership categories are chosen with a view to compare two distinct groups of companies, of which one has the ability to shift profits abroad (foreign multinational subsidiaries) and one does not (domestic standalones). Specifically, I analyze foreign multinational subsidiaries which have no further subsidiaries themselves and which report having positive trading turnover. I ensure that these selected companies are comparable with domestic standalones in terms of their observable characteristics. What is more,

[1] HMRC's description of the diverted profits tax can be found at http://bit.ly/1sFOLcc.

[2] The UK 2016 Budget, p.56 (http://bit.ly/1R2QgNv).

[3] For the OECD report, see http://www.oecd.org/ctp/beps.htm.

[4] Johannesen *et al.* (2016) find that companies are more likely to report near-zero accounting profits in their home country, the higher the average foreign tax rate of their subsidiaries is.

since foreign multinational subsidiaries are generally larger and generate higher levels of profits than domestic standalones, I use the ratio of taxable profits to total assets as a main comparison measure between those two ownership types.[5]

In order to appropriately account for the difference in size between foreign multinational subsidiaries and domestic standalones, as well as the endogeneity problem arising from self-selection into being a multinational, I adopt the propensity score matching approach (Paul R. Rosenbaum (1983), Rosenbaum and Rubin (1985)). I 'match' companies based on the size of their assets and industry and find that the unweighted mean ratio of taxable profits to total assets for foreign multinational subsidiaries is 12.4 percent, whereas for matched domestic standalones it is 25.2 percent, i.e. foreign multinational subsidiaries report 12.8 percentage points lower taxable profits relative to total assets than domestic standalones. If we attribute all of the difference between these matched samples of foreign multinational subsidiaries and domestic standalones to profit shifting, then foreign multinationals shift over half of their taxable profits out of the UK.

The difference between the matched samples of foreign multinational subsidiaries and domestic standalones is almost entirely explained by the fact that a higher proportion of foreign multinational subsidiaries report zero taxable profits (59.2 percent) than domestic standalones (27.5 percent).[6] In particular, 85 percent of the average difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones can be attributed to foreign multinational subsidiaries reporting zero taxable profits. When restricting the sample to companies which report positive taxable profits, the difference in the ratio of taxable profits to total assets between the ownership types is small and insignificant. Once foreign multinational subsidiaries decide to report positive taxable profits, their reporting behaviour does not differ from that of domestic standalones.

One possible explanation for the large number of zero taxable profit reporting multinationals is that foreign multinational subsidiaries, unlike domestic standalones, are able to use various methods of profit shifting, such as debt shifting, patent or royalty location or transfer pricing to minimize their taxable profits in the UK (Dharmapala (2014)).[7] An example of debt shifting is when a UK subsidiary of a foreign multinational borrows from its parent company in a low tax country so as to reduce its taxable profits (tax base) in the UK (since interest payments are tax deductible), subject to Controlled Foreign Com-

[5] See Habu (2017) for a discussion of various measures to compare taxable profits of multinational and domestic companies.

[6] The taxable profits are either zero or positive in the tax returns form; negative profits are reported as zeros. Hence, the data is censored at zero. We can recover taxable losses from the back of the tax returns form, but only the portion of the losses which is related to trading activities. I discuss this further in the empirical section.

[7] This supports the evidence from Johannesen *et al.* (2016) who use bunching of the ratio of accounting profits to total assets around zero to estimate the extent of profit shifting of multinationals in Europe. They find that reporting near-zero accounting profits may be linked with aggressive tax avoidance by multinational companies and is related to the tax rate of their foreign parent.

pany (CFC) rules.[8] This increases the tax base in the lower tax country, so as to reduce the overall tax burden for the company. In a similar way, multinational can use transfer pricing to reduce its total tax liability; i.e. purchase goods from its foreign subsidiary at higher than a market price (Grubert (2003), Markle (2012)).[9] Finally, multinationals often set up subsidiaries in low tax countries where they hold a large proportion of their intellectual property, which they then license to their subsidiaries in higher tax countries, such as the UK. In this paper, I find that in the UK domestic standalones report 14 percentage points lower leverage than comparable foreign multinational subsidiaries. Further, 40 percent of the gap in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones can be explained by the differences in leverage between ownership types. When restricting the sample to companies which report positive taxable profits, the difference in leverage between ownership types is reduced to 7 percentage points. This is consistent with the hypothesis that some companies use leverage to reduce their taxable profits to zero.

The large number of zero taxable profit reporting foreign multinational subsidiaries suggests a very aggressive form of profit shifting for some foreign multinationals. Moreover, a puzzle emerges, as I cannot identify any major differences in observable firm level characteristics between tax-payers and non tax-payers. This may suggest that firms instead differ in their unobservable characteristics such as their ability to shift profits or reputational costs of aggressive tax planning[10].

There are other possible explanations for why I find such a large difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones, which are unrelated to profit shifting. In this paper, I empirically test their importance and find that only leverage explains a significant portion of the difference in the ratio of taxable profits to total assets between the analyzed ownership types. In turn, I find that foreign multinational subsidiaries, in spite of reporting lower taxable profits, are actually 25 percent more productive than domestic standalones. This suggests that the differences in profitability between ownership types do not arise because of the differences in productivity.[11]

[8] "The CFC rules are anti-avoidance provisions designed to prevent diversion of UK profits to low tax territories. If UK profits are diverted to a CFC, those profits are apportioned and charged on a UK corporate interest-holder that holds at least a 25% interest in the CFC." For more details see https://www.gov.uk/guidance/controlled-foreign-company-an-overview

[9] For a detailed analysis of profit shifting using transfer pricing by multinationals see Liu and Schmidt-Eisenlohr (2017). They use tax and trade linked data from the HMRC to look at transfer pricing strategies of multinational companies.

[10] The accounting literature identifies a relationship between firm's CEO who may be an aggressive tax planner and the amount of accounting profits that a firm reports (Armstrong *et al.* (2012), Armstrong *et al.* (2015)).

[11] For the discussion of other possible factors that could affect the size of the gap in the ratio of taxable profits to total assets between domestic standalones and foreign multinational subsidiaries see Habu (2017). These are, for instance, losses made in this or previous periods or different industry and size distributions.

The differences in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones are related to traditional measures associated with profit shifting. In the previous literature the extent to which firm's profit is related to leverage, tax rates or firm structure, such as a presence of tax havens, has been used as an indicator of profit shifting (Hines and Rice (1994)). In this paper, I find that, for instance, foreign multinational subsidiaries headquartered in tax havens report much lower taxable profits in the UK relative to domestic standalones than foreign multinational subsidiaries headquartered in higher tax countries. If we consider being headquartered in a tax haven as a sign of being a profit shifter, this suggests that companies which are more likely to be shifting profits out of the UK, report the lowest ratios of taxable profits to total assets in the UK.

I find that the UK corporate tax rate cuts did not have an effect on the ratio of taxable profits to total assets reported by foreign multinational subsidiaries relative to that reported by domestic standalones. If marginal cost of shifting profits abroad is equal to marginal benefits, we would expect a cut in the domestic corporate tax rate to reduce the marginal benefit of shifting profits abroad. This could induce a company to report higher taxable profits in the UK. The fact that I find no such response, suggests that the cost of reducing taxable profits may not be a convex function of firm's profits. Instead, it points towards firms in my sample having fixed cost of shifting profits. This is also consistent with the fact that the zero taxable profits reporting pattern is prevalent for foreign multinational subsidiaries, as those companies may be inelastic to changes in the corporate tax rates, in so far as they already report zero taxable profits.

Previous studies, which used accounting profits to proxy for taxable profits, may have underestimated the extent of profit shifting by multinational companies. To compare taxable and accounting profits I include in taxable profits, which are otherwise censored at zero, trading losses that companies report in the tax returns form. I find that companies which report positive profits, report significantly higher accounting profits than taxable profits.[12] Further, bunching at zero (or near-zero) profits is much stronger in the tax returns data than in the accounting data. Both of those differences are systematically larger for foreign multinational subsidiaries, which suggests that they may be driven by factors unrelated to reporting standards and instead may be an indication of aggressive tax planning practices of multinational companies. Comparison of the propensity score matching results using accounting and taxable profits data reveals that the extent of the gap in the ratio of taxable profits to total assets estimated using accounting data is much

[12] The difference between what companies report on their accounting statements and the taxable profits they report is to be expected (Desai and Dharmapala (2009)) due to the differences in accounting standards and tax reporting standards. This is partly due to the fact that accounting depreciation tends to be less generous than tax depreciation, which means that after taking into account capital allowances, accounting profits can be expected to be higher than taxable profits (Hanlon and Heitzman (2010), Dharmapala (2014)).

smaller than that estimated using tax returns data.

The advantage of the work presented in this paper over previous approaches is threefold. First, unlike most of the profit shifting literature, which uses accounting profits as a proxy for taxable profits, I use administrative data on taxable profits directly from the tax returns. Secondly, I select the sample of foreign multinational subsidiaries and domestic standalones from a full population of UK companies. This means that I have larger than previously analyzed sample of comparable companies. Finally, previous approaches have focused on studying the relationship between tax rates and logarithm of profits to estimate the extent of profit shifting of multinational companies (see Dharmapala (2014) for review of the literature). Using the logarithm of profits means that these studies have implicitly concentrated their analysis on the positive taxable profits.[13] In this paper, I show that the most important aspect of understanding how much taxable profits foreign multinational subsidiaries report, is the zero taxable profit reporting behaviour.

Egger *et al.* (2010) use accounting data to show that multinationals earn significantly higher profits than comparable domestic firms in low tax countries, but earn significantly lower profits in high tax countries. They define low tax countries as countries with statutory tax rates lower than the median in their sample. Given that the UK was a relatively high tax country during the sample period, their findings would suggest that multinationals operating in the UK would report lower accounting profits than domestic companies. If we assume that accounting profits are a good proxy for taxable profits, this is consistent with my finding that foreign multinational subsidiaries report lower ratios of taxable profits to total assets than domestic standalones.

In what follows, section 2 briefly describes the data used in this paper, section 3 outlines the empirical methodology and the challenges associated with it, section 4 discusses the results and section 5 concludes.

2 Data description and sample selection criteria

The primary data source used in this paper is the confidential universe of unconsolidated corporation tax returns in the UK for the years 2000 - 2011 provided by HMRC. The dataset comprises all items that are submitted on the corporation tax return form (CT600 form) and the unit of observation is an unconsolidated statement in each of the years. The HMRC data does not offer any firm level characteristic variables, apart from trading turnover. Therefore I merge the HMRC data with the accounting data from the FAME dataset. FAME dataset, collected by Bureau van Dijk, provides balance sheet information for UK companies. For instance, it gives me information on total assets, accounting

[13] The profit shfiting literature does not directly omit the negative and zero profits from their analysis. Instead, they often add a constant to the profits number and hence they do include negative and zero profits. However, this does not enable them to study the zero profits phenomenon directly.

profits, age of firms, number of employees, industry or leverage.

Matching the HMRC data with accounting data restricts the sample size. I find a matched unconsolidated accounting statement in FAME for 76 percent of unconsolidated tax returns from the HMRC data, which includes 89 percent of the total tax liability and 92 percent of total trading turnover in the UK. I further ensure that I have non-missing total assets information and full 12 months accounting period for each matched HMRC-FAME observation.[14]

The FAME dataset also includes information on firm ownership, which I use to identify firms into various ownership categories. The FAME ownership dataset is a cross section from the latest edition of the dataset (2013). For the purpose of this paper, I focus on two distinct ownership categories, UK subsidiaries of foreign multinational companies which are subsidiaries of multinational companies that have headquarters outside of the UK; and UK standalone domestic companies, which are independent companies with no affiliates. These two types of companies constitute about 30 percent of the total taxable profits in the UK and hold 50 percent of total assets. Their observable characteristics are similar to other types of multinationals and domestic companies, which makes them representative of the ownership classes they were chosen from. I have chosen those two groups of companies with a view to find the two most comparable ownership groups, of which one has the ability to shift profits abroad (foreign multinational subsidiaries) and one does not (domestic standalones). To strengthen their comparability, I limit the foreign multinational subsidiaries sample to include affiliates with zero subsidiaries and with positive trading turnover.

The total number of foreign multinational subsidiaries in the sample is 270,000, of which 200,000 have no subsidiaries themselves. This means that I exclude from the main analysis around 25 percent of foreign multinational subsidiaries. This addresses two possible concerns: appropriate asset size and presence of overseas income. The total assets numbers that multinationals with zero subsidiaries report is not affected by the equity value of their subsidiaries, as they report to have none.[15] Also, the effect of overseas income on their taxable profits should be negligible after including only companies with no subsidiaries.[16,17]

[14] For a detailed description of the HMRC-FAME matched dataset see Habu (2017).

[15] Note that the ratio of taxable profits to total asstes increases for the foreign multinational subsidiaries sample as I introduce the addtional selection criteria. This is consistent with the total assets number being larger than the size of the operations of foreign multinational subsidiaries with subsidiaries in the UK.

[16] Some of the foreign multinational subsidiaries that report to have no subsidiaries themselves have reported overseas income in the UK. This may be because my ownership data may not capture the ownership structure of companies perfectly.

[17] The concern here could be that the treatment of overseas income has changed following the 2009 dividend tax reform, after which firms were no longer required to report overseas income on their tax returns. This could create a discord between the taxable profits of multinationals with overseas income before and after 2009. What is more, part of the overseas income was sheltered by double tax relief in the UK. This means that multinational companies only paid tax on part of the reported overseas income.

Further, I ensure that foreign multinational subsidiaries selected for the analysis report having positive trading turnover in the UK. Out of 200,000 foreign multinational subsidiaries with no subsidiaries themselves, just under 150,000 also report to have positive trading turnover. This means that they have trading activities in the UK and do not exist solely as holding companies to transfer profits between company affiliates.

Sample size has plagued previous studies as important parts of the economy were omitted by excluding small firms. Accounting datasets generally report missing data for a large portion of observations. I am the first to use the HMRC tax returns data with universal coverage to solve this problem. When estimating the size of the difference in taxable profits between foreign multinational subsidiaries and domestic standalones I additionally rely on accounting information to obtain total asset figures. In contrast to information on accounting profits, data on total assets has substantially better coverage.[18] Therefore, in my propensity score matching analysis, I have larger than previously analyzed sample of foreign multinational subsidiaries and domestic standalones. I am able to find comparable domestic standalone companies not only for large foreign multinational subsidiaries, but also for smaller foreign multinational subsidiaries, for which a large number of comparable domestic standalones exists.

