Assessing profit shifting using Country-by-Country Reports: a non-linear response to tax rate differentials

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Assessing profit shifting using Country-by-Country Reports: a non-linear response to tax rate differentials

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Abstract

We assess the size of global MNEs' profit shifting and associated tax revenue losses using administrative, firm-level data from Country-by-Country reporting (CbCR). This is a new dataset constituting one of the most comprehensive and detailed global datasets of multinationals (MNEs) and their affiliates. After assessing how CbCR outperforms existing datasets, we expand the analysis of the non-linear response of profits to tax rates and investigate non-linear responses by MNE nationality and size. Our results depart substantially from the existing literature, suggesting that the elasticity of profits with respect to corporate tax rates is eight times larger than conventional estimates in the lowest tax jurisdictions, and sixty percent lower than conventional estimates amongst jurisdiction-pairs where tax rate differences are smaller. Further, we find that profit shifting increases with MNE size but to a decreasing degree, suggesting that MNEs incur fixed costs when shifting profits that only become sustainable above a certain MNE size. We also observe different patterns of profit shifting among multinationals headquartered in Europe, the Americas, and Asia-Oceania. Finally, we account for the impact on profit shifting and global tax revenue arising from the 2017 US Tax Cuts and Jobs Act. We also assess the impact of an international corporate tax reform introducing a minimum level of taxation. Our results highlight the concentration of profit shifting in a few small, low tax jurisdictions, suggesting that international tax reforms aimed at guaranteeing a minimum level of taxation may be an efficient way to reduce profit shifting.

Keywords: Profit shifting, BEPS, International taxation, corporate income tax, multinationals, country-by-country reporting

JEL: H25, H26, H32, F23

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1 Introduction

Multinational corporations (MNEs) remain at the centre of a heated and long-standing debate on the amount of corporate income tax they effectively pay. In the past decade, leaked documents leading to scandals such as LuxLeaks, together with increased media attention for the tax affairs of MNEs, have fuelled the debate by providing anecdotal evidence on how multinational firms are capable of reducing or even abating completely their corporate tax liability.

The increased attention paid to the base erosion and profit shifting (BEPS) behaviour of MNEs has been accompanied by the emergence of a crescent-like heterogeneity among firms. There is a large body of evidence showing that firms have become larger and their sales more concentrated among superstar firms (Van Reenen, 2018), possibly because of economies of scale driven by increased digitalisation and sustained globalisation.

The contraposition between the increasing economic relevance of multinational enterprises, the corresponding fall in the importance of domestic firms, the evidence of increased mark-ups (Hall, 2018) and a decrease in the labour share of GDP (Autor et al., 2020), have contributed to the rising widespread social discontent toward the largest MNEs not paying "their fair share" of taxes. This is the context in which the OECD and the so-called Inclusive Framework have rolled out the BEPS programme of anti-avoidance measures in 2015.

The increasing relevance of profit shifting within the international taxation debate has induced a recent surge in the number of papers attempting to evaluate this phenomenon. Comprehensive literature reviews and meta-analyses have been carried out by Dharmapala (2014), Hines (2014), the OECD (2015), Heckemeyer and Overesch (2017) and, more recently, by Beer, de Mooij and Liu (2020). While the methodologies and magnitude of results may vary, the papers provide general evidence for the existence of profit shifting.

The different approaches used to estimate profit shifting vary according to the type of data used. While part of the literature uses macroeconomic data (see Crivelli, de Mooij and Keen 2015; Acciari et al. 2015; Bolwijn et al. 2018; Tørsløv, Wier and Zucman 2018), another strand evaluates profit shifting using micro data (see Huizinga and Laeven 2008; Beer and Loeprick 2014; Dowd et al. 2017; Johansson et al. 2017; Fuest et al. 2021).

Our paper consists of a micro-based econometric analysis exploiting a novel dataset: Country by Country Reporting (CbCR). This is the first paper using a CbCR dataset covering domestic

and foreign MNEs across all jurisdictions where a corporate group has a taxable presence.[2] This type of data has never been available to researchers before. Its key advantage is that, for each MNE and in every country, it allows us to disentangle information on real activities from tax-related determinants of profit allocation. This paper contributes to the literature in several ways:

i) We first provide evidence of the advantages of our data with respect to the most commonly used dataset (Orbis Bureau van Dijk). We also combine CbCRs with tax return data to explore the magnitude of possible double counting in CbCR data because of how dividends are reported. This enables us to obtain a much more accurate picture of the activities of an MNE across different countries.

ii) We then estimate the semi-elasticity of profit shifting and we find a lower linear elasticity than in the current literature. While the literature estimates that an increase of one percentage point in the CIT rate in a jurisdiction is correlated with a decrease of between 0.8% and 1.5% in profits allocated to that jurisdiction, our estimates predict a decrease in profits by 0.68%.

iii) Next, we provide evidence of statistically significant and economically sizable non-linearities in profit shifting behaviour with respect to different levels of CIT statutory rates and CIT rate differentials. Our model suggests that low tax countries face an eight times larger semi-elasticity than is suggested by the literature. Furthermore, we find that the propensity to profit shift is sixty percent lower than the literature estimates for countries with CIT rates similar to the rate observed in other countries. Our findings suggest that the location of profits in low tax jurisdictions is strongly driven by tax savings motives rather than economic motives, implying that even a small increase in the tax rate in a low tax country would substantially reduce the profits reported there. On the other hand, in countries with a CIT tax rate closer to the worldwide average, where profits are more aligned with genuine economic activity, a change in the CIT tax rate would have a smaller effect on the reported profits.

iv) We provide evidence for differences in the propensity to shift profit of MNEs headquartered in different countries finding that European MNEs shift on average less profits than their American and Asian-Oceanian counterparts,. However,

[2] While Fuest et al. (2021) use micro-based CbCR, their data report information only on German MNEs.

MNEs in Europe and the Americas are more inclined to shift profits towards extremely low tax countries than their Asian and Oceanian counterparts.

v) We provide evidence that larger MNEs are involved in higher levels of profit shifting. Moreover, our results provide novel evidence of the existence of a non-linear relationship between size and profit shifting as the rate of increase in profit shifting decreases for larger MNEs. Our findings may reflect the existence of fixed costs in shifting profits which may become relatively less important once the MNE has reached a certain size.

vi) Finally, at country level we estimate revenue losses and gains associated with profit shifting. We also estimate how profit shifting estimates would decrease when accounting for two key reforms in international corporate tax: the 2017 US Tax Cuts and Jobs Act and the proposed minimum effective corporate income tax system.

1.1 Country and firm coverage

The majority of the literature following the micro-data approach uses the Orbis BvD dataset to estimate profit shifting. Despite being one of the most used and most complete cross-country firm-level dataset that has been accessible up to now, one of the most relevant limitations of using Orbis BvD is the lack of data for specific subsets of countries and firms. More specifically, Orbis shows an important under-representation of firms, firms with subsidiaries located in the United States, and firms located in investment hubs or tax havens. Evidence of this under-representativeness has been provided by the literature (Tørsløv, Wier and Zucman, 2018). Section 2.2 reports additional evidence of this limitation. The low coverage of these specific subsets of companies and countries is a major problem in estimating profit shifting. As more profit shifting is expected to be associated with tax havens or investment hubs, by not observing profits in these countries, the estimates obtained may be substantially biased. At the same time, US MNEs make up a substantial share of MNEs worldwide both in number and profit. Due to the limited coverage of these firms, profit shifting analysis based on Orbis may overlook a significant part of the story. One additional source for worldwide activities of MNEs is the US Bureau of Economic Analysis dataset, which however only contains data for US MNEs, thus not permitting a cross-country comparison by MNE nationality.

Our paper therefore makes a substantial contribution to the literature by being, to the best of our knowledge, the first to exploit a new dataset on MNEs: disaggregated Country-by-Country Reporting (CbCR) data referred to MNEs with different nationalities. Our dataset includes CbCRs filed by Italian and foreign MNEs having at least one subsidiary in Italy, thus being the most comprehensive and detailed dataset used for profit shifting analysis until now.

Being a novel dataset available only within national tax administrations, micro-based CbCR has not yet been used extensively for profit shifting analysis. Fuest et al. (2021) analyse profit shifting using disaggregated CbCR, however, they focus solely on German MNEs, while our analysis considers MNEs with multiple nationalities and is therefore able to capture more broadly profit shifting activities. Furthermore this crucial difference allows us to also compare the propensity of MNEs to profit shift according to their nationalities.

CbCR was implemented under BEPS Action 13 "Transfer Pricing Documentation and Country-by-Country Reporting". It consists of an innovative reporting tool to be filed by the largest MNE groups.[3] CbCRs provide firm-level financial information for each MNE affiliate in every jurisdiction where the MNE group is present. More detailed information on CbCR is provided in

By using CbCR, we are able to overcome the issues arising from the under-representativeness of Orbis BvD data, as firms must file their information in every jurisdiction in which they are present. Our first contribution to the profit shifting literature is therefore estimating the phenomenon using, for the first time, firm-level data on MNEs' global structure that does not lack in the representativeness of the specific subset of firms and locations. Section 2.2 will describe in more detail how the representativeness of firms located or based in the United States and in investment hubs is different in the CbCR dataset relative to Orbis BvD.

An additional benefit of using CbCR consists in the clarity of the connections among firms within the same multinational group. As CbCR data are filed by MNE groups, the linkage between the entities and the MNE group is clear: each MNE group must provide data on all entities in every country where the group is present. This allows us to control for multinational-specific characteristics more precisely and estimate profit shifting, taking into account all locations where the MNE is present. By comparison, the recognition of the MNE

[3] CbCRs are filed by MNEs with global revenues above €750 million. Seventy-six jurisdictions have multilateral or bilateral competent authority agreements in place for the exchange of information on CbCR. See Country-by-Country Reporting – Compilation of Peer Review Reports for more information.

group and of its operations by country in Orbis is not immediate as it requires multiple steps to build an ownership chain that often lacks precision.

By providing information of any subsidiary within each MNE, CbCRs are the only dataset available to depict the entirety of MNE activities.

We therefore use this novel dataset to estimate the semi-elasticity of profit shifting, finding lower linear semi-elasticities than those estimated by the literature; however, we find evidence of non-linearity in profit shifting, which is described in the next paragraph.

1.2 Relaxing the linearity assumption

As mentioned, our paper also contributes to the literature by relaxing the linearity assumption on several elements; firstly, on the effect of CIT rate differentials on profit shifting and secondly, by proving the existence of non-linearities in profit shifting activities related to MNE nationality and size.

Existing estimates of the semi-elasticity of pre-tax profit to the CIT tax rate differential tend to centre around -1, implying that a one-percentage point increase in the tax rate differential is correlated with a profit decrease in the country of about -1%.[4] However, most existing papers carrying out the micro-based profit shifting estimation assume a linear relationship between profit allocation and taxation. One exception to this is the work of Dowd, Landefeld and Moore (2017) (henceforth DLM). While their linear regression shows a semi-elasticity of -1.4, they also find a non-linear effect of profit shifting with a 4 to 7 times higher semi-elasticity for profit shifting towards low tax subsidiaries.

Our paper, in addition to providing an estimation of profit shifting by applying the standard linearity assumption, is closely related to DLM in that it analyses non-linearity in MNE behaviour. Similarly to DLM, we investigate the existence and magnitude of non-linearity in the responses of firms to changes in CIT rates and CIT rate differentials. We find strong

[4] The meta-analysis carried out by Heckemeyer and Overesch (2017) found a semi-elasticity of -0.8, while Huizinga and Laeven (2008) observed a -1.4 semi-elasticity. In their meta-analysis, Beer, De Mooij and Liu (2020) find a mean semi-elasticity of -1.5 in the most recent years and observe that estimates using micro data are lower, in absolute terms, than the estimates obtained in macro analyses. The recent paper by Dharmapala (2019) examines the differences between micro and macro estimates; while his studies based on micro data reported a semi-elasticity of -0.8 (Dharmapala 2014), other papers based on macro data suggest that about 40 percent of the foreign profits of MNEs are shifted to tax havens (Tørsløv, Wier and Zucman 2018).

evidence that this phenomenon exists and it is of significant statistical and economic importance.

We further develop this analysis and move beyond DLM in several respects. First, we provide estimates of the elasticity of profit allocation with respect to CIT rate differentials and not just CIT rates; our approach is therefore more consistent with the theoretical models of profit shifting.[5] Secondly, we estimate non-linear elasticities on a set of MNEs with different nationalities, thus, unlike DLM, we do not restrict our analysis only to US MNEs. Finally, we examine further how MNEs react to changes in CIT rates when locating profits in countries with rates higher than average. While DLM's approach leads to counter-intuitive positive elasticities in these countries, i.e. increases in CIT rates may induce a higher profit allocation in these jurisdictions, our specification delivers negative semi-elasticities.

Our results seem to suggest that the location of profits in low tax jurisdictions is strongly driven by tax saving motives, rather than economic motives; thus, we find that even a small increase in the tax rate in a low tax country would substantially reduce the profits reported there. On the other hand, in countries with a CIT tax rate closer to the worldwide average, where we expect profits mainly driven by genuine economic activity, we find that a change in the CIT tax rate would have a smaller effect on reported profits. Finally, when a firm faces a tax rate that is too high with respect to the average, it will tend to begin relocating its activities abroad with rising intensity.