In my empirical analysis I do not consider domestic multinationals for two distinct reasons. First, one may think that they would be a good comparison group for foreign multinational subsidiaries. However, since domestic multinationals have similar opportunities to shift profits abroad as foreign multinationals, the size of the difference between these two groups would not give me any information on the potential size of profit shifting. On the other hand, they may present an interesting comparison with domestic standalones. However, the size of the total assets of domestic multinationals in my dataset is not a good approximation of the size of their operations in the UK. This is because all but a few of the domestic multinational observations in the selected sample report having at least one subsidiary, either foreign or domestic.[19] This means that the total assets figures in unconsolidated accounts of those companies may include the equity value of those subsidiaries, while their taxable profits do not include taxable profits of the subsidiaries. Thus, the ratio of their taxable profits to total assets will be biased

The exclusion of the sheltered portion of overseas income from the taxable profits would decrease the numerator of the taxable profits to total assets ratio for multinational companies which receive overseas income. To allieviate this concern the main empirical analysis is performed using foreign multinational subsidaries with zero subsidiaries themselevs and in any case only 2.6% of the analysed sample has reported to bring any overseas income to the UK. Therefore the issue of including overseas income which is sheltered by double tax relief in the taxable profit measure is not a major one. I test this further in the empirical analysis.

[18] For instance, out of 150,000 foreign multinational subsidiaries for which I have total assets and taxable profits information, only 65,000 have reported profits information in their accounting statements.

[19] This is the case for both parent companies and their subsidiaries alike. This is not the case for foreign multinational subsidiaries, as only 25 percent of them report to have subsidiaries themselves and those I exclude from the sample.

downwards relative to companies with no subsidiaries which report the same taxable profits. Therefore those companies might not be as comparable to domestic standalones in terms of the main variable of interest as foreign multinational subsidiaries without any subsidiaries are. Further, half of domestic multinationals report only consolidated accounts in the FAME dataset.[20]

I also do not focus the empirical analysis on the differences between foreign multinational subsidiaries and domestic groups. The exclusion of domestic groups from the empirical analysis comes from the fact that I cannot identify those types of companies with certainty. I can say with confidence that they are not domestic standalones, but due to missing ownership data, it is entirely plausible that a company that I have classified as a domestic group based on the lack of foreign income and the presence of domestic parent and no foreign subsidiaries, is actually a foreign multinational subsidiary.

2.1 Descriptive statistics

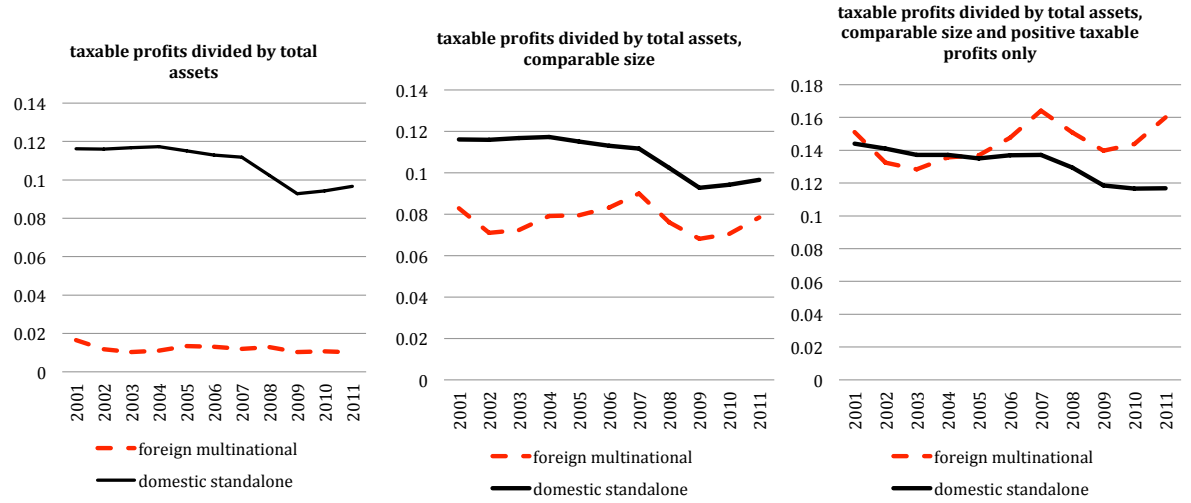
In this section I present descriptive evidence on the differences in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones. In Figure 1 I plot the weighted mean ratios of taxable profits to total assets for the two analyzed groups. Specifically, I sum up all taxable profits in each year for each ownership type and do the same for total assets. I then divide one sum over the other to obtain the weighted means. In Panel A I consider the whole sample of observations for both ownership types. In Panel B I consider only companies of similar size, excluding very large foreign multinational subsidiaries for which no comparable domestic standalones exist and excluding very small domestic standalones for which no comparable foreign multinational subsidiaries exist. In Panel C I further impose a restriction that the companies considered in Panel B report positive taxable profits only.

I find that in the raw data, domestic standalones report 6 times higher ratio of taxable profits to total assets than foreign multinational subsidiaries. When I compare companies of similar sizes, by excluding the very large multinationals and the very small domestic companies, they report more comparable taxable profits. The difference in the ratio of taxable profits to total assets between the two ownership types in Panel B is about 4 percentage points; foreign multinational subsidiaries report their ratio of taxable profits to total assets to be 8 percent, while domestic standalones report that to be 12 percent. Further, excluding companies which report zero taxable profits (almost 60 percent of foreign multinational subsidiaries and 27.5 percent of domestic standalones) we can see that the difference in the ratio of taxable profits to total assets between foreign multinational

[20] An alternative would be to use trading turnover reported in the tax return form as a measure of size for domestic multinationals. However, this is not possible as trading turnover for domestic multinationals is almost always missing (likely because companies are not required to report turnovers). It means that I have no data source to approximate the size of domestic multinationals in the UK.

subsidiaries and domestic standalones disappears. Moreover, in the second half of the sample period foreign multinational subsidiaries which report positive taxable profits, report higher taxable profits than domestic standalones which also report positive taxable profits.

Figure 1: Taxable profits comparisons: foreign multinational subsidiaries vs domestic standalones.



Note: Differences in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones, The ratios are calculated by summing up all taxable profits of a particular ownership category in each year and dividing these by the sum of total assets of that paritcular ownership category in that particular year. Years used 2000 - 2011, selected sample. Source: merged HMRC and FAME data.

3 Empirical methodology

In this section I describe the empirical strategy I use to estimate the size of the difference in the ratio of taxable profits to total assets between domestic standalones and foreign multinational subsidiaries. The most straightforward and commonly used in the literature approach would be to use panel estimators, such as pooled OLS or within firm transformation to estimate the average difference in the taxable profits relative to total assets between multinationals and domestic standalones. Previous approaches have used changes in the tax rate differential between countries to identify the relationship between tax rates and reported accounting profits (the approaches following Hines and Rice (1994)).

However, this yields two types of biases. Firstly, foreign multinational subsidiaries are much larger than domestic standalones, hence, the OLS results may include companies which are not of comparable size. The evidence from Habu (2017) shows that the very large multinationals report lower ratios of taxable profits to total assets than smaller multinationals for which comparable domestic standalones exist. Conversely, very small

domestic standalones report higher ratios of taxable profits to total assets than larger domestic standalones for which comparable foreign multinational subsidiaries exist. Hence, the OLS results on the whole sample may be upward biased. Secondly, foreign multinational subsidiaries and domestic standalones differ not only in terms of size, but also across other observable characteristics. For instance, trade literature over the last decades has documented that multinational and domestic firms differ in terms of productivity, size and wages (Harrison and Aitken (1999), Javorcik (2004), Sabirianova *et al.* (2005), Yasar and Morrison Paul (2007)).[21] This suggests that there may be a selection into being a multinational company that is a function of observable firm level characteristics.

The econometric approach that has been used extensively in trade and industrial economics literature to alleviate the two concerns raised above has been a non-parametric matching method.[22] This method calculates predicted probabilities of being in the treatment group based on observable firm level characteristics and finds observations with similar propensity scores from treatment and control groups. Instead of comparing the average differences between two groups of companies, the propensity score matching method compares companies with similar propensity scores and calculates the average difference using the comparable pairs.

In the first stage a logit model is estimated with multinational dummy on the left hand side and determinants of being a multinational company on the right hand side. I use this regression to calculate the predicted probabilities of being a multinational company for each observation. These are called propensity scores (Paul R. Rosenbaum (1983), Rosenbaum and Rubin (1985)).

$$multinational_i = \alpha_i + \delta \mathbf{K}_{it} + ind_i + year_t + \epsilon_{it}. \quad (1)$$

where $multinational_i$ is a multinational dummy equal to 1 if a company is a multinational and 0 otherwise, $\mathbf{K}_{it}$ is a set of determinants of being a multinational, ind_i and $year_t$ are industry and year fixed effects. I use a nearest neighborhood matching strategy within a 0.1 caliper radius without replacement, which for each foreign multinational subsidiary finds a closest comparable domestic standalone within the 0.1 radius in terms of the propensity score.[23] That particular domestic standalone is used only once, hence

[21] This endogeneity has also been explored theoretically (Markusen and Venables (1998), Helpman *et al.* (2004)).

[22] The non-parametric nature of the propensity score matching is important since it avoids misspecification of the equation as could be the case with OLS. To ensure OLS specification yields similar results to matching, we would need to control for a fully flexible industry size matrix. However, if OLS is correctly specified, it is more efficient (Hirano *et al.* (2003), Abadie and Imbens (2006)).

[23] Various robustness checks have been performed using different caliper and the results are not very sensitive to the choice of the radius. William G. Cochran (1973) and Rosenbaum and Rubin (1985) suggest using a caliper width that is a proportion of the standard deviation of the logit of the propensity score, specifically 0.2 of standard deviation was suggested to eliminate approximately 99% of the bias due to the measured confounders. Since the standard deviation of the logit of the propensity score is 0.5 in my baseline matching model, I choose 0.1 caliper width.

the sample size of foreign multinational subsidiaries and domestic standalones used for matching without replacement is the same.[24] Furthermore, I impose a common support restriction for total assets, hence no company larger than the largest domestic standalone and no company smaller than the smallest foreign multinational is in the sample. This last condition is crucial and makes the propensity score matching (PSM) method a preferred approach to OLS especially in the light of very different size distributions between ownership types.

There are various other algorithms which can be used to obtain matched samples based on propensity scores, such as kernel or radius. Radius matching uses all domestic standalone companies with propensity scores within a certain radius from a given multinational to estimate the size of the difference. Kernel matching uses all domestic standalones, but weights the control observations inverse-proportionally to the propensity score difference to the multinational company. Using more observations for matching increases precision, but the more observations you use the less suitable they are as comparisons. This could lead to large biases. Since larger multinationals are not comparable to smaller ones in terms of the ratio of their taxable profits to total assets, I use nearest neighborhood matching to avoid large biases and trade off efficiency of the estimates.[25]

The critical difficulty of this paper is in finding the appropriate group of companies to achieve the best matching possible. For each foreign multinational affiliate I want to find a comparable domestic standalone from the same industry of the same size. Therefore I keep the set of matching variables as simple as possible and in the baseline results use the following observable characteristics: industry, year and total assets.[26]

The propensity score generated in the first stage divides the sample into a group of "treated" foreign multinational subsidiaries for which a comparable domestic standalone with a similar propensity score was found, and remaining companies, which constitute the unmatched sample. Since the main outcome of interest is the ratio of taxable profits to total assets, in the second stage a difference in the mean ratios of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones is estimated using the matched sample (Paul R. Rosenbaum (1983)). This effect is presented as the average treatment effect on the treated (ATT, Imbens (2004)). Hence, the ATT is the percentage point difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic companies accounting for selection into being a multinational. This approach is applied to alternative outcome variables as well.

[24] The replacement feature enables the same domestic standalone to be used as a comparable company for foreign multinational subsidiaries multiple of times. This might be important in the right hand side tail of the distribution where there are not very many large domestic standalones to create a comparable group for foreign multinational subsidiaries. I test the robustness of the baseline estimates using the replacement feature.

[25] For a detailed description of differences in the size distributions between foreign multinational subsidiaries and domestic standalones see Habu (2017).

[26] I check the robustness of the choice of the baseline matching variables in Section 2.4.1.

The PSM results may be directly compared to the OLS estimates. However, this hinges on including a fully flexible size and industry interaction matrix together with exclusion of companies outside of the overlapping regions. For more discussion on the differences between PSM and OLS see Appendix 6.1.

Habu (2017) documents large differences in the proportions of observations that report zero taxable profits between foreign multinational subsidiaries and domestic standalones. Therefore, the estimation of the unconditional means of the ratio of taxable profits to total assets is not the only interesting margin of comparison between the ownership types. The unconditional mean can be decomposed into the share of zeros and a mean conditional on reporting positive taxable profits in the following way:

$$E(y) = (1-p)E(y|y=0) + pE(y|y>0) = 0 + pE(y|y>0) = pE(y|y>0) \qquad (2)$$

where $p = prob(y > 0)$ and $y = \frac{\text{taxable profits}}{\text{total assets}}$.[27] This suggests dividing the analysis into three main components; the unconditional mean of taxable profits relative to total assets, the mean of taxable profits conditional on reporting positive taxable profits and the binary outcome analysis of zero taxable profit reporting, that will directly estimate p. Dropping observations with $y = 0$ and performing PSM is a first attempt to consider the conditional mean, while selectivity correction may be considered a refinement. Since applying selectivity correction does not change the main result relative to PSM, I do not discuss it in the main body of the paper. For more details on the two-stage Heckman selection approach and the results see Appendix 6.2.

The difference in ATT between the unconditional and conditional means indicates how much of the difference in taxable profits between foreign multinational subsidiaries and domestic standalones I can attribute to zero taxable profit reporting. Furthermore, I consider zero taxable profits dummy defined as one when the company is reporting zero taxable profits and zero otherwise as an outcome variable. The ATT coefficient on that outcome variable will tell me the difference in the proportion of observations that are reporting zero taxable profits between the two ownership types in the matched sample.

Another factor which may contribute to the differences in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones is differences in leverage.[28] This leads me to consider leverage as an additional outcome variable in the propensity score matching approach. I consider two measures of leverage, total liabilities divided by total assets - stock measure of leverage - and net interest

[27] $E(y|y=0)$ is zero when y is reported taxable profits, censored at zero. However, UK tax system allows carryforward of losses for tax purposes, which would mean that $E(y|y=0)$ may not be zero when y measures the actual taxable profits. I discuss this particular feature of the UK tax system later in this section.

[28] Higher leverage makes zero taxable profits more likely. Hence, differences in leverage and the proportion of zero taxable profits cannot be considered as separate factors.

(interest paid minus interest received) divided by profit and loss before interest - flow measure of gearing.

Furthermore, the propensity score matching approach allows me to calculate the proportion of the difference in taxable profits between foreign multinational subsidiaries and domestic standalones that can be attributed to the differences in leverage. To do so, in the first stage of PSM I use leverage as a matching variable. Therefore now, in the second stage, I will be comparing companies of similar size with similar leverage. The difference in the ATT coefficient between matching with and without leverage (on the same sample) will give me the fraction of the difference explained by leverage.

The question also arises whether we are only interested in taxable profits as they are recorded on the tax return form, i.e. taxable profits=max(0, taxable income), or whether we are also interested in the underlying taxable income, which may be either positive or negative. This is conceptually unclear, given the asymmetric treatment of profits and losses. In the UK tax system when a company makes a loss it does not receive a tax credit on that loss, but instead records zero taxable income and hence pays no corporation tax on that income. It is then allowed to bring some of the losses it made forward into future periods and offset them against positive taxable profits, once it is profitable again. Alternatively, it can also bring the losses back one period and offset them against last year's profits, if those profits were positive. In the case of loss carryback the company would receive tax credit in that particular year. When taxable profits are positive, the corporation tax liability is paid. This means that the taxable profits are censored at zero.

What this implies for the purpose of this paper is that with fully symmetric treatment, we would only be interested in the underlying taxable income, with fully asymmetric treatment (no carry back or carryforward of losses), we would only be interested in the recorded taxable profits (censored at zero). With the actual treatment (some carry back and carryforward at nominal value) we may be interested in both. We can potentially use additional information from the tax return, e.g. on losses, to recover or estimate the underlying taxable income. One of the possible sources of information is trading losses in the CT600 form, where firms have to report the amount of losses arising from their trading activities. The advantage of this measure is that we could simply subtract those trading losses from recorded taxable profit to recover some of the underlying taxable income. This measure would be more closely related to tax payments in the same year. The disadvantage is that we have no information on other sources of losses that companies may be incurring, which means that we are introducing a measurement error into the analysis. In the empirical analysis I primarily focus on the censored taxable profits as an outcome variable. However, I discuss comparisons between taxable income and recorded taxable profits measures when I compare propensity score matching results using taxable and accounting profits.

4 Results

In this section I present the results from propensity score matching. I then test their robustness, discuss channels which companies use to lower their taxable profits and compare my results with those using accounting profits. Finally, I consider the heterogeneity of the estimated differences.

The matching algorithm is based on size and industry, hence in the first stage I estimate a logit model using logarithm of total assets, 2 digit industry and year dummies.[29] First, I use the propensity score from this baseline regression to perform the nearest neighborhood matching procedure and look at the ATT from those estimations. The outcome variables I consider are taxable profits divided by total assets, tax liabilities divided by total assets, zero taxable profits dummy and taxable profits divided by total assets for positive taxable profits only. I then limit the matching sample to positive taxable profits only and repeat the matching exercise to obtain the ATT on the ratio of taxable profits to total assets for that smaller sample.

Using the first stage of PSM to create matched and unmatched samples, I first present descriptive statistics on foreign multinational subsidiaries and domestic standalones. I show mean unweighted outcome variables, such as size (total assets and trading turnover) and age. The results in Table 1 suggest that the matching procedure makes the two analyzed ownership types more comparable to each other in terms of main observable firm level characteristics. In the first row of each panel I show that the two ownership categories are very similar in terms of the matching variable (logarithm of total assets) after matching is performed. Further, the differences in the means of other observable firm level characteristics between the two ownership types are insignificant in the matched sample. Foreign multinational subsidiaries in the matched sample are on average smaller than in the unmatched sample, while domestic standalones are larger, both in terms of total assets and trading turnover. Foreign multinationals are younger in the matched sample than in the unmatched one, while domestic standalones are older.

The third column in Table 2 shows the mean of treated observations: foreign multinational subsidiaries, while column 4 presents the mean of control observations: domestic standalones, both for matched sample. The average treatment effect (ATT) is the difference between those two means. The last two columns show the number of observations in both treated and control groups. The ATT estimates for the ratio of tax liabilities

[29] The PSM analysis assumes that we have matched on all relevant characteristics and that there is no unobserved confounders that may account for the difference across the treatment and control groups. I test that assumption using Rosenbaum bounds sensitivity analysis (Rosenbaum (2002), see Appendix Table 8). The Roseunbaum analysis tests how much the unobserved covariate would need to increase the odds of being a multinational company before we could attribute the difference between foreign multinational subsidiaries and domestic standalones to unobserved factors. The results indicate that the unobserved factor would need to increase the likelihood of being a multinational more than three times before we could attribute the observed difference in the outcome variables to that unobserved factors. This suggests that the matching procedure is not sensitive to hidden bias.

Table 1: Summary statistics.

	foreign multinationals	domestic standalones
	whole sample	
log total assets	14.6	11.0
total assets (million)	118.0	0.27
trading turnover (million)	26.0	1.06
log trading turnover	14.5	11.5
age	20.6	13.3
	matched sample	
log total assets	13.1	13.1
total assets (million)	1.83	1.76
trading turnover (million)	3.17	2.29
log trading turnover	13.6	13.1
age	17.9	19.8
	unmatched sample	
log total assets	16.5	10.8
total assets (million)	255.0	0.19
trading turnover (million)	58.6	0.99
log trading turnover	15.9	11.4
age	23.7	12.9

Note: Unweighted means of observed firm level characteristics: comparison of whole, matched and unmatched samples for foreign multinational subsidiaries and domestic standalones, Matched sample is created using propensity score matching methodology described above, where I use total assets and industry as matching variables. The differences in the means of the observable firm level characteristics between foreign multinational subsidiaries and domestic standalones are significant in the whole and unmatched samples. In the matched sample, the differences in the means of observable firm level characteristics between foreign multinal subsidiaries and domestic standalones are insignificant for total assets, trading turnover and age. 2000 - 2011, selected sample. Trading turnover and total assets are in millions of pounds. Source: merged HMRC and FAME data.

and taxable profits to total assets in the baseline specification are negative and highly significant (standard errors are in the column titled SE). The difference between domestic standalones and foreign multinational subsidiaries is estimated to be 12.76 percentage points for the ratio of taxable profits to total assets, while the difference in the ratio of tax liabilities to total assets is 2.51 percentage points. The mean of taxable profits relative to total assets for foreign multinational subsidiaries is 12.41 percent while that same ratio is 25.17 percent for domestic standalones. This implies that foreign multinational subsidiaries report just over 50 percent lower ratio of taxable profits to total assets and 46.7 percent lower ratio of tax liabilities to total assets.

The estimates of the difference in the ratios of tax liabilities and taxable profits to total assets are different. This is due to the proportion of small and medium companies that pay lower tax rate in the UK. I match companies on size measured by total assets rather than profits, the latter being the determinant of which tax band applies to a

company.[30] If all companies were subject to the same tax rate in the UK, the difference between foreign multinational subsidiaries and domestic standalones for tax liabilities and taxable profits should be the same. However, the UK has lower tax rate for small and medium companies and these companies constitute a much larger proportion of domestic standalones than foreign multinational subsidiaries. This is the case even after matching procedure is applied, as the average tax rate is lower for domestic standalones than for foreign multinational subsidiaries in both whole and matched samples.[31] We would expect domestic standalones on average to pay lower tax on the same taxable profits, if they were subject to lower tax rate. Therefore we would expect the difference between multinationals and domestic standalones in terms of taxable profits to be larger than that on tax.

Furthermore, the ratio of tax liability to total assets divided by the ratio of taxable profits to total assets gives an implied tax rate. Comparison of those ratios for the treated and control groups reveals that the implied tax rate for foreign mutational subsidiaries is actually higher - 23 percent - than that for domestic standalones, 21.3 percent. The top statutory tax rate in the UK for most of the sample duration was 30 percent. However, a substantial portion of domestic standalones was subject to much lower, 20 percent, small and medium statutory tax rate over the sample period in the UK. Therefore, absent profit shifting, we would expect the difference in the implied tax rates between the two groups to be much larger.

I also find that foreign multinational subsidiaries are 31.8 percentage points more likely to report zero taxable profits in the matched sample; 56.7 percent of observations in the foreign multinational subsidiaries category and 22.9 percent of observations in the domestic standalones category report zero taxable profits. This leads me to explore the mean taxable profits to total assets ratio conditional on making positive taxable profits as an outcome variable. The ATT for the ratio of taxable profits to total assets is -1.45 percentage points and is insignificant, while the ATT for the ratio of tax liabilities to total assets turns positive and is also insignificant. This means that over 85 percent of the difference in taxable profits between the two ownership types can be attributed to the differences in the proportions of companies reporting zero taxable profits.[32]

[30] For more details on which tax rates apply to which types of companies see: https://www.gov.uk/government/publications/rates-and-allowances-corporation-tax/rates-and-allowances-corporation-tax

[31] The average tax rate is calculated as the ratio of tax liability to taxable profits in the tax returns data. If all companies were subject to the top statutory tax rate, this ratio would be equal to the top statutory tax rate. However, small and medium companies in the UK were subject to lower - 20 percent - corporate tax rate during the sample period. Hence, we would expect the average tax rate for of domestic standalones to be lower than for foreign multinational subsidiaries.

[32] Alternatively, I do PSM on all companies and present the results for conditional mean of taxable profits to total assets. The results for matching on the baseline sample, but using restricted outcome variable show the ATT estimate to be -1.89 percent which is not statistically significantly different from the one obtained doing PSM on the resticted sample.

Table 2: Propensity Score Matching baseline results.

sample	variable	treated	control	ATT	SE	obs treated	obs control
Baseline	taxable profits/total assets	0.1241	0.2517	-0.1276	0.0118	149,581	149,581
Baseline	corporation tax/ total assets	0.0286	0.0537	-0.0251	0.0011	149,581	149,581
Baseline	taxable profits/total assets>0	0.2640	0.2830	-0.0189	0.0243	72,313	72,313
Baseline	zero taxable profits	0.5466	0.2288	0.3179	0.0014	149,581	149,581
Positive taxable profits only	taxable profits/total assets>0	0.2630	0.2775	-0.0145	0.0241	72,843	72,843
Positive taxable profits only	corporation tax/ total assets	0.0612	0.0598	0.0014	0.0022	72,313	72,313

Note: Results from the baseline propensity score matching estimatation, 2000 - 2011, selected sample. Matching on total assets and within industry and year. Baseline sample: foreign multinational subsidiaries and domestic standalones, Positive taxable profits only sample: foreign multinational subsidiaries and domestic standalones with positive taxable profits. Treated observations are foreign multinational subsidiaries, control observations are domestic standalones. Source: merged HMRC and FAME data.

4.1 Robustness checks

In this section I test the robustness of the baseline estimates of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones (Table 3). I first consider how various first stage matching specifications affect the main result. I use non-linear forms of total assets, such as square and cube of the logarithms. Instead of matching within each year, I use a cross-section regression with one observation for each firm, and with the average logarithm of total assets over the sample period to identify the matched observations, i.e. I match on static data so that a company is either always in the control or in the treatment group. I further test whether the estimates are robust to disaggregated industries and hence match using 3 digit rather than 2 digit industry codes. These changes to the first stage matching procedure alter the ATT estimates to a very small extent. The estimated size of the difference between ownership types varies between 12.53 and 13.42 percentage points.

There may be a concern about the effect that overseas income may have had on taxable profits of multinational companies. Since my sample includes only foreign multinational subsidiaries without any subsidiaries themselves, foreign multinational subsidiaries in the matched sample should have no subsidiaries which could be paying dividend income back to the UK. However, 2.6 percent of foreign multinational subsidiaries in the matched sample report to have some overseas income. This may be because I have no data on their subsidiaries and hence I did not exclude them in the selection process, or because their headquarters have paid dividends to their subsidiaries in the UK.

The concern is that overseas income as reported in the tax returns is calculated before double tax relief. This means that part of that overseas income in not actually liable to corporation tax and hence I may be overstating income of foreign multinational subsidiaries by not accounting for the sheltered portion of that income. To understand the effect of overseas income on my results I exclude profits sheltered by double tax relief from my taxable profits numbers (row 6 in Table 3).[33] Alternatively, I use only years before the 2009 dividend tax reform (row 5 in Table 3). The exclusion of overseas income sheltered by double tax relief increases the ATT coefficient slightly. Excluding later years in the sample increases the size of the baseline coefficient significantly. I discuss the yearly heterogeneity of the estimated coefficients in section 4.4.

I exclude the ring-fenced profits from the taxable profits number to see whether my results are driven by the North Sea oil rig companies reporting large taxable incomes. In a similar spirit I exclude mining sector altogether, since companies from that sector report incomparably high ratios of taxable profits to total assets.[34] These exclusions do

[33] In the tax return form a company has to report the amount of double tax relief claimed, based on the amount of its tax liability. I use the tax rate that applies to each company and multiply that by the amount of double tax relief to obtain the amount of profits sheltered by double tax relief.

[34] For evidence of sectoral differences in the ratio of taxable profits to total assets between ownership

not change the results significantly (rows 7 and 8 in Table 3).

I further exclude companies that report to have positive investments on their balance sheets as part of their fixed assets number (row 9 in Table 3). This number is an approximate for equity value of their subsidiaries. This effectively excludes all companies that may have any subsidiaries, but which reported no information on this in the ownership data and hence have not been excluded during the sample selection process; 29 percent of foreign multinational subsidiaries and 5 percent of domestic standalones report data on investments in the FAME dataset. However, the exclusion of investments from the total assets measure does not seem to affect the main results; it changes the size of the estimated difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones only marginally.

I then consider matching using only the sub-sample of companies that report no trading losses to make sure that my estimates are not driven by companies reporting trading losses (row 10 in Table 3). The ATT estimate is 12.28 percentage points, which implies that foreign multinational subsidiaries report 40 percent lower ratio of taxable profits to total assets than domestic standalones. This suggests that the baseline results are indeed driven by zero taxable profit reporting foreign multinationals with no trading losses.

Furthermore, I explore whether matching with replacement affects my results and whether utilizing more than one domestic standalone to match with foreign multinational subsidiary makes a difference (rows 11 and 12 in Table 3). As discussed in the empirical methodology, using more observations as a control group increases the efficiency of the estimates, but might affect the bias of the coefficient. Using matching with replacement I can use the same large domestic standalone in the right hand side tail of the company size distribution several times, if it is the best match for a particular foreign multinational subsidiary. Therefore it is conceivable that I am using more comparable domestic standalones in this approach. Using matching with replacement results in the ATT increasing marginally to 13.17 percentage points. In turn, using 5-nearest neighborhood matching, instead of 1-nearest neighborhood matching, decreases the size of the estimated difference to 9.98 percentage points[35]. However, using various matching algorithms does not affect the implied size of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones; it remains around 50 percent.

Finally, I test how different is the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic group subsidiaries using the same matching approach as in the case of domestic standalones. I find that the gap in the ratio of tax-

types see Habu (2017).

[35] 5-nearest neighbourhood matching uses 5 closest comparable domestic standalones for each foreign multinational subsidiary, instead of 1. The matching is still performed within the 0.1 predicted probability radius.

able profits to total assets between foreign multinational subsidiaries and domestic group subsidiaries is just over a third of what it is between foreign multinational subsidiaries and domestic standalones; the ATT is -4.82 percentage points. This implies that foreign multinational subsidiaries report almost 30 percent lower ratio of taxable profits to total assets relative to domestic groups. This is 20 percentage points lower than their implied taxable profits difference relative to domestic standalones.

This is to be expected for two reasons. As I have already discussed, I am not certain whether some of the domestic groups subsidiaries are not part of the foreign multinational category. This introduces downward bias into the size of the estimated difference. Secondly, domestic groups have been shown to have as high leverage as foreign multinationals and since leverage can be used to shelter taxable profits, we would expect their taxable profits to be more comparable. However, foreign multinational subsidiaries can shift profits abroad while domestic group subsidiaries (if identified correctly into that ownership category) cannot. Therefore we may expect the differences in the ratio of taxable profits to total assets between domestic group subsidiaries and foreign multinational subsidiaries to signify, among other factors, the differences in profit shifting ability. In turn, the difference between foreign multinational subsidiaries and domestic standalones signifies a broader set of tax avoidance opportunities available to groups of companies.