Estimating both linear and non-linear elasticity, we provide further evidence that the linear approach over-estimates profit shifting by assigning a too high semi-elasticity to countries with CIT rates near the average, while at the same time under-estimating profit shifting in very-low and very-high tax countries. As developed countries tend to have similar CIT rates to one another, and with the majority of global profits allocated to high income countries, linear estimation of profit shifting may result in estimates that are artificially large. Moreover, as the estimated semi-elasticity is almost zero for the majority of developed countries, our results may suggest that actions intended to address BEPS issues should mainly focus on a few low tax jurisdictions, which would minimise profit shifting while at the same time not overburdening tax compliance in countries with average rates. Agreements on the matters of

[5] Theoretical models suggest that profit shifting is dependent upon both the CIT rate of the country to which the firm chooses to shift profit and the outside option for the firm, i.e. the average CIT rate applied on all other MNE subsidiaries. Thus, the differential among rates is the best determinant for profit shifting decisions.

international corporate income taxes may be also easier to reach if their impact is mainly restricted to a limited, yet significant in terms of profit shifting, subset of countries.

The uniqueness of our dataset allows us to provide two additional contributions to the profit shifting literature by exploiting heterogeneity in MNE nationality and size and assessing if these characteristics impact profit shifting activities.

We are therefore the first, to the best of our knowledge, to provide evidence of differences in profit shifting behaviour among MNEs in Europe, the Americas, and Asian-Oceania.

Furthermore, we provide evidence of the relevance of MNE size on profit shifting activities, showing that bigger firms are correlated with higher engagement in profit shifting. While it is often reported as anecdotal evidence that big MNEs shift more profit, empirical analyses on the role of size on profit shifting activity is still scant. [6] Finally, we further contribute to the literature by demonstrating that size and profit shifting have a nonlinear relationship consistent with the existence of fixed costs in profit shifting.

Overall, our paper provides evidence of the existence of fixed costs in profit shifting in different ways, thus coming to the same conclusion as a recent strand of literature addressing this topic (Bilicka, 2019).

After analysing profit shifting, our paper produces estimates of total profits being shifted and computes the estimated revenue losses and gains at country level caused by this phenomenon.

The remainder of the paper is organised as follows. Section 2 describes the data and provides a comparison between CbCR and Orbis BvD in terms of geographic coverage before providing some descriptive statistics of the dataset. Section 3 details the methodology we follow in identifying the effect of changes in taxation over profit allocation. Section 4 outlines the results of the estimated regressions and discusses the findings, while section 5 provides an estimation of the amount of shifted profit and induced revenue loss. Section 6 concludes.

[6] Reynolds and Wier (2018) investigate the role of MNE size, finding that the largest firms engage in more profit shifting.

2 Data

2.1 About the Country-by-Country Reporting Data

Under BEPS Action 13 "Transfer Pricing Documentation and Country-by-Country Reporting", countries implemented the Country-by-Country Report (CbCR), a new reporting tool to be filed by MNE groups with global consolidated revenues of at least €750 million. MNE groups must report CbCRs in the jurisdiction of tax residence of the Ultimate Parent Entity (UPE) of the group or, in some circumstances, the report may be filed in another country via a surrogate parent entity or through local filing.[7] Tax administrations exchange the information contained in the CbCR on an automatic basis with all of the foreign jurisdictions in which the MNE operates. As a result of this system of exchange, each tax administration has access to micro-data on both domestic and foreign MNEs that operate in the country.

Within the CbCR, MNEs report information on a set of variables, notably profits, total, related-party and unrelated-party revenues, taxes paid, number of employees and tangible assets. All variables are reported on a country by country basis, by aggregating values referred to all the entities operating in the country – the so-called "subgroup". Hence, the number of subgroups reported in each country indicates the number of MNEs having at least one entity located in the country.

The uniqueness of the CbCR dataset is threefold: first, it has extensive geographic coverage; second, it combines in one single source financial and tax information; and third, it connects the activities of entities in different jurisdictions with the MNE group to which they belong. Furthermore, being data filed with tax authorities, it can be thought of as having a high level of accuracy as tax authorities can cross-reference CbCR information with other available information to them such as tax payments, the transfer pricing master, and local file.

The CbCR data used in this study are CbCRs filed by MNEs that have their Ultimate Parent Entity in Italy and foreign MNEs with at least one subsidiary in Italy. Given that Italy is both a country with substantial manufacturing activity (the second largest in Europe in this regard)

[7] The Surrogate Parent Entity (SPE) is an entity of the MNE Group that has been appointed as a substitute for the UPE to file the CbCR in that entity's jurisdiction of tax residence, on behalf of the MNE Group. Entities act as surrogate parent entities in the case that the country of their UPE has not implemented CbCR filing. For a more detailed description of the structure of the CbCR, its comparison with existing data sources, and challenges related to the use of CbCR, see Santomartino, Bratta and Acciari (2020). A thorough analysis of the limitations of CbCR data is provided by the OECD in the disclaimer accompanying the release of CbCR statistics as well as in the relevant section of the Corporate Tax Statistics Publication.

and is an important market, the presence of MNEs is extensive and the global coverage of the dataset substantial, as described below.

In spite of these substantial advantages, the data has some limitations that are both of structural and transitory nature.

Transitory limitations include filing mistakes connected with the novelty of the data. In order to address this issue, we perform an in-depth cleaning procedure in line with that carried out by Santomartino, Bratta and Acciari (2020).[8]

The main structural limitation of CbCRs lies in the possible inclusion of intra-company dividends within the reported profits, as the first version of the OECD guidelines on CbCR did not explicitly address whether these should be included in the profit variable. Despite "profits before taxes" in financial accounts normally including dividends, the inclusion of dividends into profits could cause two types of issue. One may consist of computing a lower backward-looking Effective Average Tax Rate (EATR) as dividends are usually partially exempt[9], however this does not affect our analysis as we do not include backward-looking EATR in our estimations. The second problem may result in a possible double counting of profits (Horst and Curatolo 2020).[10] Double counting in the profit variable is an issue that is not exclusive to CbCRs since it also affects other data sources, such as Orbis-BvD and the US Bureau of Economic Analysis data (Blouin and Robinson 2020). We address this issue first by exploring its magnitude, which is achieved by matching CbCRs with tax return data, and secondly by accounting for it in the regressions.

In order to address the problem of profit overestimation in CbCR due to the inclusion of dividends, we use Tax Return data to determine the relevance of dividends in profits for Italian

[8] Common mistakes included multiple identical reports sent for the same MNE group from different reporting entities, the use of country-specific currencies instead of the Euro, and unit mistakes, e.g. values expressed in thousands, with the number of employees mistakenly multiplied by 1,000. Please also refer to OECD (2019), *Common errors made by MNEs in preparing Country-by-Country reports*.

[9] As an example, a holding company receiving dividends without other operational activities would have high profits without tax liability, as dividends are (in principle) already taxed at the level of the subsidiary that has generated the profits.

[10] Horst and Curatolo identify two additional double counting issues, referred to as stateless entities and permanent establishments, which are however broadly referred to US-based MNEs. As to stateless entities, we do not consider profits reported as "stateless", therefore no double counting should arise. In relation to the double counting of profits of permanent establishments, the OECD Action 13 Report clearly states that permanent establishment data should be reported by reference to the tax jurisdiction in which it is situated and excluded from the tax jurisdiction of residence of the business unit of which the permanent establishment is a part. Horst and Curatolo state that the IRS instruction did not accurately reflect the OECD indication in this respect, however the instructions issued by the Italian Revenue Agency are clear in this respect, thus indicating that this issue may concern mainly US-based MNEs.

and foreign MNEs in Italy. We match all entities reported in Italy as resulting from the CbCRs with the relevant tax returns and then compute the net of dividend profits.[11] We find dividends to be concentrated in a modest share of MNEs, accounting for 14% of the sample, and that they concentrate mainly in MNEs with Italian UPE. We also find that dividends account for 12% of profits reported in Italy by foreign MNEs and 38% of profits reported there by Italian MNEs. This implies that the dividend issue mainly concerns UPEs, thus suggesting that controlling for the UPE's country effect on profit allocation in the regression may tackle this issue. See Section 3.1 for additional information on methodology.

Finally, a second structural limitation regards the absence in the dataset of MNEs with a total revenue below €750 million, we address this caveat by applying a correction in the revenue estimation to account for smaller MNEs by using Orbis BvD proportions.

2.2 Comparison with Orbis BvD dataset

This section provides a detailed comparison between the CbCR dataset and that of Orbis BvD.

As Orbis BvD has been among the most used datasets for profit shifting estimation, we compare the two datasets in order to provide evidence on the improvements brought about by CbCR in this respect. To this end, we carry out a comparative analysis of CbCR and Orbis BvD data in terms of extensive and intensive coverage. From the first perspective, we compare how countries and country groups are represented in the two datasets in terms of total amount of profit and revenue. This enables us to compare the geographical coverage of the two datasets at the aggregated level. From the second perspective - intensive coverage - we compare MNEs; therefore, we explore whether the same MNEs are depicted in a different way in the two datasets. This second aspect is particularly relevant when carrying out a profit shifting analysis at micro-level, as observing partial profit distributions among countries within the MNEs may lead to different profit shifting estimations.

As to the extensive coverage analysis, in order to better align the two datasets, we compare CbCR data with Orbis BvD data. Thus, we select from Orbis BvD the same universe of firms included in the CbCR dataset, so referring to all MNEs with a total revenue of at least €750 million with at least one subsidiary in Italy. The Orbis BvD dataset has been constructed by

[11] We are able to carry out this analysis as our dataset also contains the list of names and tax codes of all entities included in each subgroup. In the case of missing information on tax codes, we use Orbis BvD to obtain the relevant tax code by means of the entity name. Next, we collect the tax returns of these entities and aggregate dividends at country level for each MNE in order to make the data comparable with CbCR.

using Italian tax returns to identify Italian subsidiaries that are part of an MNE, either domestic or foreign; hence, we reconstruct the MNE structure using Orbis ownership information.[12] We then compare the geographical distribution of activities. One of the most important limitations of using Orbis BvD data lies in the low geographical coverage of specific countries and firms of specific nationalities. This refers to an under-representation of US MNEs, of affiliates of non US-MNEs located in the United States, and the low coverage of affiliates of MNEs operating in low tax and investment hub countries.

Figure 1 reports pre-tax profits in CbCR and Orbis BvD across country groups classified by income levels.[13] Data are reasonably comparable as we consider the same variable, i.e. profit before tax in both datasets. Table 20 in the Appendix lists countries by their income group classification. The data refers to the location of subsidiaries. The separate representation of the United States from its income level group is intended to highlight the extent of the under-representation of MNEs in the US in the Orbis BvD dataset.

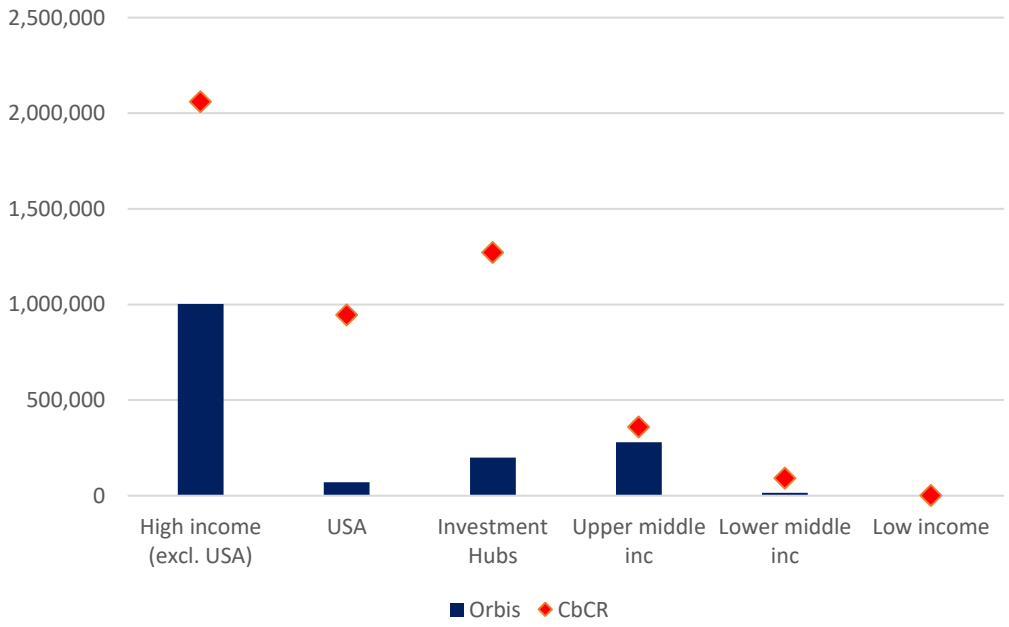

Figure 1. Profit before tax by income groups in Orbis and CbCR (€ million)

Source: Authors' calculations based on CbCR data for fiscal year 2017 and Orbis BvD for 2016. Both the data refer to MNEs with total revenue above €750 million reporting at least one subsidiary in Italy.
Note: Income group classification follows the World Bank classification. We define Investment Hubs as jurisdictions with inward FDI stock over GDP above 150%, in line with the OECD approach (OECD 2020).

[12] Data refers to 2016 due to data availability issues, however we do not expect that a different reference year would change relevantly the overall distribution and coverage of the dataset.
[13] Following OECD (2020), countries included in the Investment Hubs category are the British Virgin Islands, Cayman Islands, Cyprus, Malta, Hong Kong, Singapore, Liberia, Ireland, Luxembourg, Mozambique, Anguilla, the Netherlands, Switzerland, the Bahamas, Congo, Seychelles, Saint Vincent and the Grenadines, Saint Kitts and Nevis, New Caledonia, Mongolia, Somalia, Guernsey, and Jersey.