In the second part of Table 3 I explore various company size measures which could be used as alternatives to total assets in the first stage of propensity score matching. I use number of employees, fixed assets and trading turnover. For each of the size variables, I perform PSM twice; first, matching on this alternative size variable and second, comparing the results to matching on total assets on the limited sample of observations for which I have data on each of those alternative size variables. This allows me to examine whether various matching alternatives change the inference in terms of the size of the gap in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones.

I find that matching on the number of employees, fixed assets or trading turnover instead of total assets increases the estimated size of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones twofold (see Panel B, Table 3). Most of the difference comes from the much higher ratio of taxable profits to total assets for domestic standalones. Foreign multinational subsidiaries in my sample often have a large proportion of their total assets held in intangible assets, while domestic standalones do not have the same proportion of intangible assets. Therefore, for instance, when matching only on fixed assets (rows 3 and 4 in Table 3), a multinational with large intangible assets that was previously a match for a domestic standalone, with no intangible assets will now be matched with much smaller domestic standalone company. As we have seen in Table 2 smaller domestic standalones tend to report higher ratios of taxable profits to total assets. This explains why the ratio

of taxable profits to total assets in the control group is much higher when matching on fixed assets. In case of matching on trading turnover this indicates that domestic standalones, which have similar trading turnover to foreign multinational subsidiaries, report higher taxable profits to total assets ratio than domestic standalones with similar total assets.

Further, I explore what happens when instead of having the ratios of taxable profits to total assets as an outcome variables, I perform the baseline matching analysis with trading profits to trading turnover as an outcome variable.[36] The mean ratio of trading profits to trading turnover for foreign multinational subsidiaries is lower than that for taxable profits to total assets. Since a large proportion of foreign multinational subsidiaries taxable income comes from sources other than trading profits, we would expect the size of the difference estimated here to be much smaller than the one for the ratio of taxable profits to total assets. This seems to be the case, as the ATT estimate is -6.2 percentage points; foreign multinational subsidiaries report 41 percent lower ratio of trading profits to trading turnover than domestic standalones.

Finally, multinational companies can have multiple subsidiaries in the UK and can choose to locate their taxable profits in one of those subsidiaries and report zero taxable profits in their remaining affiliates. This would be a concern especially because a large number of foreign multinational subsidiaries in the UK indeed report zero taxable profits. A direct way to deal with this concern would be to aggregate data on UK groups of companies. However, the issues of double counting of total assets arise if one company in the group owns another. Since, the ownership data does not have full coverage of all ownership links in the UK, hence, aggregating companies into groups would introduce a measurement error.

Alternatively, to alleviate those concerns I perform two additional tests. First, I do PSM on the sample of foreign multinational subsidiaries, which reported to have only one subsidiary in the UK. The results are similar to the ones using the whole sample of foreign multinational subsidiaries. Foreign multinational subsidiaries report about 50 percent lower ratio of taxable profits to total assets than domestic standalones. Again, the difference between the two ownership types in entirely driven by the zero taxable profit reporting foreign multinational subsidiaries. Second, I calculate the weighted means of taxable profits relative to total assets for both ownership types on the PSM matched

[36] Scaling trading profits by trading turnover is an alternative measure to compare taxable profits of the two chosen ownership types. HMRC data has information on trading turnover of companies, which is the total value of sales of a company which arise from its trading activities. Since trading turnover only covers information on trading activities of companies, for consistency purposes the taxable profit measure used when scaling by trading turnover should only include profits from trading activities, i.e. trading profits. However, a substantial fraction of taxable profits of multinational companies (over 30 percent) comes from outside trading activities, such as overseas income, interest on loans, capital gains. This is not the case for domestic standalones which derive almost all of their profits from trading activities. Therefore using this measure would disproportionately bias downwards the ratio of taxable profits to size for multinational companies.

sample. The feature of the weighted mean is that it sums the observations for the denominator and the numerator. In a way, this will account for the presence of multiple subsidiaries of the same company in the UK. I find that the weighted ratio of taxable profits to total assets for foreign multinational subsidiaries in the matched sample is 10.8 percent, while it is 5.4 percent for domestic standalones. Hence, foreign multinational subsidiaries report 50 percent lower weighted ratio of taxable profits to total assets. This confirms that the baseline results is not driven by multiple subsidiaries of the same company reporting zero taxable profits.

4.2 Channels companies use to lower their taxable profits

In this section I explore potential factors driving the wedge in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones. For each potential channel that a company may be using to reduce its taxable profits, I use that channel as an outcome variable in the baseline propensity score matching to explore direct differences between foreign multinational subsidiaries and domestic standalones. In addition, I run a PSM using that factor as an additional matching variable and then perform baseline matching on the sample of observations for which I have data on this additional matching factor. That allows me to estimate whether the change in the ATT estimate is due to the sample composition or whether the variable itself affects the size of the estimate. In this section I consider flow measure of gearing, stock measure of gearing - leverage, capital allowances and total factor productivity.

In Table 4 I show results in groups of three, for each potential channel that companies could use to reduce their taxable profits. For instance, in case of leverage, I first present results from matching on leverage and total assets, then from matching on total assets only with the ratio of taxable profits to total assets as an outcome variable and finally matching on total assets only with leverage as outcome variable; the latter two are performed using a sample of observations for which I have leverage data.

First, I consider the amount of debt that foreign multinational subsidiaries can take on. I look at both stock and flow measures of gearing, where stock measure is leverage, i.e. total liabilities divided by total assets, while flow measure is net interest divided by profit and loss before interest. First, I use leverage as an outcome variable in PSM and I find that foreign multinational subsidiaries take on about 14.1 percentage points more debt than comparable domestic standalones. Further, to estimate the importance of leverage, I run PSM using debt as an additional matching variable. I find leverage to be an important factor. The ATT from matching on leverage and total assets is -2.67 percentage points which is about 40 percent of what it is when matching on total assets only on the sample of observations with non-missing data on leverage (ATT of

-4.21 percentage points)[37]. This would suggest that leverage explains 40 percent of the difference in taxable profits to total assets ratio between foreign multinational subsidiaries and domestic standalones.[38,39] This could suggest use of more debt shifting among UK subsidiaries of foreign multinational companies. However, it may also be that companies want to locate their debt in the UK due to highly advantageous tax system (low interest, CFC rules, etc.).

The other - unexplained - portion of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones may be attributed to other profit shifting strategies, such as transfer pricing and royalties licensing. I am unable to investigate this further since the effects of both transfer pricing and royalties licensing are already incorporated in the taxable profits (or trading losses) figure reported by foreign multinational subsidiaries on their tax income statements.

I further explore the results from matching on the ratio of capital allowances to total assets (rows 10 and 11 in Table 4) and TFP (rows 7-9 in Table 4). The difference in the ratio of capital allowances to total assets between the two ownership types in insignificant and matching on capital allowances in addition to total assets does not alter the estimates of the difference in the ratios of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones relative to baseline estimates.

I find that foreign multinational subsidiaries report to have significantly higher productivity than domestic standalones. Moreover, when matching on TFP, the size of the difference in the ratio of taxable profits to total assets between the two analyzed ownership types falls from -0.56 to -0.42.[40] Foreign multinational subsidiaries are more productive than domestic standalones, yet conditional on having similar productivity levels they report lower taxable profits to total assets ratio than domestic standalones. This suggests that around 25 percent of the difference in the ratio of taxable profits to total assets between ownership types is explained by differences in productivity between firms.

[37] This large reduction in the ATT estimates when matching on total assets on the sample on non-missing leverage data arises mainly because I only have data on leverage for larger foreign multinational subsidiaries and domestic standalones. These companies have lower ratios of taxable profits to total assets than the ones in the full analyzed sample; see the heterogeneity analysis in Section 4.4.

[38] Note that this evidence stands in stark contrast to Buettner and Wamser (2013), who provide evidence that debt shifting is unimportant for German affiliates.

[39] I find that differences in the flow measure of gearing do not alter the size of the baseline estimates.

[40] Again, when matching on TFP and total assets or on total assets on the sample of non-missing TFP observations, I find that the ratios of taxable profits to total assets for both ownership groups are much lower than in the sample analyzed in the baseline matching. This is again because we only have information on TFP for larger firms, which report lower ratios of taxable profits to total assets.

Table 3: PSM robustness tests.

sample	variable	treated	control	ATT	SE	obs treated	obs control
1st stage total assets enter as a square	taxable profits/total assets	0.1250	0.2503	-0.1253	0.0118	148,842	148,842
1st stage total assets enter as a square & a cube	taxable profits/total assets	0.1250	0.2523	-0.1274	0.0118	148,759	148,759
1st stage: matching on static data in logit model	taxable profits/total assets	0.1206	0.2548	-0.1342	0.0117	147,794	147,794
1st stage: 3 digit industry FEs	taxable profits by total assets	0.1235	0.2549	-0.1315	0.0117	150,370	150,370
use only years 2000 - 2008	taxable profits/total assets	0.1346	0.2333	-0.0987	0.0172	99,622	99,622
taxable profits less those sheltered by dtr	taxable profits (less sheltered overseas income) by total assets	0.1194	0.2543	-0.1348	0.0117	149,584	149,584
exclude comps with ring fenced profits	taxable profits by total assets	0.1228	0.2518	-0.1290	0.0117	149,584	149,584
exclude mining sector from analysis	taxable profits by total assets	0.1230	0.2589	-0.1359	0.0118	148,024	148,024
take out companies with larger investment to total assets ratio >0	taxable profits by total assets	0.1287	0.2664	-0.1377	0.0132	132,734	132,734
match of companies which report zero trading loss	taxable profits/total assets	0.1772	0.2999	-0.1228	0.0169	104,055	104,055
matching with replacement	taxable profits/total assets	0.1043	0.2360	-0.1317	0.0102	197,064	2,848,342
5 nearest neighbourhood	taxable profits/total assets	0.1043	0.2041	-0.0998	0.0099	197,064	2,848,342
foreign multis vs domestic groups	taxable profits/total assets	0.1182	0.1664	-0.0482	0.0379	135,296	163,093
Different size measures							
match on employment	taxable profits/total assets	0.0827	0.2260	-0.1433	0.0050	30,214	30,214
baseline (exmployment sample)	taxable profits/total assets	0.1050	0.1690	-0.0640	0.0082	30,214	30,214
match on fixed assets	taxable profits/total assets	0.0887	0.2430	-0.1543	0.0015	106,452	106,452
baseline (fx assets sample)	taxable profits/total assets	0.0959	0.1776	-0.0817	0.0018	106,452	106,452
match on trading turnover	taxable profits/total assets	0.1220	0.3262	-0.2042	0.0135	122,125	122,125
baseline (tr turnover sample)	taxable profits/total assets	0.1308	0.2319	-0.1011	0.0141	122,125	122,125
baseline (tr turnover sample)	trading profits/trading turnover	0.0939	0.1580	-0.0642	0.0006	122,125	122,125

Note: Results from the Propensity Score Matching estimates, various robustness tests. In Panel A of the table I show results from robustness specifications described in Section 2.4.1. In Panel B of the table I show results using alternative size measures instead of total assets in the first stage of PSM. The first row in panel B refers to matching on employment instead of total assets, the second row to matching on total assets, but using only the sample for which employment observations are avalable. The remianing rows perform the same comparison, using fixed assets and trading turnover. Treated observations are foreign multinational subsidiaries, control observations are domestic standalones. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Table 4: PSM channels.

sample	variable	treated	control	ATT	SE	obs treated	obs control
match on leverage	taxable profits/total assets	0.0878	0.1145	-0.0267	0.0008	53,064	53,064
baseline (leverage sample)	taxable profits/total assets	0.0843	0.1264	-0.0421	0.0009	54,512	54,512
baseline (leverage sample)	leverage	0.7618	0.6207	0.1411	0.0018	54,512	54,512
match on flow of gearing	taxable profits/total assets	0.0863	0.1393	-0.0530	0.0055	32,263	32,263
baseline (flow of gearing sample)	taxable profits/total assets	0.0866	0.1420	-0.0554	0.0052	32,672	32,672
baseline (flow of gearing sample)	flow of gearing	-0.0933	-0.1749	0.0817	0.0029	32,672	32,672
match on TFP	taxable profits/total assets	0.0878	0.1300	-0.0422	0.0021	19,877	19,877
baseline (TFP sample)	taxable profits/total assets	0.0870	0.1431	-0.0560	0.0022	20,552	20,552
baseline (TFP sample)	TFP	2.5623	2.4795	0.0828	0.0031	20,552	20,552
match on capital allow	taxable profits/total assets	0.1241	0.2558	-0.1317	0.0118	149,581	149,581
baseline (capital allow sample)	capital allowance	800,254	760,477	39,777	848,497	149,581	149,581

Note: Results from the Propensity Score Matching estimates showing channels which companies use to reduce their taxable profits. The first row shows results using leverage as additional matching variable to total assets and industry. The second row shows results from baseline matching on total assets and within industry, but only on the sample for which leverage data is available. The third row shows results from baseline matching on total assets and within industry, but uses leverage instead of the ratio of taxable profits to total assets as an outcome variable. The remiander of the table shows the results in similar groups of three for the following variables: flow of gearing, TFP and capital allowances. Treated observations are foreign multinational subsidiaries, control observations are domestic standalones. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

4.3 Comparison of taxable and accounting profits

Most of the previous literature on profit shifting uses accounting profits to proxy for taxable profits. Since taxable profits are censored at zero, while accounting profits can take negative values, to compare taxable and accounting profits directly the literature tends to use two distinct approaches. The first method takes trading losses from the tax return form and subtracts them from taxable profits to recover the negative portion of taxable profits and obtain a measure which is closer to the current taxable profits. The second method converts all negative accounting profits into zeros, effectively censoring them in the same way as taxable profits are censored in the tax returns. The accounting dataset - FAME - includes variables related to taxable profits, namely gross operating profits less depreciation and profit and loss before taxes. In Figure 2 I compare the positive taxable and accounting profits by plotting the distributions of logarithms of 3 different measures of profits.

Accounting profits as measured by profit and loss before tax or by operating profits less depreciation overestimate the taxable profits reported by foreign multinational subsidiaries (Panel A, Figure 2). The distribution of positive accounting profits is shifted to the right relative to the distribution of positive taxable profits. However, accounting profits seem to be a better approximation of taxable profits of domestic standalones (Panel B, Figure 2).[41] Accounting depreciation is smaller than tax depreciation, which is one of the reasons why we would expect accounting profits less accounting depreciation to be larger than trading profits, but to the same extent for both ownership types.

The PSM estimates suggest that the main difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones lies in the differences of the number of observations reporting zero taxable profits. Therefore I also compare the distributions of taxable profits minus trading loss scaled by total assets relative to profit and loss before taxes scaled by total assets around zero (method 1).

Figure 3 contains 4 panels where each panel plots distributions of the ratios of profits to total assets; the left hand side panels (A and B) refer to comparisons of accounting and taxable profits, the right hand side panels (C and D) compare foreign multinational subsidiaries with domestic standalones. The horizontal axis in those figures shows the ratios of profits to total assets, while on vertical axis we have kernel density estimate, which shows the density of observations at each particular value of the ratio of profits to total assets.

Bunching around zero profits in prevalent in both accounting data (as shown by Johannesen *et al.* (2016)) as well as tax returns. What is more interesting is that bunching around zero is much larger for taxable profits relative to accounting profits for foreign multinational subsidiaries than for domestic standalones (see LHS figures, Figure 3). In

[41] Interest and royalty payments both are deducted at the operating profit levels already.

addition, foreign multinational subsidiaries bunch around zero taxable profits to a larger extent than domestic standalones (Panel C). However, there is no difference in bunching around zero accounting profits between foreign multinational subsidiaries and domestic standalones (Panel D).[42]

Furthermore, zero taxable profit reporting companies appear to come from the missing mass to the right of the taxable profits distribution, where the accounting profits distribution indicates that companies report much higher ratio of accounting profits to total assets. This suggests that accounting profits may overestimate taxable profits, especially in case of foreign multinational subsidiaries. Therefore I consider comparisons of PSM results using ratios of accounting and taxable profits to total assets as outcome variables, using the two methods described above.

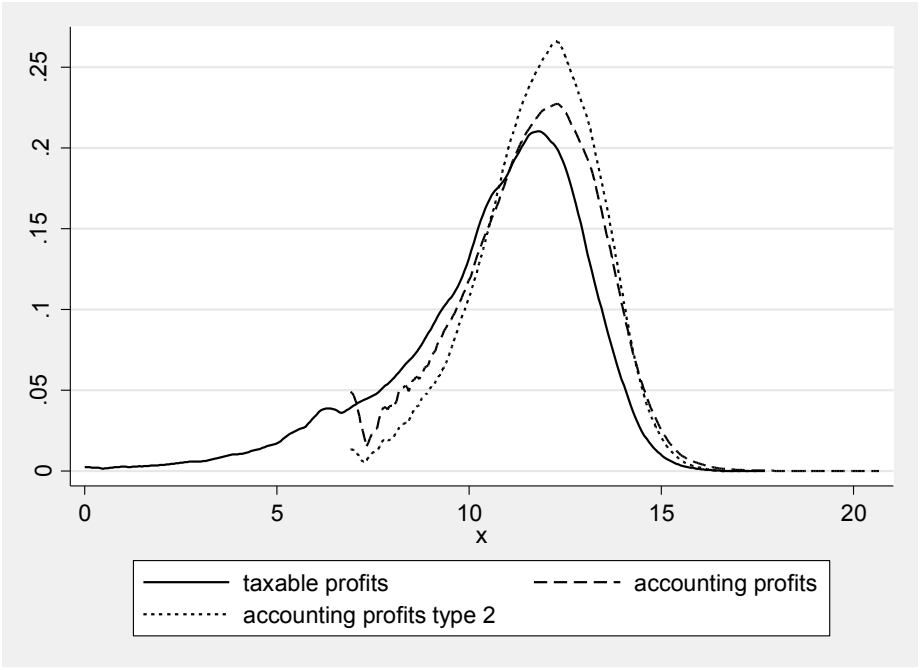
In Table 5, using the first method I find that the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones is estimated to be -14.7 percentage points (row 3), while the difference in the ratio of accounting profits to total assets on the same sample is -7.0 percentage points (row 4). Using the second method, I find the difference in taxable profits between the two ownership types to be -5.9 percentage points (row 1), while the difference in accounting profits is -2.7 percentage points (row 2). In both cases the estimates of the difference in the ratio of profits to total assets between foreign multinational subsidiaries and domestic standalones are substantially smaller when using accounting profits data than using taxable profits data. What is more, the ratios of taxable profits to total assets for foreign multinational subsidiaries are generally smaller than the ratios of accounting profits to total assets for both methods. This suggests that the previous estimates of profit shifting obtained using accounting data might be underestimating the true size of profit shifting of foreign multinational companies. Since the PSM results are driven by the zero taxable profit reporting companies, this is not at all surprising. Foreign multinational subsidiaries seem to be reporting positive profits in their accounts, while at the same time reporting zero taxable profits on their tax returns. This would bias the estimates of profit shifting obtained using accounting data downwards.

Finally, the last row in Table 5 considers differences in the effective tax rates between foreign multinational subsidiaries and domestic standalones. The effective tax rates are calculated as ratios of tax liability from tax returns to accounting profits measure (profit and loss before taxes). I find that foreign multinational subsidiaries report lower effective tax rates in the UK than comparable domestic standalones. A more rigorous comparison of taxable and accounting data is outside the scope of this paper. Using tax returns data instead of accounting data to understand the reporting behaviour of multinational companies is an interesting avenue for further research.

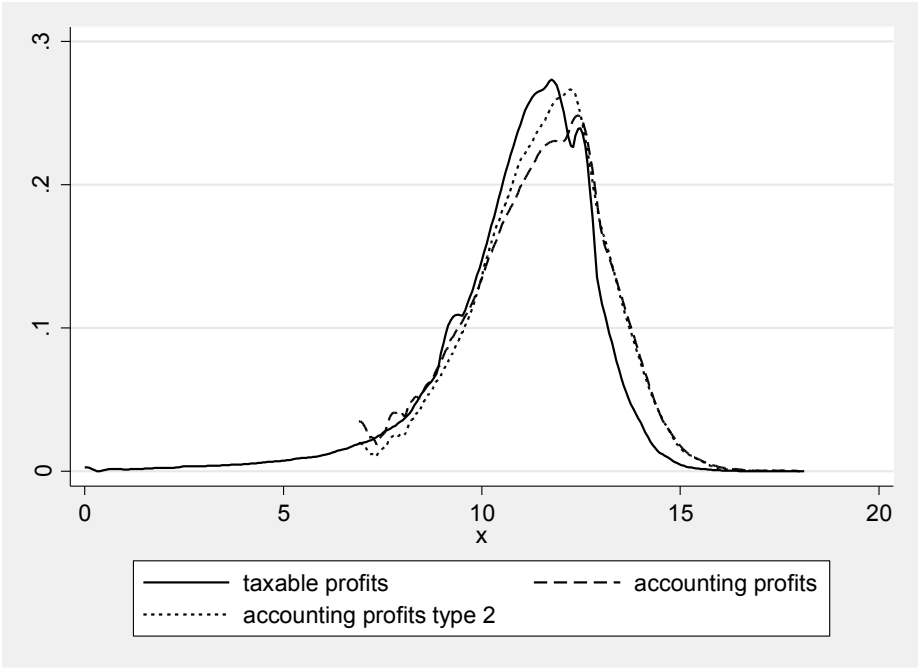
[42] For additional evidence on the discrepancies between tax and accounting profits see Devereux *et al.* (2015) and Maffini *et al.* (2016).

Figure 2: Distribution of profits. Comparison between tax and accounting measures.

Panel A: Foreign multinational subsidiaries



Panel B: Domestic standalones



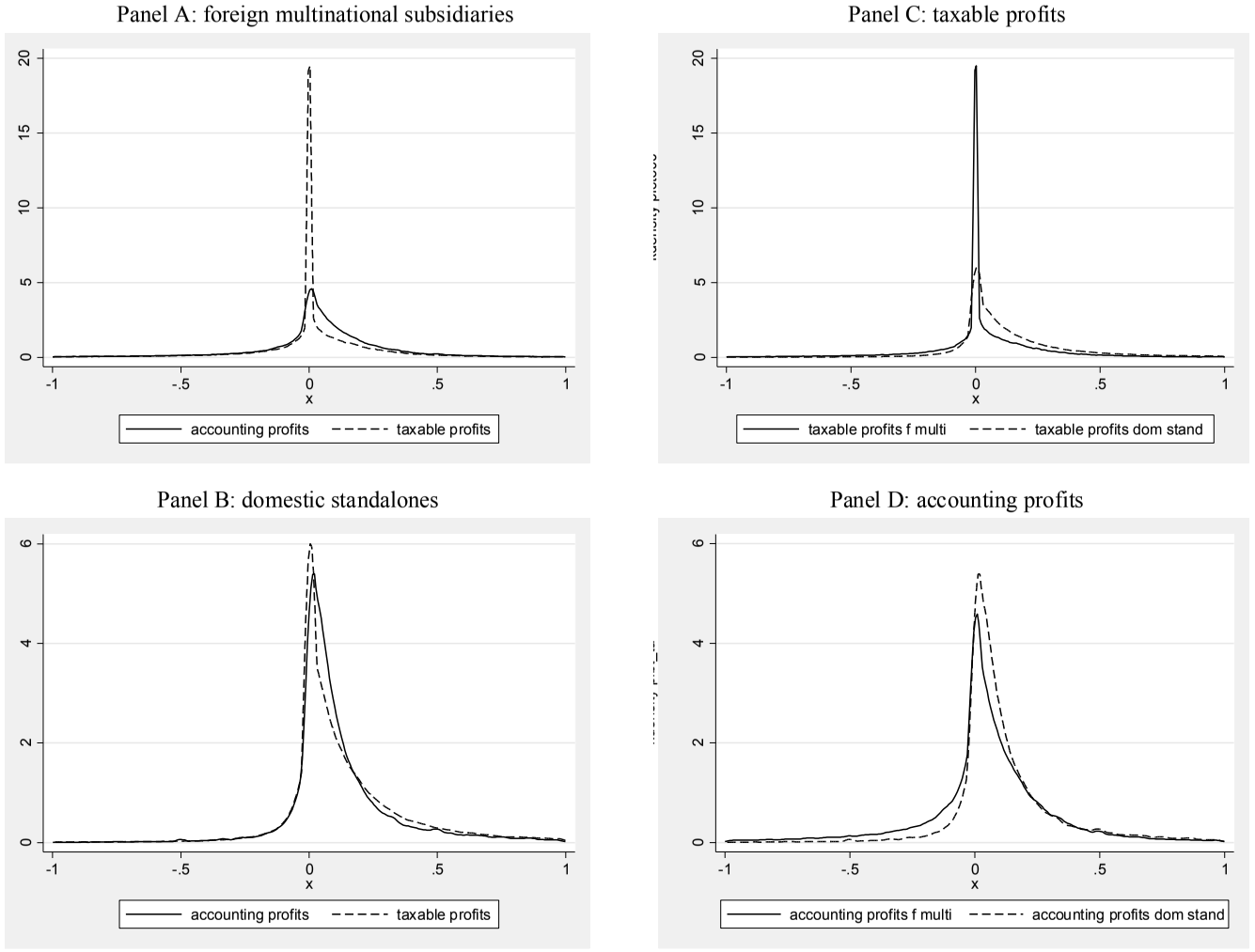
Note: Distribution of logarithm of profits, comparison between FAME and CT600 using the sample of matched companies. The propensity score matching was performed using total assets and within industry, 2000 - 2011. Accounting profits refer to profit and loss before tax, accounting profits type 2 refer to operating profits less deductions, taxable profits measure comes from the tax return form. Source: merged HMRC and FAME data.

Table 5: PSM results - comparison of taxable and accounting profits.

robustness test	variable	treated	control	ATT	S.E.	obs treated	obs control
accounting profits sample	taxable profits by total assets	0.0801	0.1340	-0.0539	0.0021	65,543	65,543
accounting profits sample	accounting profits (negative is zero) by total assets	0.1140	0.1407	-0.0266	0.0008	65,543	65,543
accounting profits sample	taxable profits (incl loss) by total assets	-0.0408	0.1065	-0.1473	0.0180	65,543	65,543
accounting profits sample	accounting profits by total assets	0.0503	0.1206	-0.0703	0.0012	65,543	65,543
accounting profits sample	tax by plbt	0.2057	0.2454	-0.0397	0.0135	47,406	47,406

Note: Results from the Propensity Score Matching estimates using total assets and within industry matching variables, The table provides comparison of taxable and accounting profits, where rows 1 and 2 are directly comparable and so are rows 3 and 4. In row 1, I use taxable profits divided by total assets as an outcome variable, in row 2 I use profit and loss before taxes, where all negative values were turned to zero, in row 3 I use taxable profits measure from the tax returns data from which I subtract trading losses that companies report in the current period, while in row 4 I use profit and loss before taxes from accounting statement without any adjustments. In row 5 the outcome variable is an effective tax rate - tax measure from tax returns divided by profit and loss before taxes. Treated observations are foreign multinational subsidiaries, control observations are domestic standalones. Accounting profits sample refers to observations for which I have accounting profits data. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Figure 3: Distributions of taxable and accounting profits - comparisons.



Note: Distribution of the ratios of taxable profits (including trading losses) from HMRC and profit and loss before taxes from FAME scaled by total assets, propensity score matched sample only, 2000 - 2011. The left hand side panels refer to comparisons of accounting and taxable profits for foreign multinational subsidiaries (Panel A) and domestic standalones (Panel B), the right hand side panels compare foreign multinational subsidiaries with domestic standalones for taxable profits (Panel C) and accounting profits (Panel D). Source: merged HMRC and FAME data.

4.4 Heterogeneity of the estimated coefficients

In this section I explore the heterogeneity of the baseline estimates of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones. I specifically focus on three aspects of heterogeneity; first, I discuss differences in the ATT estimates as the size of companies increases, then I focus on the yearly variation in the estimated coefficients and finally on the differences between foreign multinational subsidiaries depending on the location of their headquarters. The analysis of the latter two heterogeneities is aimed at linking the estimated difference in the ratio of taxable profits to total assets between ownership types to profit shifting.

First, I focus on estimating the differences in the ATT by size bins. I divide the sample of foreign multinational subsidiaries and domestic standalones into 10 equally-sized size bins based on total assets. Within each bin, I perform propensity score matching using total assets, within each industry. This gives me 20 different ratios of taxable profits to total assets, 10 for foreign multinational subsidiaries in each size bin and 10 for comparable domestic standalones in each of those size bins.

The results in Table 6 suggest that the size of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones declines as companies get larger, the only exception being the very smallest companies in size bin 1. Further, the ratios of taxable profits to total assets for both ownership categories fall as well. Hence, the implied size of the gap in the ratio of taxable profits to total assets between the two analyzed ownership types decreases as well. However, the implied gap in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones only significantly changes once companies are much larger than median in my sample.

The UK has introduced several corporate tax rate cuts starting in 2008. For a company for which the marginal cost of shifting its taxable profits out of the UK is equal to the marginal benefit, we would expect that a cut in the domestic corporate tax rate may induce subsidiaries of foreign multinational companies to report more taxable profits in the UK, if the tax rates in other countries in which they have affiliates remained the same. This is because the marginal cost of reporting lower taxable profits in the UK increases following the domestic corporate tax rate cut.