Profits reported in the United States in Orbis BvD account for around €70 billion, a value that clearly shows the under-representation of MNEs in US in the Orbis BvD dataset, especially if compared with profits reported in the CbCR that are equal to €946 billion. Additionally, by reporting €1.3 trillion of profits in the investment hubs, CbCR provides better coverage of these countries. By contrast, Orbis BvD, which reports a total of €199 billion, does not seem to be a suitable dataset for analysing investment hubs. Profits reported in the CbCR dataset are also higher than in the Orbis BvD data for the other income groups, indicating an overall broader coverage of CbCR data with respect to Orbis BvD data, although the coverage issues seem to be less egregious for these categories. The results are consistent even when looking at other variables such as total revenue. It is worth noting that in this case CbCR also outperforms Orbis BvD in terms of data coverage.

Figure 2 presents the shares of the two datasets for different income groups in terms of the percentage of overall profits reported. Profits reported in the US account for 20 per cent of world profits in the CbCR dataset, whereas they only account for 4% of global profits in the Orbis BvD dataset. Investment hubs account for 27% of total profits in the CbCR dataset, while the share is lower – only 13% – in Orbis BvD.

Similar conclusions can be drawn by analysing the comparison between both datasets when examining the distribution of profits and revenues by income groups of the Ultimate Parent Entity (UPE). In Orbis BvD, the profits and revenues of MNEs based in the US account respectively for 18% and 15% of the world total, whereas they account respectively for 30% and 35% of the world total in the CbCR.

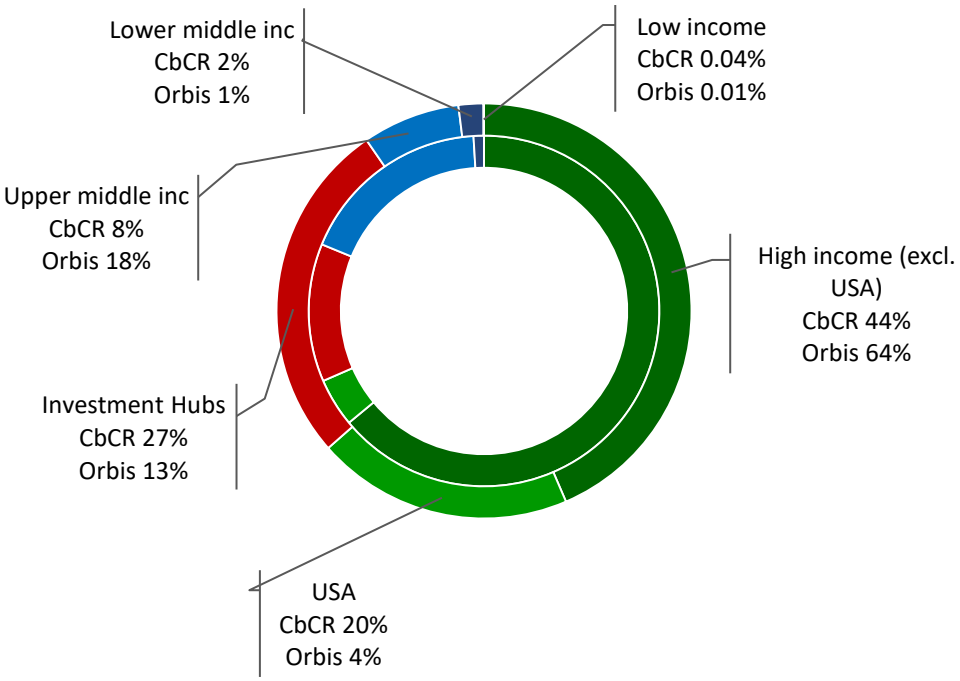

Figure 2. Profit distribution by income groups in Orbis and CbCR (% share over total; Outer circle CbCR, Inner circle Orbis)

Source: Authors' calculations based on CbCR data for the fiscal year 2017 and Orbis BvD for 2016. Both sets of data refer to MNEs with total revenue above €750 million reporting at least one subsidiary in Italy.
Note: Income group classification follows the World Bank classification. We define Investment Hubs as the jurisdictions with inward FDI stock over GDP above 150%, in line with the OECD approach (OECD 2020).

As to the intensive coverage analysis, since CBCR is compiled once for each MNE and contains information on the activities carried out worldwide by any subsidiary of that MNE, it is the best dataset available to describe MNE structure from an MNE perspective.
Hence, we analyse the capability of Orbis BvD to describe the complete MNE structure in a way that is consistent with the actual structure observed in CbCR.
We merge the two datasets, associating the identification codes of the reporting entity in the CbCR with that reported in the Orbis BvD dataset. Next, we explore MNE groups that are observable in both CbCR and Orbis BvD (1,459 MNEs) in order to be able to directly compare the representativeness of the two datasets with respect to the same MNEs.

The diagram reported in Figure 3 shows the possible outcomes of this exercise.

Let us assume that we observe MNE XY in the CbCR dataset; we then know that it is present in Country A and Country B and we have information on the level of activities (e.g. profits, revenues) carried out in each of these two countries. Next, we observe the information reported in Orbis BvD for the same MNE group XY and check whether Country A and

Country B are both present in the dataset and if information is available for each of these two countries. Focussing on the availability of information, the comparison can lead to three cases: i) both countries are present in both datasets and quantitative information on the activities carried out is reported; ii) the countries are present in both datasets but Orbis BvD does not report any information on the activities carried out there[14]; iii) one or more countries are missing in the Orbis BvD dataset.

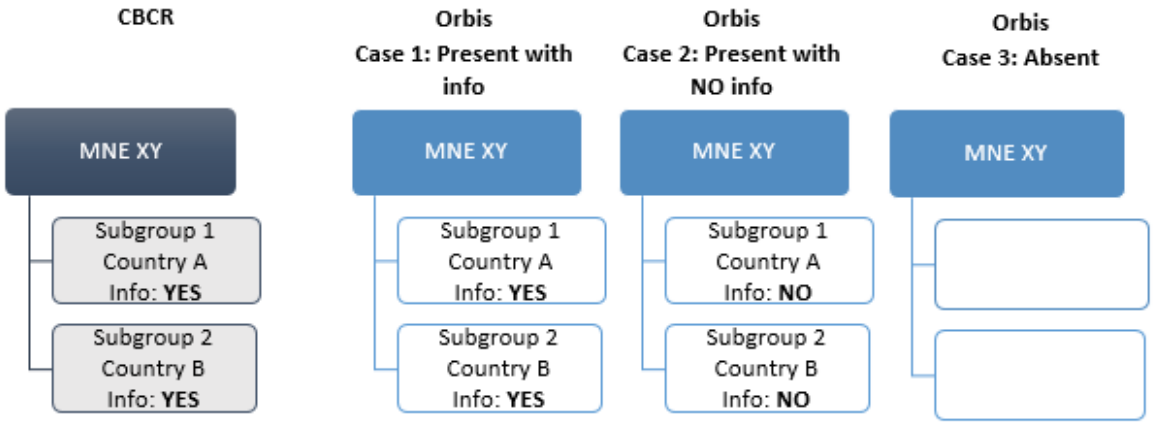

Figure 3. Comparison of same MNE in CbCR and Orbis BvD

We find that the share of subgroups with missing information in Orbis BvD (subgroups in Case 2 + Case 3 in the diagram) over the total number of subgroups observed in CbCR is equal to 63 per cent. This implies that 63% of the subgroups present in the CbCRs are missing in Orbis BvD. If we decline the analysis by geography, we observe that the share of missing information is higher for non-European countries (83%) with respect to European countries (40%), and is particularly relevant for Africa (93%) and the Americas (92%). If we look at the income level of countries with missing information, we observe the highest shares in low income and lower middle income jurisdictions (respectively 99% and 83%), followed by upper middle income (78%), investment hubs (61%), and high income (53%)[15].

Next, we can look beyond the share of missing information and assess how important the country is in terms of MNE presence. In fact, missing 50 per cent of observations in Orbis for a country where only 2 MNEs are present is less dramatic than missing 50 per cent of observations for a country where 1,000 MNEs are present.

[14] We define as missing information the observation not reporting at the same time any information on profits-loss before taxes, ebit, tangible and intangible assets, number of employees, operating revenue, and sales.
[15] We also compare profits in CbCR and Orbis BvD for each country for which information is available in both datasets (Case 1 in the diagram). We find that profits in CbCR are higher by 64% than those reported in Orbis. Hence, even for the same geographical coverage, CbCRs is more informative.

Figure 4 represents the first 20 countries for which missing information is most relevant if we consider not only the share of missing information, but also the number of MNEs in the country. Countries are ranked according to their share of missing observations weighted for the country's importance in terms of the number of MNEs present there, relative to the average.

We anticipate that our results regarding profit-shifting estimation show that 8 of these countries are among those experiencing the highest estimated losses or gains from profit shifting.[16]

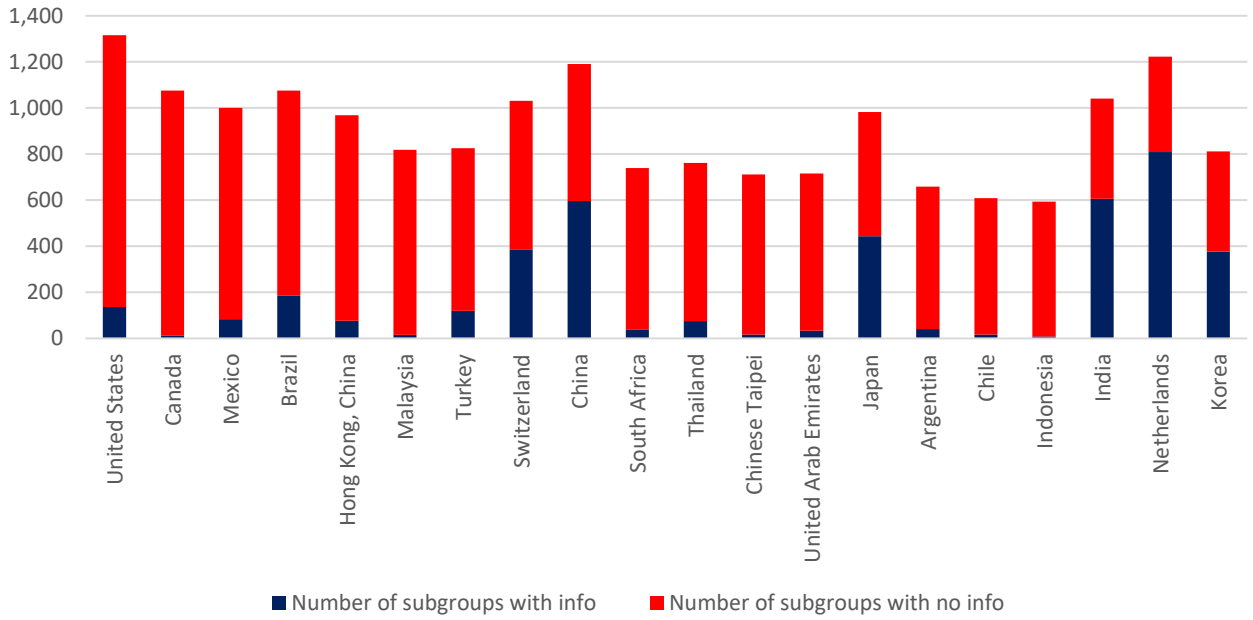

Figure 4. Missing information in Orbis vis-à-vis CbCR for the same MNEs

Note: Countries are ranked according to their share of missing observations weighted for the country's importance in terms of number of MNEs present in the country relative to the average. The average number of MNEs present in each country is 245, therefore a country with a total number of MNEs above 245 will be ranked higher compared to a country having the same share of missing observations but with a total number of MNEs lower than 245.

Within our dataset, 15 jurisdictions report a 0 per cent CIT rate, if we turn to the percentage of missing information for these countries, we find that they have among the highest share of missing information in Orbis BvD ranging from 95 per cent to 100 per cent. Hence, our analysis suggests that the lack of data is not random and is associated with the specific country's characteristics (such as the low CIT rate or specific geographical area), thus estimating profit shifting using Orbis BvD will deliver biased results.

[16] Results on profit shifting by jurisdiction are shown in Table 19.

While until now we focused on the country location of subgroups being under-represented in Orbis BvD, the uniqueness of our CbCR dataset also allows us to assess which MNE nationality is most affected by the lack of information in Orbis BvD.

If we consider the share of missing observations by jurisdiction of the UPE, we find that the highest share is found for MNEs based in Chinese Taipei and Jersey (100% of observations missing in BvD). However, in our sample, MNEs based in these two countries only account for 1 per cent of total MNEs.

If we also account for the importance of the country of the UPE in terms of share of MNEs having their UPE therein, we find that missing information in Orbis BvD is a particularly significant issue for the countries listed in Table 1.

We observe that the nationality affected the most by the missing information in Orbis BvD is the United States. MNEs with their UPE in the United States number 420 (representing 29% of total MNEs in the sample used for comparison) and the average share of missing information is 61 per cent.

Table 1. Main countries of UPEs with missing information in Orbis.

Country of UPE	Number of MNEs	Average share of missing information
United States	420	61%
Germany	161	62%
Japan	161	56%
France	115	57%
Italy	109	54%
United Kingdom	89	64%
Switzerland	57	62%
Luxembourg	38	74%
Spain	37	56%
Netherlands	34	53%
Total MNEs	1,459	61%

Note: Countries are ranked according to their share of missing observations weighted for the share of MNEs with their UPE in the country over the total number of MNEs in the sample (1,459). Therefore, a country representing a higher share of total MNEs will be ranked higher compared to another with the same share of missing observations, but representing a lower share of total MNEs.