However, it may well be that foreign multinational subsidiaries do not respond to the UK corporate tax rate cuts, because the benefit they accrue from reducing their taxable profits in the UK is not a convex function of their profits. Instead, they have fixed cost of shifting profits. Large companies with elaborate profit shifting strategies in place may be inelastic to changes in the tax rates, in so far as they already report zero taxable profits. The reduced tax rate would not offer them incentive high enough to exceed the fixed cost of switching to a different tax planning strategy to report higher (or even positive) taxable

profits in the UK. This is consistent with a large and continuously increasing fraction of foreign multinational subsidiaries that report zero taxable profits in the UK. Of course, it may be that in more recent years, the reputational gain from reporting positive taxable profits may be of importance, especially in the context of a recent increase in naming and shaming of the largest companies (Google, Amazon, Starbucks). This may incentivize companies to report more taxable profits in the UK. However, this is likely to be outside of my analysis period, which ends in 2011.

Using the UK corporate tax rate cuts as a quasi-natural experiment and comparing taxable profits of foreign multinational subsidiaries to the ones of domestic standalones before and after the rate cut would help in linking the differences in the ratio of taxable profits to total assets with tax rate differentials. The previous literature on profit shifting has shown a very strong relationship in tax rate differentials between countries and the amount of profits reported in those countries.

The corporate tax rate cuts, together with the continuous effort of the tax revenue authorities to reduce profit shifting activities of multinational companies, mean that the question arises whether the size of the estimated difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones has decreased accordingly. To answer this question, I estimate the PSM for each sample year separately and calculate the ATT for the ratio of taxable profits to total assets for each of the years 2000 - 2011. I then plot those ATT estimates alongside the confidence intervals in Figure 4. In addition to the ratio of taxable profits to total assets, I also plot the ATT estimates of the differences in the proportions of zero taxable profits between foreign multinational subsidiaries and domestic standalones.

I find that the size of the difference in the ratio of taxable profits to total assets between the two ownership types has increased from -5.1 percentage points in 2000 to -20.6 percentage points in 2011 with some fluctuations around the financial crisis. This increase can possibly be attributed to a constantly increasing difference in the fraction of zero taxable profit reporting companies. This has increased from 26 percentage points in 2000 to 37 percentage points in 2011. All of the yearly ATT estimates are significant. This confirms the hypothesis of fixed costs of profit shifting, as the size of the difference in taxable profits between foreign multinational subsidiaries and domestic standalones did not react to corporate tax rate cuts in the UK.

Finally, I explore differences in the ratio of taxable profits to total assets reported by foreign multinational subsidiaries depending on where their headquarters are located. This offers an alternative identification strategy to link the estimated size of the difference in the ratio of taxable profits to total assets between ownership types to profit shifting. There is some evidence in the literature that companies with affiliates in tax havens tend to report lower accounting profits, which is often interpreted as sign of profit shifting (Desai *et al.* (2006), Slemrod and Wilson (2009), Grubert and Slemrod (1998), Hines and

Rice (1994)). Should that be the case, we would expect foreign multinational subsidiaries with parents in tax havens to be reporting lower ratios of taxable profits to total assets in the UK than foreign multinational subsidiaries with parents in higher tax countries. What is more, media has been pointing towards the US headquartered companies, such as recently 'named and shamed' Google, Amazon, Apple or Starbucks as those which tend to pay very little tax in the UK.[43] I explore both of those claims below.

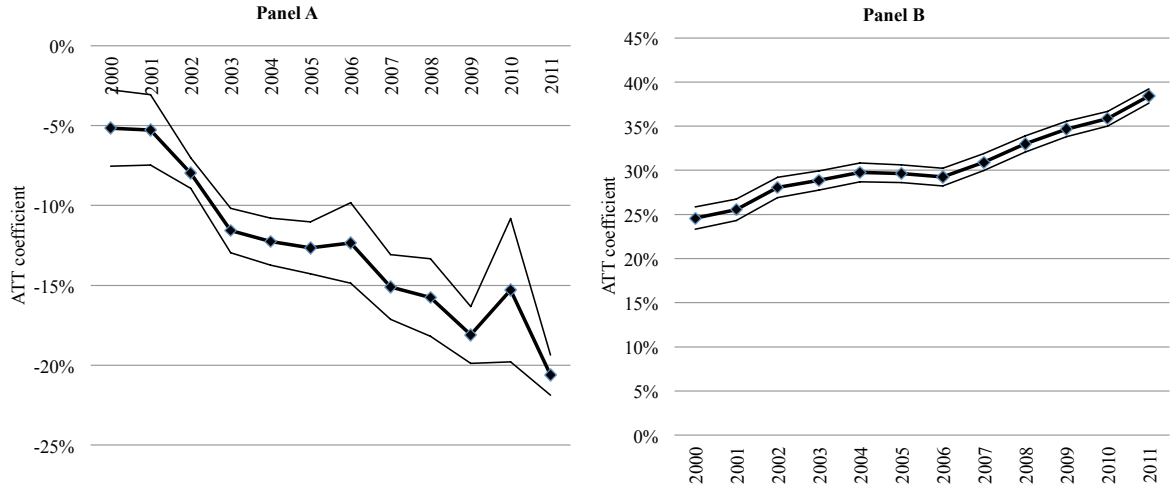
To estimate the differences in the ratios of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones depending on where the multinational headquarters are located I perform PSM. I divide the sample of foreign multinational subsidiaries according to the location of their global ultimate owner. I then perform PSM separately for each of those sub-groups of foreign multinational subsidiaries finding the nearest neighborhood match among all domestic standalones. I use the whole population of domestic standalones for each of the sub-groups of foreign multinational subsidiaries with various headquarter locations, hence the same domestic standalone can be used in each sub-sample. I distinguish between the following headquarter locations: tax haven (excluding large tax havens), large tax haven such as Hong Kong, Singapore, Netherlands and Ireland, French multinationals, German multinationals, other European multinationals, US multinationals, Asian multinationals, other foreign multinationals.

The results from this matching procedure are presented in Table 7 and are ranked according to the size of the estimated difference in the ratio of taxable profits to total assets, from largest to smallest. The number of foreign multinational subsidiaries headquartered in each of the country groups are reported in the observation treated column. I find that foreign multinational subsidiaries headquartered in tax havens report much lower ratios of taxable profits to total assets in the UK relative to domestic standalones (the size of the difference is -16.95 percentage points). They are followed by foreign multinational subsidiaries headquartered in large tax havens. The smallest difference to domestic standalones, by far, is reported by other foreign multinationals (-3.34 percentage points). US headquartered companies do not report particularly low ratios of taxable profits to total assets in the UK relative to companies headquartered in other countries. This is especially interesting, considering that most of the very large multinational companies accused of profit shifting in the media are the ones headquartered in the US (e.g. Starbucks or Amazon). Further, subsidiaries of multinationals headquartered in other European countries (apart from France, Germany, Netherlands and Ireland) tend to report very similar ratios of taxable profits to total assets relative to domestic standalones in the UK.[44]

[43] See articles in e.g. BBC (http://www.bbc.co.uk/news/magazine-20560359), which talk about very large companies avoiding tax in the UK.

[44] I can alternatively compute the weighted mean ratios of taxable profits to total assets for each of the headquarter location groups to see which foreign multinational subsidiaries report lowest ratios of taxable profits to total assets. In Figure 5 in the Appendix I show that foreign multinationals located in

Figure 4: PSM - yearly heterogeneity.



Note: Results from the Propensity Score Matching estimated year by year. PSM using total assets and within each industry. The comparison group is foreign multinational subsidiaries and domestic standalones, I plot the ATT coefficients from propensity score matching, hence the numbers reflect the difference between treatment and control groups. Panel A: the outcome variable is the ratio of taxable profits to total asstes, Panel B: the outcome variable is zero taxable profits dummy. The estimated ATT coefficients for each year are significant. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

large tax havens tend to report lowest ratios of taxable profits to total assets in the UK.

Table 6: PSM results - by size bins.

size quantile	variable	treated	control	ATT	SE	implied gap	obs treated	obs control
1	taxable profits/ total assets	0.8487	1.2086	-0.3599	0.3643	30%	4,718	4,718
2	taxable profits/ total assets	0.2685	1.1086	-0.8402	0.0423	76%	3,610	3,610
3	taxable profits/ total assets	0.2888	0.8555	-0.5666	0.0644	66%	3,805	3,805
4	taxable profits/ total assets	0.1858	0.6724	-0.4866	0.0320	72%	4,741	4,741
5	taxable profits/ total assets	0.1709	0.4645	-0.2936	0.0165	63%	6,431	6,431
6	taxable profits/ total assets	0.1228	0.3373	-0.2145	0.0044	64%	9,385	9,385
7	taxable profits/ total assets	0.1147	0.2387	-0.1239	0.0039	52%	14,724	14,724
8	taxable profits/ total assets	0.0969	0.1731	-0.0761	0.0017	44%	22,424	22,424
9	taxable profits/ total assets	0.0820	0.1231	-0.0411	0.0014	33%	39,111	39,111
10	taxable profits/ total assets	0.0583	0.0765	-0.0182	0.0009	24%	38,128	38,128

Note: Results from the Propensity Score Matching estimates using total assets and within industry matching variables. Each row corresponds to one of the 10 different size quantiles. Matching is performed separately in each size quantile. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Table 7: PSM results - headquarter location heterogeneity.

sample	variable	treated	control	ATT	SE	obs treated	obs control
tax haven	taxable profits/total assets	0.0925	0.2621	-0.1695	0.0068	27,127	27,127
large tax haven (HK SG NL IE)	taxable profits/total assets	0.0997	0.2322	-0.1325	0.0051	30,387	30,387
French multinationals	taxable profits/total assets	0.0926	0.2162	-0.1235	0.0081	9,269	9,269
Asian multinationals	taxable profits/total assets	0.0781	0.1976	-0.1195	0.0054	13,913	13,913
other European multinationals	taxable profits/total assets	0.1113	0.2197	-0.1084	0.0147	18,043	18,043
US multinational	taxable profits/total assets	0.1308	0.2345	-0.1037	0.0085	47,941	47,941
German multinationals	taxable profits/total assets	0.0926	0.1872	-0.0947	0.0100	9,853	9,853
other foreign multinationals	taxable profits/total assets	0.0182	0.0516	-0.0334	0.0007	19,445	19,445

Note: Results from the Propensity Score Matching estimates, using total assets and within industry. I perform matching for each headquarter sub-sample to find comparable domestic standalones. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

5 Conclusion

This paper uses the administrative corporate tax returns data to show that foreign multinational companies report lower ratios of taxable profits to total assets than comparable domestic standalone companies. The propensity score matching approach controls for the differences between the two groups coming from size and industry variation, and estimates the remainder of the difference to be 12.76 percentage points. Assuming that similar sized companies from similar industries should be reporting similar taxable profits, unless they are involved in practices that aim at minimizing their tax liability in the UK, the difference estimated in this paper suggests that foreign multinational subsidiaries shift a large proportion of their taxable profits out of the UK. Specifically, the baseline propensity score estimates suggest that foreign multinational subsidiaries underreport their taxable profits by about 50% relative to domestic standalones. This is the first study of that type which measures the size of the potential profit shifting of the UK companies.

Using the net tax payable from the tax returns together with the implied estimates of the size of the difference in the ratio of taxable profits to total assets, I can calculate the implied revenue gain from equalizing the taxable profits of domestic standalones and foreign multinationals. From the yearly PSM estimates, we know that the size of the gap in the ratio of taxable profits to total assets varies between 30 and 70 percent. Back of the envelope calculations show that the potential revenue gains from equalizing the tax payments of foreign multinational subsidiaries and domestic standalones would vary from £3 billion pounds at the beginning of the sample to £25 billion in 2011. Relative to the total UK corporate tax revenue, which was £30 billion in 2000 and £35 billion in 2011, this would imply that a full elimination of the differences in the taxable profits between domestic standalones and foreign multinational subsidiaries would lead to revenue gains of 10 percent in 2000 and 70 percent in 2011.[45] In the context of the recent proposals to reform the corporate tax system by introducing the destination base cash flow tax in the US, these welfare gain calculations could help understand the benefits of equalizing the tax treatment of foreign and domestic companies. This is because destination base cash flow tax aims at elimination of the current channels of profit shifting and equalization of the tax treatment of foreign and domestic companies.

According to the propensity score matching estimates almost all of the estimated difference in the ratio of taxable profits to total assets between domestic standalones and foreign multinationals can be attributed to the large fraction of zero taxable profit reporting companies amongst foreign multinationals. Once multinational companies report positive taxable profits, their reporting behaviour does not differ substantially from that of domestic standalones. This suggests that most of the profit shifting is actually quite

[45] These calculations do not take into account possible behavioural changes that are likely to occur if such an equalization was possible.

aggressive and occurs via reporting zero taxable profits.

These findings also have implications for theoretical modeling of profit shifting costs. If zero taxable profits are prevalent and they explain most of the difference in the taxable profit reporting behavior between foreign multinational subsidiaries and domestic standalones, then the assumption of fixed costs will be preferred to the previously assumed convex marginal costs of profit shifting. This means that firms may be less responsive to marginal tax rate changes than previously thought, as they bear a fixed cost of shifting profits and once they are large enough to incur that, they report no taxable profits. This may explain why the recent work using firm level data does not find large effects of tax rate changes on profits reported by firms. In contrast, majority of the previous literature that used aggregate data has found large responses. These large aggregate responses may come from firms near the fixed cost of profit shifting kink switching in and out of reporting positive taxable profits in response to tax changes. These may be thought of as extensive margin responses.

I further find that the previous estimates of profit shifting based on accounting data might be underestimating the true size of the problem. The extent of zero taxable profit reporting is much larger than near-zero accounting profit reporting for foreign multinational subsidiaries, but not for domestic standalones. Further work in this area is required to shed more light on the differences between the estimates of the ratio of profits to total assets using accounting and taxable profits.

I also estimate that about 40 percent of the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones in the matched sample comes from the differences in leverage between ownership types. Since difference in leverage suggests a presence of debt shifting, this could mean that up to 40 percent of foreign multinational profit shifting may be explained by debt shifting.

Finally, the estimate of the size of profit shifting presented in this paper is likely to be an underestimate of the true size of profit shifting of all foreign multinational subsidiaries. This is because the propensity score matching leads to an exclusion of the very large foreign multinational subsidiaries (since no comparable domestic standalones exist) that report much lower ratios of taxable profits to total assets than the smaller foreign multinational subsidiaries in the matched sample. Specifically, the unweighted ratio of taxable profits to total assets is 5.6 percent for the very large, unmatched foreign multinational subsidiaries, less than half of the ratio for foreign multinational subsidiaries in the propensity score matched sample. This is inevitably more speculative since we do not have large enough domestic standalones to compare them to the largest multinationals and hence we are unable to say whether larger domestic standalones would have also reported lower taxable profits as a fraction of their size.