Overall, the analysis provided in this section shows that the CbCR dataset provides a better coverage of MNE activities; by covering some country groups that were previously under-represented, it is among the best datasets to use in an analysis of multinational activity worldwide and to estimate profit shifting[17]. This comparison also shows that the availability of this new source of data for economic analysis is a crucial achievement with respect to the recommendations included in the Action 11 "Measuring and monitoring BEPS" final report of the OECD/G20 BEPS project (OECD 2015a). [18]

[17] Apart from its broader geographical coverage, CbCR performs better in reporting profits.
[18] CbCR is also better with respect to Orbis BvD when analysing taxation variables, as Orbis BvD based on accounting data. See Blouin and Robinson (2020) for a detailed analysis on the double counting issue associated with using Orbis BvD and the benefits of using CbCR data.

2.3 Data description and Statistics

This section reports some of the main statistics on the variables used in our econometric analysis.

For the purpose of our analysis, we focus on firms with positive profits. This is an immediate consequence of using the log-level methodology, because profits allocated in a jurisdiction are estimated using their logarithm value. The methodology will be examined in detail in Section 3.

The descriptive statistics refer to the sample used in the econometric analysis and thus we drop observations for which we either do not know the affiliate's number of employees, tangible assets, and unrelated party revenues of an MNE in a given country or if the respective value is zero. We therefore end up with a dataset composed of 46,563 observations, where each observation contains the financial information of an MNE in a jurisdiction.

The observations refer to 2,262 MNEs located in 221 tax jurisdictions. Note that as CbCRs is filed for tax purposes, information is reported by tax jurisdiction. For simplicity of exposition, throughout the paper we use the term *country* and *jurisdictions* indifferently. If we group countries by their geographical area and count the number of MNEs being present with at least one subsidiary in the area, we observe that 2,209 MNEs have at least one subsidiary in Europe, 1,933 have at least one subsidiary in Asia and Oceania, 1,866 in the Americas, and 962 MNEs in Africa.

In terms of the geographical area of the Ultimate Parent Entity, 1,193 are European MNEs, 750 are from the Americas (i.e. MNEs with their UPE in the American continent), 307 have a UPE in Asia and Oceania, and 12 are African. Table 2 reports some descriptive statistics of the data. Additional information on UPE characteristics (i.e. sector and income group of the UPE's country) is reported in the Appendix.

Table 2. Descriptive Statistics by geographic area of subsidiaries

		Geographic Area of subsidiaries			
		Europe	Americas	Asia & Oceania	Africa
Positive Profits (€ millions)	Average	101	172	79	21
	Total	2,289,160	1,320,656	1,072,624	51,255
Unrelated Parties Revenue (€ millions)	Average	389	1,006	460	102
	Total	8,857,949	7,746,768	6,270,045	254,661
Total Revenues (€ millions)	Average	666	1,430	692	145
	Total	15,152,153	11,009,032	9,425,283	359,788
Tangible Assets (€ millions)	Average	203	467	201	102
	Total	4,627,320	3,592,655	2,731,352	252,665
Employees	Average	977	2,352	1,440	585
	Total	22,224,947	18,100,251	19,609,449	1,455,546
Profits/unrelated party revenues (median*)		8%	10%	11%	14%
Profits/Tangible Assets (median*)		51%	42%	59%	57%
Profits/Employees (€ median*)		21,428	21,724	21,332	16,970

Source: Authors' calculations based on CbCR data for the fiscal year 2017, coincides with the sample used in the econometric analysis.
*Note: Profits, revenues and assets are in millions of Euro. Positive profits refer to strictly greater than 0 pre-tax profits in the jurisdictions. The values are assigned to an area according to the geographic area of the jurisdiction in which they are reported. * For reasons of confidentiality, Medians are computed as the average value of the variable among the observations between the 45th and 55th percentile.*

Europe reports the highest values of all variables, while the American continent reveals the highest averages. This means that while we observe more European MNEs in our dataset with the result that the total amount of variables is higher, on average, MNEs subsidiaries located in the Americas are larger in terms of average profits, revenues, tangible assets, and number of employees.

The median share of profits over unrelated party revenues does not appear to vary significantly among geographical areas, however Africa presents the highest share (14%), whereas Europe accounts for the lowest share (8%). When analysing the share of profits over assets, Asia and Oceania and Africa report the highest median shares (59% and 57% respectively), whereas the Americas report the lowest (42%). As to the amount of profits per employee, this also does not vary significantly among geographical areas, with the exception of the low value reported in Africa.

Interestingly, when looking at the distribution of profits, revenues and employees according to the geographic area of the UPE, the MNEs with the highest average values are those from Asia and Oceania (Table 3). The heterogeneity in MNE nationality we observe in these descriptive statistics will be analysed in more detail in Section 3.2.2 in which we will assess whether nationality impacts the profit shifting activity carried out by MNEs.

Table 3. Descriptive statistics by geographic area of the Ultimate Parent Entity (UPE)

		Geographic Area of the UPE			
		Europe	Americas	Asia & Oceania	Africa
Positive Profits (€ millions)	Average	109	86	112	59
	Total	2,702,032	1,305,465	714,159	12,039
Unrelated Parties Revenue (€ millions)	Average	451	477	727	409
	Total	11,189,441	7,227,440	4,629,478	83,063
Total Revenues (€ millions)	Average	714	721	1,126	550
	Total	17,731,232	10,932,407	7,170,868	111,749
Tangible Assets (€ millions)	Average	227	225	327	368
	Total	5,640,898	3,406,503	2,081,864	74,727
Employees	Average	1,179	1,271	1,980	1,190
	Total	29,267,105	19,270,080	12,611,425	241,583

Source: Authors' calculations based on CbCR data for the fiscal year 2017, coincides with the sample used in the econometric analysis.
Note: Profits, Revenues and Assets are in millions of Euro. Positive profits refer to strictly greater than 0 pre-tax profits in the jurisdictions. The values are assigned to an area according to the geographic area of the jurisdiction of the UPE.

Figure 5 reports average profits by income group, comparing it with unrelated party revenues and tangible assets. We use the income group classification by the World Bank and define, in line with the OECD approach (OECD 2020), investment hubs as countries with inward FDI stock over GDP above 150%.[19]

[19] As Guernsey, Jersey, and the Cook Islands are not present in the World Bank dataset, we follow for them the classification used by OECD (OECD 2020a). For a very small remaining set of countries it was not possible to associate an income group due to the lack of data in both the World Bank dataset and OECD publication.

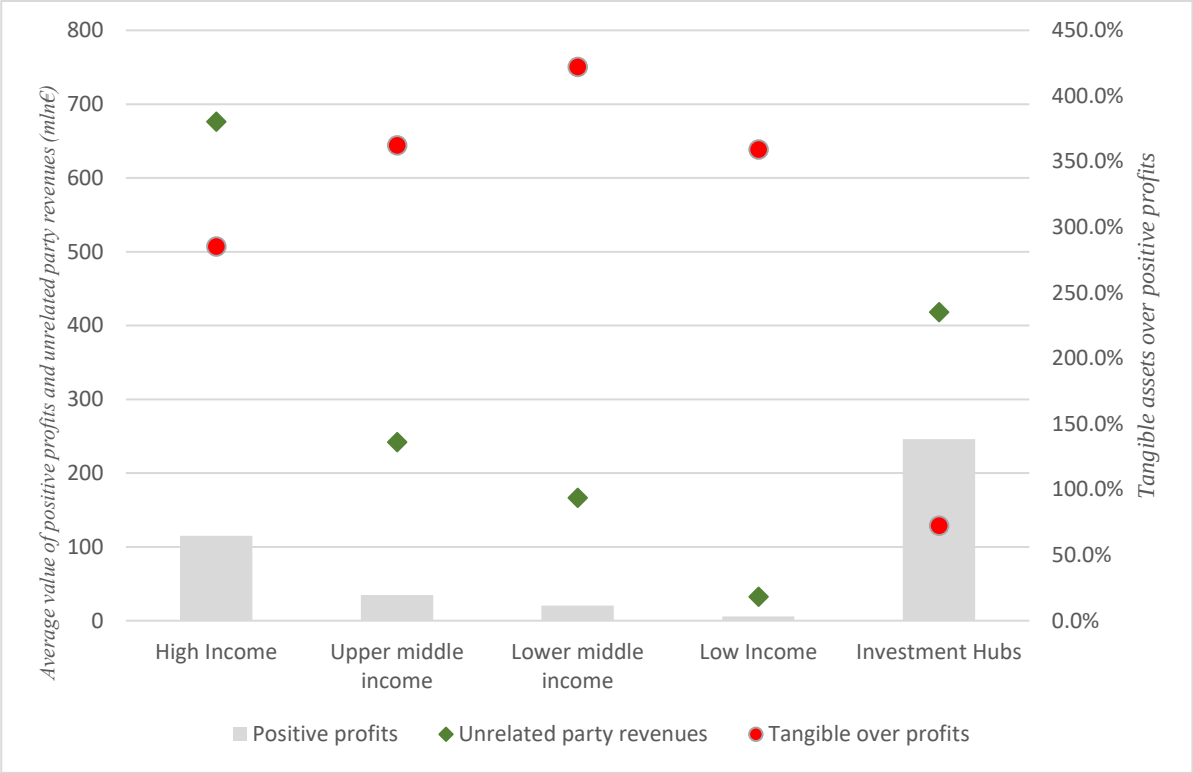

Figure 5. Distribution of profit, revenue, and tangible by income group

Note: The graph reports the average value of positive profits and unrelated party revenues on the left axis. The value are reported in million euros. On the right axis, the ratio of the value of tangible assets over positive profits are expressed in percentage points. The income group classification used is provided by the World Bank. Investment hubs are defined as jurisdictions with inward FDI stock over GDP above 150%, in line with the OECD approach (OECD 2020).

While average profits decline steadily from high to low income countries, investment hubs report extremely high values of average profits. As high profits allocated in a jurisdiction may be correlated with high values of tangible assets and therefore high remuneration, we compare profit allocation with the ratio of tangible assets over profit.[20] Figure 5 shows that the elevated presence of profits in investment hubs does not seem to correlate with a high level of tangible assets since the ratio of tangibles over profits is the lowest in investment hubs. This comparison seems to suggest that tangible assets do not explain the high profits in this group of countries.

Next, we investigate whether the high value may be correlated with extremely high revenues. The green diamonds in Figure 5 represent the average unrelated party revenues in each income group. Revenues appear higher in investment hubs than in low and middle-income countries; however, they are lower than revenues reported in high income countries. Despite the fact that

[20] We use the share of tangible asset over profits instead of the commonly used ratio of profits over tangible as many subsidiaries do not report tangible assets in investment hubs. By putting profits as the denominator we can include observations that also referred to subgroups in investment hubs with zero tangible assets.

higher revenues can be found in investment hubs, the difference in profits between investment hubs and high income countries does not seem to be explained by the difference in revenue. As a robustness check we also examine the number of employees and obtain similar conclusions as they are unable to explain the high profits in investment hubs.

We further analyse the allocation of profits and real activities by income group and MNE nationality together.

The first three columns in Table 4 display profit allocation by income group for MNEs from Europe, the Americas, and Asia and Oceania. MNEs of every nationality report the highest percentage of profits in *high income* countries, probably due to the presence of the relevant markets there. However, if we observe the residual profits reported in these countries, we observe MNEs reporting among the lowest residual profits both if proxied by profits over unrelated revenue (columns 4-6) or by profits over tangible assets (columns 7-9). Activities carried out in *investment hubs* are instead associated with the highest shares of residual profits: while the median value of profits over tangible assets in high income countries is between 33% and 65%, the same share in investment hubs is between 67% and 136%. Moreover, in terms of the median share of profits per employee (columns 10-13), investment hubs are associated with more than double the profits reported in high income countries.

In a comparison of MNEs, European MNEs report the highest percentage of profit being allocated in investment hubs (34%), however those from the Americas report the highest residual profits according to all of the residual profit proxies used. Asian and Oceanian MNEs report lower residual profits than their counterparts in Europe and the Americas in almost all income groups; however they seem to be more present, in terms of profit allocation, in lower and upper middle income countries. Despite MNEs from Asia and Oceania reporting lower residual profits than the Americas and Europe, this difference is lowest for high income and upper middle income countries.

Table 4. Profit and residual profit allocation by income group and MNE nationality

MNE's Nationality / Subgroups' income group	Profit allocation (as % of total)			Profit/Unrelated revenue (median*)			Profit/Tangible Assets (median*)			Profit/Employees (median*)		
	Europe	Americas	Asia & Oceania	Europe	Americas	Asia & Oceania	Europe	Americas	Asia & Oceania	Europe	Americas	Asia & Oceania
High income	58%	72%	70%	8%	10%	7%	45%	65%	33%	21,377	25,761	22,870
Investment Hubs	34%	18%	15%	13%	17%	10%	112%	136%	67%	45,479	72,671	48,160
Low income	0%	0%	0%	13%	16%	17%	68%	78%	37%	13,110	18,925	16,504
Lower middle income	2%	2%	3%	13%	18%	12%	55%	71%	32%	11,134	13,280	8,975
Upper middle income	6%	7%	11%	10%	13%	10%	49%	54%	30%	14,473	18,366	14,742

Note: We do not report the data referring to African MNEs as the number of observations does not allow for reporting of variables by income group. Values of the variables profits/employees are expressed in Euro.
**For reasons of confidentiality, the median values are computed as averages of values contained between the 45th and 55th percentile.*

Carrying out profit shifting analysis requires having information on CIT rates in the various countries. We therefore collect information on statutory CIT rates for all 221 jurisdictions in our sample using the OECD corporate tax statistics dataset, the KMPG CIT rates table, and gathering information on national sources for the few missing countries.

Among the 46,563 subgroups, 755 refer to countries reporting a zero-CIT rate, 2,200 report a CIT rate between 0 and 12.5%, while 43,608 subgroups refer to countries with a CIT rate above 12.5%. All MNEs report higher residual profits in countries with a zero CIT rate (Table 5). It is interesting to note that while MNEs from Europe and the Americas report a very skewed residual profit distribution among CIT rates, presenting shares of residual profits in zero-rate countries that are double those reported in the other countries, Asian MNEs are characterised by a more homogeneous distribution of residual profits. We investigate this difference in residual profit distribution further in Section 4.3.

Table 5. Residual profits by CIT rate and MNE's nationality

MNE Nationality / Subgroups' CIT Rate	Profits/Tangible Assets (median*)		
	European	Asian	Americas
$CIT = 0$	168%	46%	163%
$0 < CIT \leq 12.5\%$	61%	44%	91%
$CIT > 12.5\%$	50%	34%	66%

Note: We do not report data referring to the African MNEs as the number of observations does not allow for reporting the variables by CIT rate. Similar results can be obtained using different proxies for residual profits.
**For confidentiality, the median values are computed as averages of values contained between the 45th and 55th percentile.*

Further, we collect information on the corporate forward looking Effective Average Tax Rate (EATR)[21] by combining the rates computed by the OECD and reported in the Corporate Tax Statistics Dataset with the Oxford University Centre for Business Taxation dataset (whenever the OECD data does not report the EATR for a specific country). In the absence of data on EATR in both datasets, we approximate the EATR as follows. We impose EATR to be zero in countries with a zero CIT rate; for the remaining set of countries for which we do not possess information on EATR, we impose the effective rate to be equal to the difference between the statutory tax rate of the country and the median distance between statutory and effective tax rates observed in the dataset.[22] Table 23 reports the statutory and effective CIT rates for every jurisdiction in our sample.

Finally, we combine our data with Orbis BvD to obtain the sector of the MNE, by doing so we merge the reporting entity information within the Orbis BvD dataset and assume the reporting entity's sector to be a good representation of the MNE's activity.

3 Methodology

We commence our analysis by examining different proxies for estimating tax treatment effects on profit allocation. In the baseline scenario, described in Section 3.1, we alternatively use statutory and forward-looking effective corporate income tax rates as independent variables. Next, we introduce rate differentials in lieu of the levels as estimators for profit shifting activities.

Once we estimate the linear coefficients in Section 3.2, we relax the linearity assumption and estimate the non-linear effects of taxation on profit shifting. We further analyse the role of MNE nationality and size on profit shifting activities, investigating their non-linear effects.

3.1 Baseline Scenario

We start by estimating the effect of an increase in corporate income tax rate over profits allocated in the country. We provide estimates both by applying the statutory corporate income tax rate (CIT) and the forward looking effective average tax rate (EATR). Thus, the first specification is described in the following equation:

[21] Built on the theoretical model developed by Devereux and Griffith (1999, 2003).
[22] Among the 221 tax jurisdictions in our dataset, we have the EATR information for 78 countries. Among the remaining 143 jurisdictions for which the EATR is missing, 9 report zero statutory CIT rate and therefore we can reasonably assume their EATR to be equal to zero. Hence, we approximate the EATR for 134 countries.

$$ln(\pi_{c,m}) = \beta_0 + \delta_1 ln(K_{c,m}) + \delta_2 ln(L_{c,m}) + \delta_3 ln(R_{c,m}) + \beta_1(\tau_c) + \boldsymbol{X}_c + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (1)$$

where $\pi_{c,m}$ is profit allocated by the MNE m in country c; $K_{c,m}$, $L_{c,m}$ and $R_{c,m}$ are respectively the value of tangible assets, the number of employees, and the value of unrelated party revenues in the country. These control for the economic activity carried out by the MNE in that jurisdiction. We control for country-specific characteristics through $\boldsymbol{X}_c$ using the logarithm of GDP, population, and its square. We provide estimates controlling also for MNE-specific characteristics through the inclusion of MNE fixed effects (ϕ_m).[23] As MNEs allocate higher profits to the country in which their UPE is located, we control for this by including a dummy ($d_{UPE_{c,m}}$), being one for each MNE m only for profits located in country c if c is the country of the UPE for m. As one of the limitations of using CbCRs consists of the possible inclusion of intra-company dividends within profits, the UPE dummy also serves the purpose of controlling for this as intra-company dividends are allocated mainly to the country of the UPE, as mentioned in Section 2.1.

The relationship between profit allocation and the CIT rate in country c is modelled as τ_c, thus our coefficient of interest is β_1 as it represents the semi-elasticity of changes in tax rates on profit allocation. We estimate β_1 both using statutory corporate income tax rate and the forward-looking average effective tax rate.

Next, we depart from the use of the statutory CIT rate and estimate the effect of the difference between the CIT rate and the average CIT rate of the MNE group. This difference represents the tax saving associated with the reallocation of profits from one jurisdiction to another within the same group. It includes both the rate applicable to the profits allocated in the country and the "outside option" tax rate, i.e. a proxy of the tax rate to which profits would have been taxed if they were not allocated in the country. Our approach therefore is more in line with the theoretical model introduced by Huizinga and Leaven (2008) and later used frequently in the literature on profit shifting.

Following Johansson et al. (2017), we compute the difference between the corporate income tax rate in a country and the unweighted average of CIT rates applied to all other subsidiaries in the MNE group. The baseline equation can be written as follows:

[23] As a robustness check, we also carry out the analysis without the MNE fixed effect and by using MNE controls; our results are robust to this specification. The MNE control consist of each group's total unrelated party revenues, tangible assets (both in logarithm), total number of employees, dummy variables for the MNE nationality, and a dummy variable for the MNE sector (4 digits).

$$ln(\pi_{c,m}) = \beta_0 + \delta_1\, ln(K_{c,m}) + \delta_2\, ln(L_{c,m}) + \delta_3\, ln(R_{c,m}) + \beta_1(\tau_c - \overline{\tau}_{m,-c}) + \boldsymbol{X}_c + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (2)$$

Taxation affects profit allocation in country c by firm m ($\pi_{c,m}$) via the difference between the CIT rate in country c (τ_c) and the unweighted average of the CIT rates applied to the subsidiaries of the same group in all countries apart from c ($\overline{\tau}_{m,-c}$). As before, we control for country characteristics using the control variables described above and for MNE-specific characteristics using MNE fixed effects.

We use both statutory and effective tax rates to estimate the effect of tax rate differential on profit allocation.

3.2 Role of non-linearity

3.2.1 Non-linear effect of tax rates on profit shifting

The majority of the literature estimates the linear effect of taxation on profit shifting, thus assuming that a change in one percentage point in the tax rate (or in tax differential) gives rise to the same percentage change in reported profits independently from the taxation level.

As discussed above, however, previous research by DLM found strong evidence of non-linearity in elasticity, finding that an increase in the tax rate has a much larger negative effect on reported profits in countries with substantially lower tax rates.

We first verify the presence of non-linearities by introducing a tax-haven dummy within our linear specification, following DLM and more recently Fuest et al. (2021). [24]

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1(\tau_c - \overline{\tau}_{m,-c}) + \beta_2 TaxHaven_c + \boldsymbol{X}_c + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (3)$$

As the definition of tax haven is not unambiguous and since it entails a certain degree of subjectivity in the definition, we investigate if this non-linearity may be connected to the presence of zero CIT rates in these countries.

We therefore regress profits allocated in a country using both the CIT rate variable and a dummy variable, being one if the country has a zero CIT rate and zero otherwise. We do so to investigate if observing a zero rate provides any additional explicative power on profit allocation than that provided by the linear effect of the CIT rate variable.

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1 \tau_c + \beta_2 D_{zero_c} + \boldsymbol{X}_c + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (4)$$

As all estimations seem to point towards non-linearity in the effects of the tax rates on profit shifting, we further investigate this relationship.

Profits located in low tax jurisdictions may be considered *paper profits* located there only for tax saving reasons, they may tend to be more elastic to changes in tax rate than profits located in higher tax countries where profits may be linked to real activities.

[24] We use the classification of tax havens based on Fuest et al. (2021), the IMF (2016), and Menkhoff and Miethe (2019). Countries considered tax havens are Antigua and Barbuda, Bahamas, Bahrain, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Cook Islands, Curacao, Cyprus, Gibraltar, Grenada, Guernsey, Hong Kong, Ireland, Isle of Man, Jersey, Liberia, Liechtenstein, Luxembourg, Malta, Montserrat, Netherlands, Panama, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Singapore, Sint Maarten, Switzerland, Turks and Caicos Islands, and Vanuatu.

In order to assess if the above intuition is correct, in line with DLM, we start by examining the elasticity of profits with respect to statutory corporate income tax by including the square of CIT rate in the equation. We further develop this analysis and move beyond DLM in different directions. Firstly, we provide estimates of the elasticity of profit allocation with respect to CIT rate differentials and not just CIT rates as discussed above. Secondly, we provide evidence that non-linear relationships are present when analysing MNEs of multiple nationalities, in contrast to DLM whose sample was restricted only to US MNEs. Thirdly, we estimate higher order non-linearities than accounted for in their paper.

We therefore regress equation (5); $\mathrm{T_{c,m}}$ is the taxation independent variable either in the form of the statutory CIT rate or forward-looking EATR or in the form of the difference of each with respect to the MNE's average (computed by excluding the country under analysis).

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1 \mathrm{T_{c,m}} + \beta_2 \mathrm{T_{c,m}^2} + \boldsymbol{X}_m + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (5)$$

Next, we further examine how MNEs react to changes in CIT rates when locating profits in countries with higher than average rates. By recognising that the quadratic relation imposed by DLM produces puzzling results in countries with high enough CIT rates, suggesting these countries (such as France in 2017) would even attract more profits by increasing their tax rate, we propose and test a cubic specification. Using this specification we would expect countries with a very high CIT rate to have an incentive to decrease their rate, but at the same time we would expect the profit allocation to be less sensitive than that observed for low tax countries, as profits in countries with high tax rates are stickier.

We therefore allow for a further general formulation of the role of tax rates over profit allocation by estimating the elasticity of profit allocation with respect to the tax rate differential using equation (6).

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1 \mathrm{T_{c,m}} + \beta_2 \mathrm{T_{c,m}^2} + \beta_3 \mathrm{T_{c,m}^3} + \boldsymbol{X}_m + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (6)$$

3.2.2 Non-linear effects of UPEs nationality on profit shifting

We further explore the role of non-linearity on an additional level: the characteristics of the Ultimate Parent Entity.

First we investigate if the nationality of the UPE may be correlated with different levels of profit shifting.

We are the first, to the best of our knowledge, to be able to investigate this question thanks to the use of micro-level CbCR data on MNEs of different nationalities.

We therefore split the sample into three according to the geographic area of the UPE: MNEs located in i) Europe, ii) the Americas, and iii) Asia and Oceania.[25] Thus we regress the standard linear model as reported in equation (2) for each subsample and estimate the semi-elasticity for each of the three nationalities.

We further investigate this relationship by creating a dummy variable assuming the value of zero for European MNEs, one for the Americas, and two for Asia and Oceania. We therefore interact this dummy with the CIT rate differential and estimate the semi-elasticity of profit shifting for different nationalities following equation (7). Not splitting the sample into three parts, we are able to analyse this issue on a greater sample, hence controlling for bias to the estimation related with the sub-sample composition. Furthermore, by using this specification we are able to provide evidence that the differences in behaviour among MNEs with different nationalities are statistically significant.

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1(\tau_c - \overline{\tau}_{m,-c}) + \beta_2 D_{UPE_m} + \beta_3 D_{UPE_m}(\tau_c - \overline{\tau}_{m,-c}) + \boldsymbol{X}_c + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (7)$$

The coefficient of interest here is β_3 as it indicates how profits shift much more for MNEs in the Americans and Asia and Oceania with respect to their European counterparts.

We further regress profit allocation by using two dummy variables, assuming 0-1 values, for Americas and Asia and Oceania MNEs, thus focussing on the difference between their profit shifting propensity with respect to European MNEs.

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1(\tau_c - \overline{\tau}_{m,-c}) + \beta_2 D_{Am_m} + \beta_3 D_{Am_m}(\tau_c - \overline{\tau}_{m,-c}) + \beta_4 D_{As\&Oc} + \beta_5 D_{As\&Oc}(\tau_c - \overline{\tau}_{m,-c}) + \boldsymbol{X}_c + \phi_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (8)$$

Where D_{Am_m} is 1 only if the MNE m's UPE in from the Americas, and $D_{As\&Oc_m}$ is 1 only if the MNE m's UPE in from Asia or Oceania. Thus, our coefficients of interest are β_3 and β_4

[25] It is not possible to investigate the effect on MNEs with an African UPE due to the scarcity of these in the sample. MNEs located in the Americas are those whose UPE is located in the geographical region of the Americas.

reporting, respectively, the increase in profit shifting propensity of Americas and Asia and Oceania MNEs with respect to European ones.