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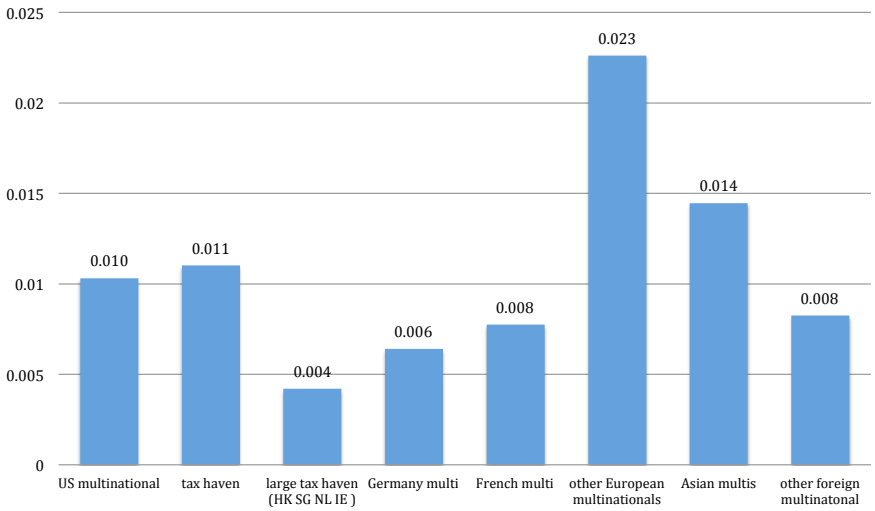
6 Appendices

Table 8: Rosenbaum sensitivity tests.

Rosenbaum bounds for delta (N = 260617 matched pairs)						
Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	-0.06688	-0.06688	-0.06763	-0.06614
1.2	0	0	-0.08267	-0.05234	-0.08347	-0.05167
1.4	0	0	-0.09685	-0.04102	-0.09772	-0.04037
1.6	0	0	-0.10994	-0.03187	-0.11087	-0.03128
1.8	0	0	-0.12219	-0.02433	-0.12319	-0.02376
2	0	0	-0.1336	-0.01798	-0.13465	-0.01741
2.2	0	0	-0.14439	-0.0125	-0.14551	-0.01195
2.4	0	0	-0.15467	-0.00771	-0.15585	-0.00719
2.6	0	0	-0.16451	-0.00356	-0.16575	-0.00307
2.8	0	0	-0.17392	-0.00023	-0.17522	-1.6E-05
3	0	0.010836	-0.18295	-4.30E-07	-0.18432	-4.30E-07
* gamma - log odds of differential assignment due to unobserved factors						
sig+ - upper bound significance level						
sig- - lower bound significance level						
t-hat+ - upper bound Hodges-Lehmann point estimate						
t-hat- - lower bound Hodges-Lehmann point estimate						
CI+ - upper bound confidence interval (a= .95)						
CI- - lower bound confidence interval (a= .95)						

Note: Results from the Rosenbaum sensitivity tests for unobserved factors affecting the PSM estimates. In this table I test the baseline specification. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Figure 5: Taxable profits by headquarter location.



Note: Weighted mean ratios of taxable profits to total assets calculated for subsidiaries of foreign multinational companies in the UK by global ultimate owner of the multinational group. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

6.1 Regression analysis

The propensity score matching results can be directly compared to the OLS estimates. The difference in the unconditional means of the ratios of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones can be estimated using an OLS regression of taxable profits scaled by total assets on the left hand side on a multinational dummy and further control variables on the right hand side:

$$y_{it} = \alpha + \beta_1 multinational_i + \gamma X_{it} + ind_i + year_t + u_{it} \tag{3}$$

In these regressions the main variable of interest is $multinational_i$, which is a time-invariant dummy equal to one if the company is a foreign multinational subsidiary and 0 if it is a domestic standalone. With the dependant variable, y_{it}, being the ratio of taxable profits to total assets for firm i in year t, the coefficient β_1 on the multinational dummy is the difference in the ratio of taxable profits to total assets between domestic standalones and foreign multinational subsidiaries. The vector X_{it} controls for firm level observable characteristics (total assets in the baseline specification), ind_i and $year_t$ are year and industry fixed effects. The constant is the mean ratio of taxable profits to total assets for domestic standalones.

The coefficient on the multinational dummy in a regression without any controls estimates the upper bound of the total size of the difference in the ratio of taxable prof-

its to total assets between foreign multinational subsidiaries and domestic standalones. Inclusion of fixed effects and further controls will attribute parts of that difference to observable firm and industry level characteristics. Including flexible form of industry and size variables into the estimation, i.e. controlling for size and industry in the full sample would bring the coefficient on the multinational dummy closer to the PSM estimates of the difference. When we restrict the sample on which such an OLS regression is run to propensity score matched sample and use multinational dummy as the only explanatory variable, the coefficient on that multinational dummy will be equivalent to the ATT estimated by the PSM.

Similar to PSM, we can utilize the decomposition of the unconditional mean into conditional one and the binary outcome. Therefore I estimate the OLS regression on the sample of positive taxable profits only using both full and propensity score matched samples. I also estimate a binary regression model for the likelihood of reporting zero taxable profits depending on the ownership status. Hence, I estimate the following equation:

$$d_{it} = \alpha + \varphi_1 multinational_i + \varphi X_{it} + ind_i + year_t + \epsilon_{it}. \tag{4}$$

where d_{it} is a dummy equal to 1 when a company reports taxable profits to be zero and zero otherwise and other variables are defined as in equation 3. I estimate this binary model using linear probability model (OLS) and maximum likelihood estimate (probit). Further, I include leverage and other potential determinants of reporting zero taxable profits, such as firm structure and previous year's losses (see Table 9 for the list of variables). This estimation is designed to understand what determines the zero taxable profit reporting behaviour of companies. One could also interact the explanatory variables with the multinational dummy to understand the differences in zero taxable profits determinants between foreign multinational subsidiaries and domestic standalone companies.[46]

6.1.1 Results from OLS and LDV specifications

In this section I present the results from the unconditional (Table 10) and conditional (Table 11) OLS estimations of the mean difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones as well as limited dependant variable estimations of the determinants of zero taxable profit reporting (Table 12).

The results from the OLS estimates (Table 10) on the unrestricted sample of foreign multinational subsidiaries and domestic standalones suggest a very large difference be-

[46] For more detailed analysis of the loss making behaviour of UK companies please see Arulampalam, Guceri and Devereux (2017).

tween the two ownership types in terms of the ratio of taxable profits to total assets. The coefficient on the multinational dummy in these regressions estimates the upper bound of the difference in taxable profits between foreign multinational subsidiaries and domestic standalones; this is 52.3 percentage points (column 1). The mean ratio of taxable profits to total assets for domestic standalones in 0.617. This means that foreign multinational subsidiaries report almost 90 percent lower ratio of taxable profits to total assets than domestic standalones.

This large difference is partially explained by industry fixed effects (column 2) and size differences (column 3). Similar to the propensity score matching estimates, about 40 percent of the difference between the analyzed ownership types is explained by differences in leverage (column 4), where the coefficient on the multinational dummy decreases substantially. Inclusion of total factor productivity (column 5) halves the coefficient on the multinational dummy, but this is primary due to sample composition. Controlling for the ratio of capital allowances to total assets (column 6) does not change the size of the coefficient on the multinational dummy.

In columns 7 - 10 instead of including a linear function of size, I include size bins, which is more similar to what propensity score matching does. It turns out that controlling for size bins the coefficient on the multinational dummy declines substantially (column 7). Further, since the mean ratio of taxable profits to total assets in each size bin is lower as companies get larger, this suggests that larger multinationals report lower taxable profits than the ones for which we can find comparable domestic standalones. Inclusion of leverage (column 8) and TFP reduce the coefficient on the multinational dummy further while capital allowances do not change it. In column 11 I provide the results from running OLS without any controls on the PSM matched sample. The coefficient on the multinational dummy is identical to the PSM estimate and is included for comparison purpose. The constant from that OLS regression is the mean ratio of taxable profits to total assets for domestic standalones and is equivalent to the one estimated using the PSM approach.

Limiting the sample to positive taxable profits (Table 11) the results looks very similar to the ones from Table 10 using the full sample of taxable profits. This suggests that in the restricted sample of positive taxable profits, the difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones exists and it is only when we use bins of total assets to control for size differences (column 7-10) that it disappears. The coefficients on the multinational dummy become insignificant and get smaller in columns 7-10 and including further controls for leverage, TFP and capital allowances reduces the coefficient to be almost zero and insignificant.

In Table 12 I present results from estimating the limited dependant variable model using OLS (the results using probit models are not significantly different).[47] The coef-

[47]Running the LDV models on the PSM sample generates very similar results.

ficient on the multinational dummy estimates how much more likely it is for a foreign multinational subsidiary to report zero taxable profits relative to a domestic standalone. In all cases the coefficient of interest is positive and significant implying that foreign multinational subsidiaries report taxable profits to be zero significantly more often than domestic standalone companies.

Table 9: Definitions of control variables used in LDV and in Heckman estimations.

variable	definition
liabilities_ta	total liabilities divided by total assets
ztp2yrs	zero taxable profits reported in at least last 2 out of 3 years; dummy 1 or 0
previous_losses_ta	dummy 1 if company has brought in forward losses from previous year to claim against taxable profits this year
guo_stattau	statutory tax rate in the country of global ultimate owner
lastyr_loss	dummy 1 if company reported zero taxable profits last year
tax_haven	dummy 1 if the global ultimate owner is located in tax haven
Ln_trading_turnover	logarithm of trading turnover (box 1) from CT600 data

These results in columns 2 - 9 explore potential factors that could be determining the likelihood of reporting zero taxable profits. Table 9 defines each of the variables used. I find that higher leverage, bringing losses forward from the previous periods, reporting taxable profits to be zero in at least last 2 out of 3 years, reporting zero taxable profits in the previous year and a parent company located in a tax haven increase the likelihood of reporting zero taxable profits. What is more, the higher the tax rate in the parent company and the higher the company's own trading turnover, the less likely a company is to report zero taxable profits in the UK. When I test the relative significance of these factors against each other (column 9), only the coefficients on previous year's losses and previous year's zero taxable profit reporting remain significant, which would suggest that persistency in reporting zero taxable profits is more important than any observable firm level characteristics. The evidence on leverage and tax haven parent are broadly consistent with the heterogeneities showed in the PSM results. They confirm that both leverage and the presence of tax haven parents affect the zero taxable profit reporting behaviour of companies as well.[48]

What is more, for the binary part, the difference between the matched (smaller) for-

[48]I can interact each explanatory variable with the multinational dummy to see whether their effects differ depending on which ownership category the company belongs to. The results show that there are differences in the magnitudes of determinants of zero taxable profits between ownership categories, but each of the variables disucssed in Table 2.12 is significant for both of the ownership groups.

eign multinational subsidiaries and the matched (larger) domestic standalones companies is very similar to the difference between all foreign multinational subsidiaries and all domestic standalones (PSM matching coefficient was 31.7 vs 31.6 in column 1 Table 12). For the ratio of taxable profits to total assets, the difference between the matched subsamples is much smaller than the difference in the full sample (Table 10 column 1 vs 11). This suggests that the differences in the propensity to report zero taxable profits are not very important in explaining the differences in the ratio of taxable profits to total assets between matched (smaller) foreign multinational subsidiaries and unmatched (larger) foreign multinational subsidiaries and between matched (larger) domestic standalones and unmatched (smaller) domestic standalones.

Table 10: OLS results - unconditional means.

	1	2	3	4	5	6	7	8	9	10	11
VARIABLES	all obs	all obs	all obs	all obs	all obs	all obs	all obs	all obs	all obs	all obs	all obs
multinational	-0.523***	-0.469***	-0.469***	-0.284***	-0.129***	-0.129***	-0.170***	-0.109***	-0.047***	-0.047***	-0.128***
	-0.082	-0.084	-0.084	-0.052	-0.029	-0.029	-0.043	-0.025	-0.009	-0.009	-0.027
total_assets			-0.000*	-0.000**	-0.000***	-0.000***					
			0.000	0.000	0.000	0.000					
liabilities_ta				0.000	0.000	0.000		0.000	-0.002*	-0.002*	
				0.000	0.000	0.000		0.000	-0.001	-0.001	
TFP_Solow					-0.003***	-0.003***			-0.002***	-0.002***	
					-0.001	-0.001			0.000	0.000	
capallowance						0.000				0.000	
						0.000				0.000	
2.pct_totass							-0.473***	-0.377***	-0.592***	-0.592***	
							-0.082	-0.047	-0.102	-0.102	
3.pct_totass							-0.852***	-0.708***	-0.977***	-0.977***	
							-0.088	-0.056	-0.118	-0.118	
4.pct_totass							-1.006***	-0.851***	-1.093***	-1.093***	
							-0.103	-0.072	-0.130	-0.130	
5.pct_totass							-1.038***	-0.901***	-1.175***	-1.175***	
							-0.105	-0.076	-0.125	-0.125	
Constant	0.617***	0.425***	0.425***	0.161***	0.148***	0.148***	1.182***	0.966***	1.297***	1.297***	0.252***
	-0.085	-0.022	-0.022	-0.013	-0.033	-0.033	-0.061	-0.071	-0.129	-0.129	-0.029
Observations	3,117,744	3,117,744	3,117,744	1,150,615	70,325	70,325	3,117,744	1,150,615	70,325	70,325	299,162
R-squared	0.003	0.012	0.012	0.066	0.079	0.079	0.026	0.152	0.247	0.247	0.000
Industry FE	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
Year FE	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
St err cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Type of matching	-	-	-	-	-	-	-	-	-	-	propensity score

Note: Results from the OLS estimations, unconditional means; foreign multinational subsidiaries and domestic standalones sample only. Columns 1 - 6 add additional explanatory variables, columns 7 - 10 instead of controlling for levels of total assets use bins of total assets as control variables. Column 11 shows results from the OLS estimation on the matched sample. The coefficient on the multinational dummy in column 11 corresponds to the ATT estimate in the PSM results. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Table 11: OLS results - conditional means.

VARIABLES	1 pos profits	2 pos profits	3 pos profits	4 pos profits	5 pos profits	6 pos profits	7 pos profits	8 pos profits	9 pos profits	10 pos profits	11 pos profits
multinational	-0.606***	-0.475***	-0.475***	-0.287***	-0.052**	-0.052**	-0.052	-0.055***	-0.005	-0.005	-0.019
	-0.086	-0.086	-0.086	-0.051	-0.023	-0.023	-0.045	-0.019	-0.009	-0.009	-0.028
total_assets			-0.000**	-0.000***	0.000	0.000					
			0.000	0.000	0.000	0.000					
liabilities_ta				0.013***	0.031	0.031		0.012***	0.016	0.016	
				0.000	-0.019	-0.019		-0.001	-0.017	-0.017	
TFP_Solow					-0.034***	-0.034***			-0.010***	-0.010***	
					-0.006	-0.006			-0.002	-0.002	
capallowance						0.000				0.000**	
						0.000				0.000	
2.pct_totass							-1.102***	-0.930***	-0.946***	-0.946***	
							-0.069	-0.030	-0.125	-0.125	
3.pct_totass							-1.611***	-1.381***	-1.402***	-1.402***	
							-0.077	-0.048	-0.133	-0.133	
4.pct_totass							-1.816***	-1.575***	-1.552***	-1.552***	
							-0.095	-0.064	-0.146	-0.146	
5.pct_totass							-1.893***	-1.653***	-1.650***	-1.650***	
							-0.098	-0.067	-0.136	-0.136	
Constant	0.831***	-2.674***	-2.674***	0.182***	0.796***	0.796***	2.143***	1.797***	1.900***	1.900***	0.283***
	-0.098	-0.057	-0.057	-0.016	-0.067	-0.067	-0.052	-0.068	-0.144	-0.144	-0.035
Observations	2,226,637	2,226,637	2,226,637	828,437	40,515	40,515	2,226,637	828,437	40,515	40,515	144,626
R-squared	0.001	0.012	0.012	0.141	0.149	0.149	0.041	0.306	0.338	0.338	0.000
Industry FE	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
Year FE	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
St err cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Type of matching	-	-	-	-	-	-	-	-	-	-	propensity score

Note: Results from the OLS estimation, conditional means; foreign multinational subsidiaries and domestic standalones, The OLS estimations are performed on positive taxable profits sample only. Columns correspond exactly to the ones from the OLS results table using unconditional means. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Table 12: LDV estimation results.