Finally, we investigate whether the MNEs are characterised by differences in profit shifting behaviour. More specifically, as mentioned in Section 2.3, we noticed that MNEs in Europe and the Americas report much higher residual profits in zero CIT rate countries than in any other country. However, those located in Asia and Oceania reported quite a uniform distribution of residual profits among countries. Hence, we investigate the presence of non-linearity in CIT rate differentials according to MNE nationality. We therefore regress equation (5) separately for every nationality.

3.2.3 Non-linear effects of MNE size on profit shifting

Next, we investigate if the semi-elasticity of profit allocation with respect to CIT rate differential is correlated with the size of the MNE. We therefore investigate the common claim suggesting that profit shifting activities are carried out in the majority by big MNEs. Thus, we contribute to the literature investigating this issue (see Fuest at al. 2021 for the latest contributions) in two ways; first, we provide further evidence that size is indeed correlated with higher profit shifting activities. Second, we expand this analysis by providing evidence of non-linearities in the relationship between MNE size and profit shifting.

We use the total sum of unrelated party revenues of all subsidiaries of an MNE as proxy of its size. Next, we split the sample into four subgroups according to the quartile of the total revenue and regress equation (2) in each subsample.

We notice a non-linear path in semi-elasticity with respect to MNE size as the semi-elasticity appears increasing, in absolute value, at a decreasing speed for bigger MNEs. This behaviour appears coherent with the existence of fixed costs in profit shifting and thus the need for firms to reach a critical mass in order to be able to bear these fixed costs.

In order to assess if this pattern is also persistent in the full sample, we further investigate the relationship between size and profit shifting by estimating equation (9).

$$ln(\pi_{c,m}) = \beta_0 + \delta f(K_{c,m}, L_{c,m}, R_{c,m}) + \beta_1(\tau_c - \overline{\tau}_{m,-c}) + \beta_2 Size_m + \beta_3(\tau_c - \overline{\tau}_{m,-c}) * Size_m + \beta_4(\tau_c - \overline{\tau}_{m,-c}) * Size_m^2 + \boldsymbol{X}_c + \boldsymbol{Y}_m + d_{UPE_{c,m}} + \epsilon_{c,m} \quad (9)$$

We regress profit allocation by assessing the impact of MNE size (defined as the standardised total unrelated party revenue of the MNE[26]) on the semi-elasticity of the CIT rate differential over profit allocation. We regress equation (9) while controlling for countries and MNE characteristics. The coefficients of interest here are β_3 and β_4 as we expect them to be respectively negative and positive in the presence of fixed costs in profit shifting.

[26] The results are also robust when we do not standardise the total revenue. However, as the total revenue in the sample is large, we use the standardised revenue for simplicity in reporting the coefficients.

4 Results

4.1 Baseline Scenario

Table 6 reports the results from estimating equation (1), while Table 7 presents the semi-elasticity of profit allocation to changes in tax rate differences following equation (2).

We find a semi-elasticity of -0.7 and -0.68 respectively for statutory CIT rate and (statutory) CIT rate differentials. This implies that an increase of one percentage point in statutory CIT rate is correlated with a reduction in profit in the country by 0.7% and that an increase in one percentage point in the CIT rate difference corresponds to a decrease in profits by 0.68%.

Our semi-elasticity is lower than that suggested by the literature, for example Heckemeyer and Overesch (2013) find an average semi-elasticity of -0.8, Beer, De Mooij and Liu (2020) find a mean semi-elasticity of -1.5, while DLM find a linear semi-elasticity of -1.4 for US multinationals.

The difference may be due to the variation in the dataset. In principle we would expect that estimates obtained by using CbCR would deliver higher semi-elasticities as the dataset reports more information on investment-hubs and low income countries. However, as pointed out in Section 2.2, CbCRs also provide additional information for high income countries and thus enable us to observe many more subsidiaries located in those countries. Furthermore, our dataset allows us to reconstruct the complete structure of each MNE, thus we are able to take into consideration MNE-specific characteristics when estimating profit shifting of the subsidiaries.

Statutory tax rates may however overestimate the firm's tax burden as they do not include the tax measures that reduce tax liability by decreasing the tax base. Therefore, as a further extension, we use the forward-looking effective average tax rates (EATRs). By computing the corporate income tax rate of each country and taking into account tax credits, deductions and allowances, EATRs are better suited to provide a more comprehensive estimation of the overall corporate income tax burden in a country.

The semi-elasticity of profit allocation with respect to the effective tax rate and the effective tax rate differential is higher than the one we observe using the statutory tax rates. The results reported in Table 6 and

Table 7 suggest that an increase of one percentage point in EATR corresponds to a reduction of about 0.9% in profits allocated in the jurisdiction.

This higher relevance for EATR changes on profit allocation decisions may suggest that MNEs choosing to shift profits may be more willing to move profits in countries where they can also narrow their tax base, rather than considering only the statutory rate.

Table 6. Baseline linear regression using Statutory and effective CIT rates

	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$
$\boldsymbol{\tau_c^{statutory}}$	-0.700***	
	(0.0849)	
$\boldsymbol{\tau_c^{EATR}}$		-0.924***
		(0.0980)
Observations	46,563	46,563
R^2	0.788	0.788

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues, and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

Table 7. Baseline linear regression using differential tax rates

	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$
$\tau_c^{statutory} - \overline{\tau}^{statutory}{}_{m,-c}$	-0.684***	
	(0.0825)	
$\tau_c^{EATR} - \overline{\tau}^{EATR}{}_{m,-c}$		-0.905***
		(0.0955)
Observations	46,561	46,561
R^2	0.788	0.788

Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues, and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by

*including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

4.2 Non-linearity in the tax system assumption

To assess the existence of non-linearities in profit shifting behaviour related to some characteristics of the countries where profit is being shifted, the first step is to verify if profit shifting is a phenomenon concentrated in a few countries.

Tax havens have been always pointed out as responsible for rising harmful tax competition among countries. Therefore, similar to DLM and more recently Fuest et al. (2021), we investigate if profit is shifted more to a tax haven than what we would expect from the linear estimation.

Thus, we estimate equation (3); Table 8 reports the results.

Table 8. Tax haven effect on profit shifting

	$ln(\pi_{c,m})$
$\tau_c^{statutory} - \overline{\tau}^{statutory}_{m,-c}$	-0.120
	(0.0829)
$TaxHaven_c$	0.873***
	(0.0250)
Observations	46,561
R^2	0.797

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

Similar to the results reported by Fuest et al. (2021), we find that once we introduce the tax haven dummy variable, the tax rate variable -in our case, the CIT rate difference- becomes not-significant. This suggests that some characteristics of a tax haven may be more relevant for profit shifting than just the linear CIT rate differential.

As the definition of a tax haven is not unique and requires a certain degree of subjectivity in the choice of the relevant variables to be considered determinant in the definition of the category, we focus on the role of the CIT rate in this non-linearity.

More specifically, we analyse if observing a zero CIT rate would provide any additional information to profit shifting behaviour than just that provided by the assumption of linearity in the CIT rate. If the presence of a zero rate was not relevant in explaining profit shifting, by including in the regression both the CIT rate and the zero CIT rate dummy, we would expect the dummy variable not to be significant. We would instead expect both variables to be significant if the presence of the zero rate has its own explicative power beyond that of the linear CIT rate.

Table 9 reports the results of estimating equation (4). We find that the zero rate dummy variable is significant at 1%, suggesting that part of the effect of the tax system on profit allocation goes beyond the mere linear relation and is approximated by the dummy variable for zero CIT rate countries.

Table 9. Zero CIT rate dummy variable impact on profit allocation

	$ln(\pi_{c,m})$
D_{zero_c}	0.466***
	(0.0644)
$\tau_c^{statutory}$	-0.335***
	(0.0885)
Observations	46,563
R^2	0.784

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues, and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively*.

Thus, we investigate the non-linearity assumption as discussed in Section 3.2. Table 10 reports the estimated coefficients from estimating equation (5).

The results provide evidence for the existence of non-linearity in the allocation of profits. The quadratic terms are always statistically significant at the 1% level in all four specifications. Additionally, we compute the Wald test for combined significance of our tax-related independent variables in all of the non-linear specifications. The test suggests a strong combined significance of the variables.

Columns (1) and (5) in Table 10 provide semi-elasticities for changes in the level of CIT rates, either by using a statutory or effective tax rate. Columns (2) and (4), respectively, show the

semi-elasticities computed for changes in differential CIT rates by using statutory and effective tax rates.

Table 10. Non-linear quadratic estimation

	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$	(5) $ln(\pi_{c,m})$	(4) $ln(\pi_{c,m})$
τ_c	-1.889***			
	(0.302)			
τ_c^2	2.323***			
	(0.530)			
$\tau_c - \overline{\tau}_{m,-c}$		-0.745***		
		(0.0862)		
$(\tau_c - \overline{\tau}_{m,-c})^2$		2.401***		
		(0.516)		
τ_c^{EATR}			-2.443***	
			(0.340)	
$(\tau_c^{EATR})^2$			3.311***	
			(0.671)	
$\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c}$				-0.928***
				(0.0964)
$(\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c})^2$				3.258***
				(0.654)
Observations	46,563	46,561	46,563	46,561
R^2	0.788	0.788	0.788	0.788

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

In order to point out the difference in results between linear and non-linear quadratic identifications, it is useful to compare the semi-elasticities in different scenarios.

Assuming a linear relation between taxation and profit allocation, an increase by one percentage point of corporate tax rate from 0% to 1% implies a decrease in reported profit by 0.7% or 1.03%, if we consider, respectively, a change in the statutory or effective tax rate. An increase in one percentage point from 29% to 30% would deliver the same percentage decrease in profits.

If we allow taxation to affect profit allocation in a non-linear quadratic way, we instead observe a far greater effect of taxation when the tax rate is low and a lower effect when it is high. An increase in one percentage point from 0% to 1% decreases profit by 1.88% or 2.44%, respectively, if we consider statutory or effective tax rates. A one percentage point increase in the tax rate from 29% to 30% would instead imply a reduction in profit by 0.54% or 0.52%.

The results obtained through the quadratic specification have relevant policy implications as they suggest that low tax countries have no incentive to increase their tax rate, because it would lead to a drain in tax base. Hence, it can be surmised that they are actually a prisoner of their own low tax rate. Conversely, countries with a higher CIT rate would not benefit from reducing their rate as their attractiveness would still be limited; any efforts made in tax competition among high tax countries would then be extremely inefficient.

We find that when using the quadratic estimation, a change of one percentage point induces a much larger decrease in profit than the linear formulation when CIT rates are low. That said, the linear estimation delivers greater effects than the quadratic one when the rates are high.

Our estimates point in the same direction as DLM but appear lower in magnitude. The difference may be due to three main reasons. First, there is a difference in the composition of the dataset: on the one hand they analyse only US MNEs, while we have a more diversified sample of firms of all nationalities. On the other, we cannot observe MNEs that do not have a subsidiary in Italy while these may be observed in their research[27]. Second, DLM estimate profit shifting in the years 2002 to 2012, therefore in the pre-BEPS period. As we estimate profit shifting in 2017, it is reasonable to assume anti-BEPS policies following the OECD's BEPS actions, finalised in 2015, had a partial effect in reducing profit shifting. Finally, part of the difference may be due to our data being a cross-section, thus different from the panel data used in their study.

In order to address the first source of difference, we perform our estimation on a sub-sample of firms composed only by US MNEs. Our estimates on US MNEs appear to be still lower by half than that observed in DLM, however, when comparing these results with those obtained from the full sample of MNE nationalities, we find them to have greater semi-elasticities[28], thus suggesting that MNEs with US nationality may participate in higher profit shifting. The

[27] To the extent that firms not locating any subsidiaries in Italy are correlated with higher degree of profit shifting, the composition of our sample may deliver downward biased estimation.

[28] A six percent increase on the linear estimation basis and up to thirty percent more for the lowest differential in the CIT rate by applying the quadratic specification.

difference in profit shifting by MNE nationality will be investigated in greater detail in Section 4.3.

We move beyond the DLM analysis of the quadratic effect of CIT rates and look at the effect of the difference in tax rate differential between the country rate and the average rates of the subsidiaries of the same group. Table 10, in column (2) and (4), reports the estimated coefficients using statutory tax rates and effective average tax rates, respectively.

To compare the results obtained using the differential tax rates with those obtained using just the CIT rates, we keep the average tax rate fixed and study the effects of an increase of one percentage point of CIT. The effect obtained using a quadratic identification is greater for high negative differences in CIT than what we find using the linear regression. The effect is instead smaller for small differences in CIT rates.

Table 11 presents the semi-elasticities of an increase in one percentage point in CIT rate differential. If in country *c* the tax differential is high and negative – e.g. a tax rate in country *c* equal to 0% while the average rate in other countries is 30% – an increase in the tax rate of country *c* by one percentage point will decrease profits by 2.18%.

If in country *c* the tax differential is low and positive – e.g. a tax rate in country *c* equal to 20% and an average rate in other countries of 19% – an increase in the tax rate of country c by one percentage point will decrease profits in country c by 0.69%.

Table 11. Semi-elasticities of CIT differentials using statutory rates in linear and quadratic regressions

Changes in CIT rate differential	Semi-elasticity	
	Linear	Quadratic
	$\boldsymbol{\tau_c - \overline{\tau}_{m,-c}}$	$\boldsymbol{\tau_c - \overline{\tau}_{m,-c}}$
From -30% to -29%	-0.684	-2.186
From 1% to 2%	-0.684	-0.697

Comparing these results with those obtained using the statutory CIT rate, we find that two countries with the same CIT rate would be subject to different profit shifting according to the worldwide presence of the MNEs with affiliates in their countries. While an increase in the

CIT rate from 0 to 1% would lead to a decrease in profits reported there by 1.8%, the same CIT rate change would lead to a 2.8% decrease in profit if the MNE faces an average tax rate worldwide of 30%. Thus, profit shifting would depend not only on country characteristics but also on the MNE's worldwide presence.

This non-linear result may not be surprising for tax planning experts. Based on the hypothesis that the location of profits in low tax jurisdictions is strongly driven by tax savings motives rather than economic motives, even a small increase in the tax rate in a low tax country would substantially reduce the profits reported there. On the other hand, in countries with a CIT tax rate closer to the worldwide average, where profits are expected to be more aligned with genuine economic activity, a change in the CIT tax rate would have a smaller effect on the reported profits.

Figure 6 displays the estimated semi-elasticity of changes in the statutory CIT rate and tax rate differential in panels *a* and *b*, respectively. In each graph, the blue dots show the semi-elasticities estimated within the linear model, while the red dots report the values obtained by assuming a quadratic relation. The log-level linear specification allows for a constant semi-elasticity. By contrast, a quadratic specification allows for a linear semi-elasticity.

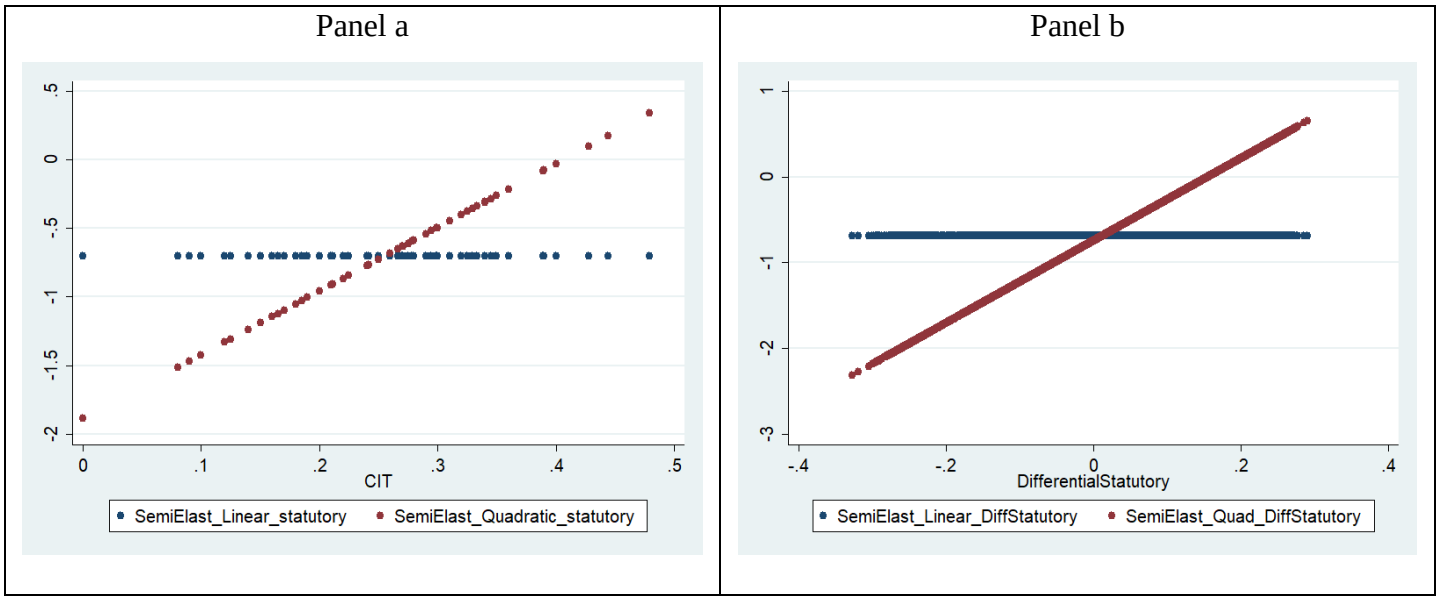

Figure 6. Semi-elasticities and Elasticities of statutory CIT rate and differential statutory CIT rates. Linear quadratic form

Note: Panels a and b represent the semi-elasticities of profit allocation in a country with respect to statutory CIT rates and the differential of the country CIT, respectively, with the average CIT of the subsidiaries of the same MNE in all other countries. Panels c and d represent the correspondent elasticities. Each point in the graph displays an observation. While for the CIT rate semi-elasticity each point corresponds to a country, for the tax rate differential each point corresponds to a sub-group of entities of the same MNE in each jurisdiction. Blue points are the results of the linear estimation; red points display the results of the quadratic estimation.

The graphs in Figure 6 show that for very low CIT rates and highly negative differential rates, the decrease in profits due to the increase in CIT is higher than that predicted by the linear estimation models. While DLM link the non-linearity of profit shifting to the level of CIT, by comparing the CIT rate and the tax differential graphs, we observe that linear and quadratic estimation coincide when the CIT rate is equal to the median average CIT rate (24%). This corresponds on average to a 0 differential tax rate.

This may suggest that the non-linear relation between CIT and profit allocation observed by DLM for US MNEs, and which we also observe in our broader sample of MNEs, may reflect a non-linear relation between tax rate differentials and profit allocation instead. This result would be consistent with the theoretical model linking the optimal level of profit shifting to differences in CIT rates.

Analysing Figure 6 we note that, similar to what was found by DLM, the semi-elasticity becomes positive for high enough CIT rates and high enough CIT differentials. This implies that a further increase in the CIT rate of a country with an already high CIT rate may induce a higher profit allocation in that country, which appears counterintuitive and not in line with the economic literature. In other words, the use of the quadratic form is useful in addressing the issue of under-estimating profit shifting in low tax countries, but at the same time does not allow for a proper estimation of the effects of changes in CIT in countries with higher CIT rates.

From quadratic estimates, countries with a statutory CIT rate above 40% would experience positive semi-elasticities. According to the quadratic specification, these countries would have the incentive to further increase their tax rate in order to attract more profit. Thus, the quadratic specification would be useless for policy makers in countries with very high tax. This issue is not minor, especially if we think that in 2017 France was above this threshold and the US was very near, thus experiencing 0 semi-elasticity despite clearly having among the highest CIT rates worldwide.[29] We would instead expect to observe an incentive for these countries to decrease their tax rate if the CIT rate is much higher than the worldwide average.

By using a further degree specification, we allow the elasticity to be estimated with fewer functional restrictions and this allows us to overcome the positive-elasticity problem. The

[29] In 2017 the combined CIT rate in United States was 39.9%, while in France it was 44.4% (OECD Corporate Income Tax database).

cubic specification implies, first, a high semi-elasticity in absolute value in countries with a CIT rate far below the average; second, an almost zero semi-elasticity when countries' CIT rates are near the average; and third, an increase in the semi-elasticity in absolute terms for countries with a rate well above the average.

Therefore, we move toward a higher degree of analysis by regressing equation (6). The results on estimated coefficients are reported in Table 12; furthermore, we report the predicted change in profits (expressed in logarithm terms) related to the changes in CIT rate differentials in Figure 7.

Column (1) of Table 12 reports the cubic estimates for the statutory CIT rate, while column (2) presents the estimates of the tax rate differential.

Table 12. Non-linear cubic estimation

	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$
τ_c	-4.545***	
	(0.703)	
τ_c^2	15.33***	
	(2.977)	
τ_c^3	-17.70***	
	(3.822)	
$\tau_c - \overline{\tau}_{m,-c}$		-0.325**
		(0.134)
$(\tau_c - \overline{\tau}_{m,-c})^2$		2.516***
		(0.524)
$(\tau_c - \overline{\tau}_{m,-c})^3$		-13.91***
		(3.585)
Observations	46,563	46,561
R^2	0.788	0.788

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

All of the coefficients are statistically significant at the one percent level. Additionally, Wald tests show the strong combined significance of the variables. The coefficients lso remain significant when removing outliers according to their CIT rate differentials or profit value.[30] Further, we perform the likelihood-ratio test comparing the cubic model with the linear model. The test suggests that assuming a cubic relationship improves the fit of the model with a confidence interval higher than 99%. We also test if the cubic regression performs better than the quadratic one using the likelihood-ratio test and find it improves the fit of the model with a confidence interval higher than 99%.

Figure 7 reports the predicted margins of changes in the differential in CIT rates on profits (expressed in logarithm), with the blue area displaying the 95% confidence interval of the predicted margins. The values of the margins refer to the cubic regression where statutory CIT rate differentials are used to predict the amount of profits being reported in a country by each

[30] As robustness checks, we keep the observations between the 1st and 99th percentile of CIT rate differentials, or of their profits (in logarithm form). We also perform the analysis by using EATR in place of statutory tax rates and the results are robust. As a further robustness check, we control for tangible assets in values instead of logarithm so as to include those observations where tangibles are zero, finding that our estimations are robust and present a more pronounced non-linearity.

MNE. The plot makes it evident that high profits are allocated in those countries with a very low CIT rate differential, i.e. with a low CIT rate with respect to the MNE average. Once the differential increases towards the zero value, the effect of changes in the CIT rate decrease to a plateau where the change in rate differential appears to be almost irrelevant for profit allocation. As CIT rate differentials become positive and increasing, profits allocated in the country start to decrease in response to the (much) higher CIT rate in the country than that observed by the MNE in the rest of the world. The size of the 95% confidence interval brackets clearly shows that the cubic effect is relevant and significant as the brackets never coincide or overlap.

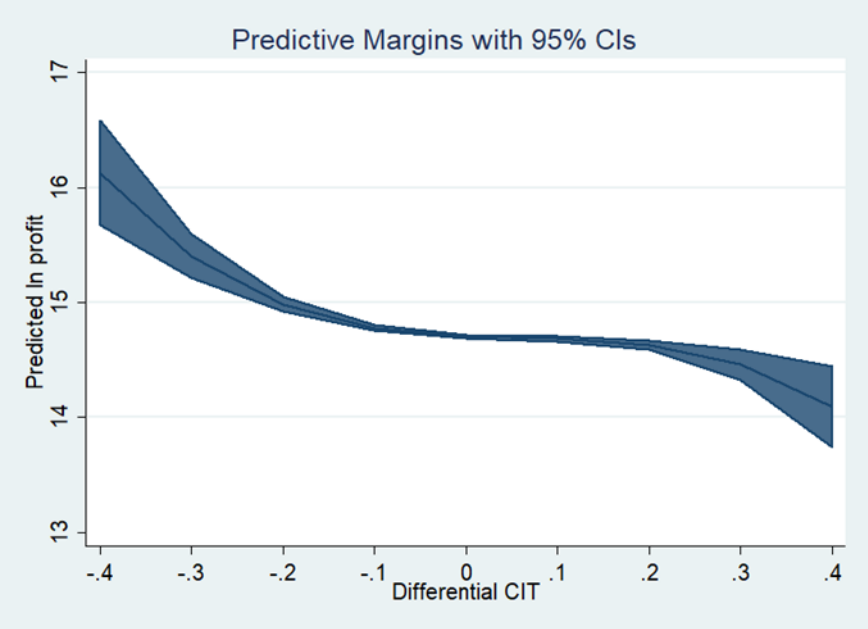

Figure 7. Predicted effect of changes in Differential CIT rates on profits (in logarithm)

Note: The graph reports the predicted margins of change in the differential in CIT rates on profits (expressed in logarithm). The blue area displays the 95% confidence interval of the predicted margins. The values of the margins refer to the cubic regression, where statutory CIT rate differentials are used to predict the amount of profits reported in a country by each MNE. The regression used for the marginal estimates include MNE fixed effects, real activity control variables, and the country's control variables. The regression is estimated assuming robust standard error.

From the graph we can observe an asymmetry between the response of MNEs to changes in the CIT rate in (very) low tax countries and in (very) high tax countries. For the same level of CIT rate differential, in absolute terms, changes in CIT rates produce a higher response in low tax countries (negative CIT differentials in the graph) than in high tax ones (positive CIT differentials). Again, this may be seen as evidence for the presence of paper profits in low tax countries that may be more volatile than profits located in higher tax countries.

In Figure 8 we compare the results obtained with the three different modelling assumptions: linear (blue dots), quadratic (red dots) and cubic (green dots).

In low tax countries the elasticity of profit allocation is even greater than that estimated using the quadratic formulation; it can be seen by comparing the green and red lines on the left in Figure 8. Changes in CIT rates in countries with a tax rate very similar to the average are associated with an elasticity close to zero. Finally, while the quadratic behaviour predicts smaller semi-elasticities in absolute terms for higher CIT rates (paradoxically becoming positive for high enough values of CIT), our prediction provides instead increasing and negative semi-elasticities (right side of Figure 8).

The intuition behind our results is that an increase in CIT rate in a country with a tax rate already above the average will lead to lower profit allocation. This decrease will be bigger the further the CIT rate is from the average.