VARIABLES	1	2	3	4	5	6	7	8	9
multinationalnew	0.316***	0.309***	0.185***	0.324***	0.311***	0.286***	0.314***	0.410***	0.194***
	(0.030)	(0.028)	(0.019)	(0.030)	(0.027)	(0.031)	(0.031)	(0.024)	(0.011)
liabilities_ta		0.000**							0.000*
		(0.000)							(0.000)
ztp2yrs			0.520***						0.404***
			(0.004)						(0.008)
previous_losses_ta				0.011***					-0.004
				(0.004)					(0.003)
guo_stattau					-0.124***				-0.031
					(0.036)				(0.028)
lastyr_loss						0.416***			0.212***
						(0.013)			(0.006)
tax_haven							0.020**		0.007
							(0.010)		(0.011)
ln_trading_turnover								-0.055***	-0.016***
								(0.004)	(0.001)
Constant	0.626***	0.234***	0.478***	0.900***	0.897***	0.549***	0.678***	1.103***	0.234***
	(0.010)	(0.013)	(0.007)	(0.044)	(0.016)	(0.007)	(0.008)	(0.042)	(0.018)
Observations	3,205,555	1,150,615	3,205,555	3,117,744	456,125	3,205,555	2,974,833	2,834,906	167,367
R-squared	0.059	0.065	0.228	0.061	0.123	0.169	0.062	0.091	0.315
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
St err cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO	NO	NO	NO
Type of matching	-	-	-	-	-	-	-	-	-

Note: Results from the limited dependant variable estimation using linear probability model (LPM) on the sample of foreign multinational subsidiaries and domestic standalones, Columns 1 - 8 test the significance of each explanatory variable separately, while column 9 includes all possible explanatory variables together. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

6.2 Selection Models

The results from the propensity score matching have revealed that the explanation for the differences in the ratio of taxable profits to total assets between matched foreign multinational subsidiaries and matched domestic standalones lies in the binary part of the distribution. The fact that the coefficient on the multinational dummy from the binary regressions is significant suggests that the estimate of the mean difference in the ratio of taxable profits to total assets between foreign multinational subsidiaries and domestic standalones from a simple OLS regression may be inconsistent and downward biased. There seems to be selection of companies into zero and positive taxable profit reporting groups, which suggests that the more appropriate model to be estimated is a selection type, such as Heckman selection model, which takes into account the bounded nature of the data. This type of model will allow me to disentangle the importance of the extensive and intensive margins for taxable profit reporting differences between ownership types. There are two choices here, either a simple censored regression model, such as Tobit (Tobin (1956)), or a more sophisticated selection model, such as Heckman (Heckman (1974), Heckman (1976)).

Tobit models assume that there is an unobservable latent variable y_{it}^*, which linearly depends on X_{it} via a parameter γ. In addition, there is a normally distributed error term u_{it}. The observable variable y_{it}, in my case the ratio of taxable profits to total assets, is defined to be equal to the latent variable whenever the latent variable is above zero and zero otherwise.

$$y_{it} = \begin{cases} y_{it}^* \text{ if } y_{it}^* > 0 \\ 0 \text{ if } y_{it}^* \leq 0 \end{cases} \tag{5}$$

where y_{it}^* is defined as :

$$y_{it}^* = \alpha + \beta_1 multinational_i + \gamma X_{it} + ind_i + year_t + u_{it}. \tag{6}$$

This is the same equation as the one estimated for the OLS model explaining the differences in the ratio of taxable profits to total assets between companies. A company can choose to report zero or positive taxable profits, the choice of which is determined by their profitability as well as, for example, their propensity to aggressively avoid tax. In case of Tobit models the latent variable absorbs both the process of reporting positive versus zero taxable profits and the 'outcome' of interest. Therefore both processes are determined by the same parameters. For a continuous variable from the vector X_{it} the partial effects of that variable in the zero taxable profit reporting equation, $P(y_{it} > 0|x)$,

and its effect in the outcome equation $E(y|x, y > 0)$ have the same sign. Therefore it is impossible for an explanatory variable to have a positive effect of the likelihood of making positive taxable profits, but negative effect on how much profits the company makes in general. This is quite a large limitation of the Tobit approach and in case of comparing the taxable profits of foreign multinational subsidiaries with those of domestic standalones might be crucial. This is because the baseline OLS and Probit models suggest that being a multinational has an effect on both the binary (extensive) and continuous (intensive) parts of the distribution. As such, it seems to be of primary importance to understand which margin of response drives the difference in taxable profits between the two ownership types. Since the PSM estimates suggest that the extensive margin is of primary importance, I test this more formally in this section.

A more sophisticated alternative to Tobit model, that allows to separate the two margins, is Heckman selection model, which introduces a second latent variable that allows the process of reporting zero taxable profits and the outcome to be independent from each other, conditional on x.

$$y_{2it} = \begin{cases} y^*_{2it} \text{ if } y^*_{1it} > 0 \\ 0 \text{ if } y^*_{1it} \leq 0 \end{cases} \tag{7}$$

In Heckman selection model the variables determining whether a company reports positive profit are separate from the variables determining how much profit a company is reporting once it decides to do so at all. Therefore, the first equation would determine why companies report positive profits

$$(1)\ y^*_{1it} = \beta z_{it} + e_{it} \tag{8}$$

$$(2)\ d_{it} = 1 \text{ if } y^*_{1it} > 0 \text{ and } d_{it} = 0 \text{ if } y^*_{1it} \leq 0 \tag{9}$$

where y^*_{1it} is a latent variable indicating the utility from reporting taxable profits, d_{it} is an indicator for profit reporting status, z_{it} denotes the determinants of this status, β is a vector of associated parameter estimates, and e_{it} is an error term with a standard normal distribution.

The second equation involves estimating a regression of taxable profits scaled by total assets conditional on $d_{it} = 1$ and a vector of explanatory variables x_{it} . This would be the same equation as the one estimated in the OLS model

$$y_{2it} = \alpha + \beta_1 multinational_i + \gamma X_{it} + ind_i + year_t + u_{it}. \quad (10)$$

The model, which comprises an equation determining sample selection and a regression model conditional on $d_{it} = 1$, is estimated jointly using the maximum likelihood technique, with (e_{it}, u_{it}) assumed to be bivariate normal. For identification purposes estimating Heckman selection model requires at least one variable in the first stage (part of z_{it}) that is not a determinant in second stage (not part of x_{it}).

Crucially, the distinction between (Heckman) selection models and (Tobit) censored regression models could be important if there is heterogeneity within the sample of multinationals, for example between 'aggressive tax avoiders' (which reported zero taxable profits most of the time) and 'unsophisticated tax planners' (which report zero taxable profits no more frequently than domestic standalones). In that case the binary part of the selection model is where the differences lay and that would be reflected appropriately in a selection model, but not in a Tobit.

This suggest that including dummies for (e.g.) reporting zero taxable profits in at least 2 of the last 3 years in the probit part of the Heckman procedure, could help identification. Further variables that could be considered as identifying factors in the first stage regression can be for example the presence of a tax haven parent which determines whether a company is an aggressive tax avoider. This will affect whether it decides to report any profits in the UK or whether it shifts everything to, for example, its tax haven headquarter. The presence of the tax haven parent per se does not affect the profitability of the company in the UK. Another variable that I could potentially use in z_{it} could be last years losses carried forward. In box 4 in the tax return form, each company has to report whether is has any losses from previous periods that it wants to use to offset against taxable profits in this period. They affect whether the company reports zero taxable profits as it can use those losses to reduce its taxable profits to zero, but they do not affect how much profit the company made this year. Additionally, I use the average industry turnover, which approximates the business cycle fluctuations that would affect the proportion of companies reporting zero taxable profits in a particular year. Average industry turnover is calculated for each year and each 2 digit industry code using mean trading turnover from the CT600 data.

I use those four variables together with total assets in the first stage equation that determines whether a company reports zero or positive profits (z_{it}). In the second stage equation I use the same variables as in the case of the OLS model discussed in Section 6.1.

6.2.1 Results from the Heckman selection model specifications

Tables 13 and 14 show the results from estimating the Heckman selection model. Table 13 shows second stage marginal effects while Table 14 shows first stage coefficients from the binary part of the distribution. Note that in the first stage regressions the zero taxable profits dummy is coded as 1 when positive taxable profits arise (reverse of what it is in the LDV estimations in section 6.1). This is dues to the specific nature of the Heckman selection model, whereby in the first stage one estimates the determinants of reporting positive profits. Therefore negative coefficients shown in Table 14 correspond directly to the positive ones from LDV regressions.

Column 1 estimates the model using unrestricted sample of foreign multinational subsidiaries and domestic standalones, while columns 2- 6 use the propensity score matched sample and experiment with various sets of explanatory variables, defined above, in the first stage regression.

First, in most of the estimations the inverse mills ratio - lambda (which estimates the significance of the selection problem) is significant suggesting that selection into reporting positive taxable profits is indeed an issue in my data. The most important feature of Tables 13 and 14 is that the estimates of the coefficient on the multinational dummy are larger and always significant in the first stage regressions. This suggests that being a multinational significantly negatively affects whether the company will report any taxable profits in the UK. Once a company reports positive taxable profits in the UK, being a multinational substantially reduces the reported ratio of taxable profits to total assets relative to domestic standalone in unrestricted sample only (column 1 Table 13). When I use comparable companies as matched through PSM, the coefficient on the multinational dummy in the second stage becomes much smaller and often insignificant. This suggests that being a multinational matters less once you report positive taxable profits (columns 2 and 3). What is more, column 1 results from second stage suggest that larger (unmatched) foreign MNCs report lower ratios of taxable profits to total assets than smaller (unmatched) domestic standalone, conditional on reporting positive taxable profits.

When the coefficients from the first stage regressions are converted to marginal effects, their magnitude oscillates around 0.3, which means that they are very similar to the ones obtained using PSM method.

In columns 4-6 I use dummies signifying zero taxable profit reporting; either for the last two out of 3 years ($ztp2yrs$), last year (ztp_11), 2 years ago (ztp_12), etc. However, the coefficient on lambda is insignificant in those regressions, which would suggest that selection is not a problem anymore. In columns 4-6 the coefficient on a multinational dummy in the second stage of Heckman selection model is marginally significant and negative which would suggest that being a multinational marginally reduces the taxable

profits of positive taxable profit reporting companies relative to domestic standalones. Importantly, this coefficient is much smaller and much less significant than the one from the first stage regression on the binary part of the distribution.

The results from Heckman selection model broadly confirm the impression also gained from the propensity score matching methodology. There is little or no difference between matched (smaller) foreign multinational subsidiaries and matched (larger) domestic standalones, conditional on reporting positive taxable profits. In turn, the results from the first stage show that being a multinational matters significantly for reporting zero taxable profits.

Table 13: Heckman selection model estimation results - second stage.

VARIABLES	(1) Heckman	(2) Heckman	(3) Heckman	(4) Heckman	(5) Heckman	(6) Heckman
multinational	-0.281***	0.002	-0.005	-0.024**	-0.018*	-0.018**
	(0.007)	(0.011)	(0.010)	(0.009)	(0.010)	(0.009)
Observations	2,894,020	488,431	488,431	488,431	521,234	521,234
Industry FE	YES	YES	NO	NO	NO	NO
Year FE	YES	YES	NO	NO	NO	NO
St err cluster	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO
Type of matching	-	propensity score	propensity score	propensity score	propensity score	propensity score

Note: Results from the Heckman selection model estimation, second stage marginal effects. Results on the smaple of foreign multinational subsidiaries and domestic standalones, Columns 1 - 6 correspond to various first stage estimations as shown in Table 14. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

Table 14: Heckman selection model estimation results - first stage.

VARIABLES **1st stage results**	(1)	(2)	(3)	(4)	(5)	(6)
multinational	-0.936***	-0.769***	-0.769***	-0.651***	-0.774***	-0.673***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
ln_total_assets	0.071***	0.018***	0.018***	0.029***	0.027***	0.030***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ztp2yrs	-1.138***	-1.176***	-1.176***	0.132***	-1.343***	
	(0.002)	(0.005)	(0.005)	(0.012)	(0.005)	
avg_indyrtrturnover	0.000***	-0.000***	-0.000***	-0.000***		
	(0.000)	(0.000)	(0.000)	(0.000)		
previous_losses_ta	-0.001	0.002*	0.002*	0.005***		
	(0.001)	(0.001)	(0.001)	(0.001)		
tax_haven	-0.011	-0.055***	-0.055***	-0.052***		
	(0.008)	(0.008)	(0.008)	(0.008)		
lastyr_loss	-0.777***	-0.514***	-0.514***	0.170***		
	(0.002)	(0.005)	(0.005)	(0.007)		
ztp_l1				-1.473***		-1.359***
				(0.007)		(0.005)
ztp_l2				-0.400***		-0.327***
				(0.009)		(0.006)
ztp_l3				-0.185***		-0.147***
				(0.008)		(0.007)
ztp_l4				-0.078***		-0.084***
				(0.008)		(0.007)
ztp_l5				-0.071***		-0.075***
				(0.008)		(0.008)
ztp_l6				-0.074***		-0.078***
				(0.008)		(0.008)
lambda	-0.075***	-0.108***	-0.093***	-0.017	-0.009	-0.009
	(0.010)	(0.028)	(0.028)	(0.024)	(0.028)	(0.023)
Constant	0.230***	0.858***	0.858***	0.827***	0.648***	0.815***
	(0.005)	(0.013)	(0.013)	(0.014)	(0.012)	(0.013)
Observations	2,894,020	488,431	488,431	488,431	521,234	521,234
Industry FE	YES	YES	NO	NO	NO	NO
Year FE	YES	YES	NO	NO	NO	NO
St err cluster	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO
Type of matching	-	propensity score	propensity score	propensity score	propensity score	propensity score

Note: Results from the Heckman selection model estimation, first stage coefficients. The sample is foreign multinational subsidiaries and domestic standalones, Columns 1 - 6 show results using various first stage variables. Selected sample, 2000 - 2011. Source: merged HMRC and FAME data.

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