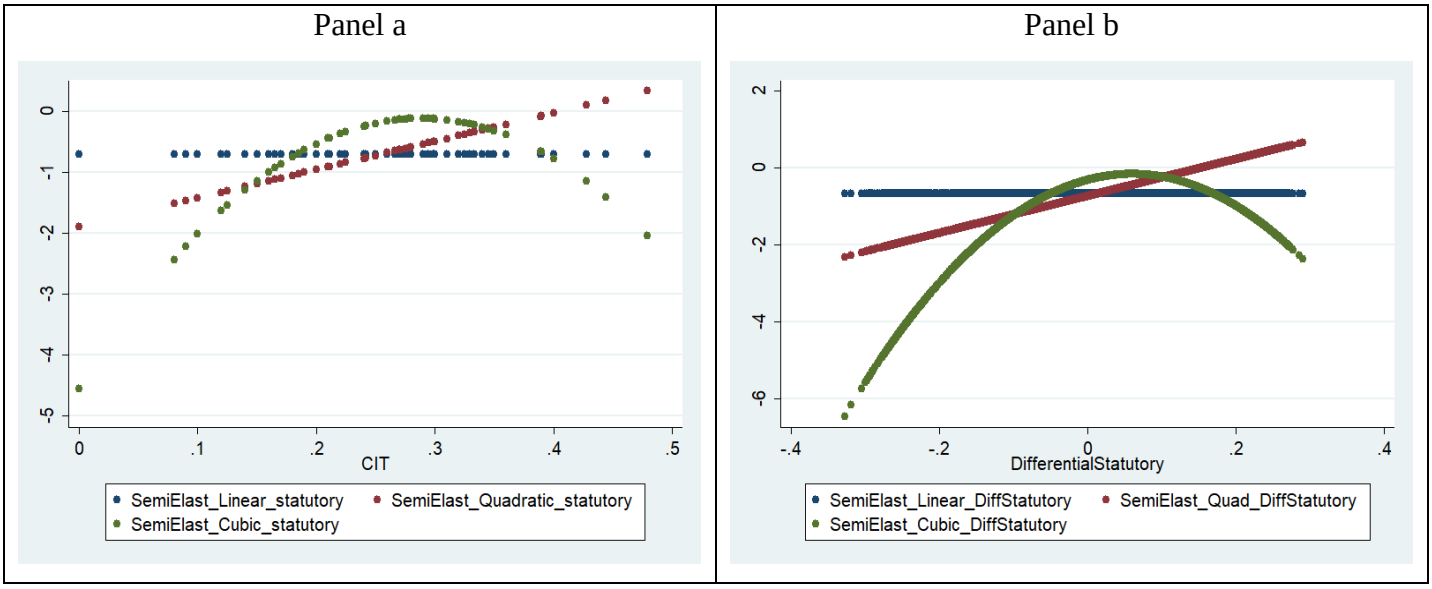

Figure 8. Semi-elasticities and elasticities of statutory CIT rate and differential statutory CIT rates. Linear quadratic and cubic form

Note: Panels a and b represent the semi-elasticities of profit allocation in a country with respect to statutory CIT rates and the differential of the country CIT, respectively, with the average CIT of the subsidiaries of the same MNE in all other countries. Each point in the graph represents an observation. While for the CIT rate semi-elasticity each point corresponds to a country, for the tax rate differential each point corresponds to a sub-group of entities of the same MNE in each jurisdiction. Blue points are the results of the linear estimation, red points display the results of the quadratic estimation, and green points represent the cubic estimation results.

Similar to Table 11, we compute the effect of an increase in one percentage point using the cubic formulation and compare it with the previously calculated semi-elasticities. We distinguish three scenarios where the three models perform differently and report the comparison in Table 13.

Table 13. Semi-elasticities of statutory CIT rates and tax rate differential in linear, quadratic and cubic formulation

Changes in CIT rate differential	Semi-elasticity		
	Linear	Quadratic	Cubic
From -30% to -29%	-0.68	-2.18	-5.59
From 1% to 2%	-0.68	-0.70	-0.28
From 16% to 17%	-0.68	+0.02	-0.59

i) An increase of one percentage point in the CIT rate in a country with a very low CIT rate, e.g. with a CIT rate differential of -30%, is associated with a decrease in profits allocated to the country by 0.68% according to the linear model, 2.18% with a quadratic formulation, and 5.59% if using the cubic identification. Thus, the cubic formulation estimates a semi-elasticity more than eight times higher than that estimated assuming a linear relationship, and almost three times larger than the quadratic estimation.

ii) When countries' CIT rates approach the global average, the semi-elasticity estimated with the cubic model is lower than that estimated using linear and quadratic models. An increase of one percentage point in the CIT rate in a country whose tax rate is just 1 percentage point higher than the average, would lead to a decrease in profits by 0.28% in the cubic model, 0.70% in the quadratic model, and 0.68% in the linear one. Thus, in this scenario, the cubic estimates are sixty percent lower than the linear estimates.

iii) If a country has a (very) high CIT rate, a further increase in the rate would drive a decrease in profits in that country by an estimated elasticity that is higher (in absolute terms) in the cubic estimation. An increase in the CIT rate in a country with a rate that is 16 percentage points higher than the average would be associated (paradoxically) with an increase in profits by 0.02%, according to the quadratic model. In the cubic model, it would instead be associated with a decrease in profits by 0.59%.

4.3 Non linearities in MNE's Ultimate Parent Entity

We explore non-linearities through a novel perspective by investigating the effect of the nationality of the Ultimate Parent Entity on profit shifting.

We are the first, to the best of our knowledge, to be able to investigate this question thanks to the use of micro-level CbCR data from MNEs of different nationalities.

We therefore regress (2), splitting the sample in three parts according to whether the MNEs' UPE is European or located in the Americas or Asia and Oceania. The results are reported in the first three columns of Table 14.

Table 14. Profit shifting by nationality of the Ultimate Parent Entity

	Asian & Oceanian MNEs	Americas' MNEs	European MNEs	All MNEs	All MNEs
	$ln(\pi_{c,m})$	$ln(\pi_{c,m})$	$ln(\pi_{c,m})$	$ln(\pi_{c,m})$	$ln(\pi_{c,m})$
$\tau_c - \overline{\tau}_{m,-c}$	-1.427***	-0.773***	-0.459***	-0.481***	-0.406***
	(0.220)	(0.150)	(0.110)	(0.0996)	(0.103)
D_{UPE_m}				-0.236	
				(0.212)	
$D_{UPE_m}(\tau_c - \overline{\tau}_{m,-c})$				-0.353***	
				(0.0978)	
$D_{Am}(\tau_c - \overline{\tau}_{m,-c})$					-0.675***
					(0.161)
$D_{As\&Oc}(\tau_c - \overline{\tau}_{m,-c})$					-0.491**
					(0.210)
Observations	6,367	15,167	24,824	46,358	46,358
R^2	0.811	0.743	0.804	0.787	0.787

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country where the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

The estimated semi-elasticity of profit shifting is higher in absolute value for Asian and Oceanian MNEs than for those with nationalities from different geographical regions. The results suggest that European MNEs are less inclined on average to engage in profit shifting, while MNEs whose UPE is located in the Americas shift profits more than their European counterparts, although less than Asian and Oceanian ones.

As the results may be partially non-comparable due to the difference in sample numerosity, we undertake a robustness check by regressing equation (7) on the full sample of MNEs with nationalities from the three geographical areas considered. Thus, we create a dummy that is 0 for European MNEs, one for the Americas and 2 for Asia and Oceania. We therefore interact the dummy with the CIT rate differential to estimate the additional propensity to profit shifting of MNEs from the Americas and Asia and Oceania with respect to European MNEs. The findings are presented in the last column of Table 14.

The results appear to confirm the tendency towards an increase in profit shifting propensity when moving from European MNEs toward Asian and Oceania and passing through NMEs in the Americas. Thus, while the semi-elasticity for European multinationals is half the linear estimation obtained from the literature, MNEs located in the Americas report a coefficient that is more than 1.7 times the European level, while the semi-elasticity of Asian and Oceanian MNEs is almost 2 and a half times the European one.

As robustness check we also perform the regression reported in equation *(8)* by using two different dummies assuming 0-1 values for Americas and Asia & Oceania MNEs. Results, reported in the last column of Table 14, confirm European MNEs to be the least engaged in profit shifting compared to their Americas and Asia & Oceania counterparts; Asia and Oceania's coefficient appears robust displaying a propensity to profit shifting 2.2 time higher than the European one. Differently, Americas' coefficient results higher than previously found being 2.7 times the European one.

Thus, our estimates provide robust evidence that European MNEs propensity to profit shifting is the lowest, and that Americas and Asia & Oceania MNEs' coefficients are more than twice those of European MNEs.

The higher profit shifting intensity found for Asia and Oceania MNEs with respect to European MNEs, seems puzzling if compared with the descriptive analysis reported in Section 2.3. More specifically, we previously observed Asian and Oceanian MNEs to have lower shares of residual profits in investment hubs and in extremely low tax rate countries than their counterparts from Europe.

However, our linear estimates and descriptive statistics would be consistent if Asian MNEs were less elastic to very low CIT rates than European and American MNEs, while exploiting to a larger extent smaller differences in CIT rates among countries. Hence, we test this hypothesis by estimating the non-linear semi-elasticity for different MNE nationalities.

Table 15 presents the results of regressing equation (5) separately for MNE nationality. While MNEs from both the Americas and Europe report statistically significant coefficients for the quadratic term of the CIT rate differential, those from Asia and Oceania do not seem to be more elastic to low CIT rates as they appear to be more inclined to exploit smaller CIT rate differentials when shifting profits. This implies that, while MNEs from the Americas and Europe carry out profit shifting by mainly shifting profits towards very low tax rate countries, those located in Asia and Oceania tend to shift profits more uniformly by exploiting even small differences in the CIT rate.

Table 15. Low tax semi-elasticities by MNE nationality

	Asian & Oceania MNEs	Americas' MNEs	European MNEs
	$ln(\pi_{c,m})$	$ln(\pi_{c,m})$	$ln(\pi_{c,m})$
$\tau_c - \overline{\tau}_{m,-c}$	-1.414***	-0.907***	-0.500***
	(0.229)	(0.165)	(0.113)
$(\tau_c - \overline{\tau}_{m,-c})^2$	-0.438	3.894***	2.227***
	(1.279)	(1.010)	(0.674)
Observations	6,367	15,167	24,824
R^2	0.811	0.743	0.804

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. We control for MNE-specific characteristics by including MNE fixed effects. We control for real activity carried out in the country by including tangible asset, unrelated party revenues and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

One of the reasons that may explain this difference can be related to dissimilarities in the cost of engaging in profit shifting, which may be consistent with the fact that MNEs from Europe and the Americas incur higher costs for every unit of shifted profit than those from Asia and Oceania. For a lower level of fixed cost, it would be profitable for a firm to carry out profit shifting even among countries with similar CIT rates; conversely, higher fixed costs may induce firms to shift profits only for high enough tax savings. The possible existence of a fixed cost in engaging in profit shifting was also raised in another work mentioning among possible factors, the cost of setting up a business in the country or the level of enforcement in the country, as well as other firm characteristics including for instance the unobservable propensity to shift profits (Bilicka, 2019). One of the possible components of the fixed cost in

engaging in profit shifting could be the strictness of certain anti-avoidance regimes in the country of the UPE, for example the strictness of CFC rules. There is evidence supporting the effectiveness of CFC rules in redirecting profits away from very low-tax countries by eliminating the largest tax saving opportunities (Clifford, 2017). To the extent that the strictness of CFC rules may vary for different enforcing countries, this difference may be one of the factors determining the fixed cost of engaging in profit shifting to vary by nationality of the UPE.

4.4 Non linearities in MNE size

Finally, we investigate if profit shifting is dependent upon the size of the MNEs.

We use as proxy the size of the MNE and the total sum of unrelated party revenues obtained by all subsidiaries of the MNE. Thus, we split the sample into four subgroups according to the quartile distribution of the sample. The results are presented in the first four columns of Table 16.

Table 16. Profit shifting by MNE size

VARIABLES	1st quartile $ln(\pi_{c,m})$	2nd quartile $ln(\pi_{c,m})$	3rd quartile $ln(\pi_{c,m})$	4th quartile $ln(\pi_{c,m})$	Full sample $ln(\pi_{c,m})$
$(\tau_c - \overline{\tau}_{m,-c})$	-0.362**	-0.682***	-0.805***	-0.815***	-0.670***
	(0.159)	(0.162)	(0.159)	(0.176)	(0.0941)
$Size_m(\tau_c - \overline{\tau}_{m,-c})$					-0.443**
					(0.183)
$Size_m^2(\tau_c - \overline{\tau}_{m,-c})$					0.0251***
					(0.00787)
Observations	11,109	11,529	11,953	11,970	44,880
R^2	0.836	0.697	0.729	0.738	0.716

*Note: Controls for country characteristics are the logarithm of GDP, Population and its square. The coefficients reported in the first four columns refer to regression where we control for MNE-specific characteristics by including MNE fixed effects. In the last column we control for MNE's total number of employees, total tangible assets, and the MNE's sector. We control for real activity carried out in the country by including tangible asset, unrelated party revenues, and number of employees reported by the MNE in the country. We also control for the effect of profits allocated in the country in which the UPE is located by including a dummy variable for each pair country-nationality of the MNE. The quartile distribution refers to MNE's total unrelated party revenues. The variable size is the standardised variable of the MNE's total unrelated party revenues. Standard errors robust to heteroscedasticity in parentheses. ***, ** and * indicate significance at the 1, 5, and 10% levels respectively.*

The estimated semi-elasticity appears to increase in absolute value for bigger MNEs, thus suggesting that bigger firms are effectively associated with higher profit shifting activities.

Further, we note that semi-elasticity seems to rise at a decreasing speed as it almost triples when passing from the first to third quartile, but becomes almost constant between the third and fourth quartiles. This is may be explained by the existence of fixed costs in shifting profits, which may be relevant to profit shifting decisions for the smallest firms and could become less important once the MNE has reached a critical mass.

We further analyse this relationship by estimating equation (9). Thus, we interact the size variable with the differential in the CIT rate and take into account the non-linear effect of size on profit shifting by interacting the square of the size with the CIT differential.

The last column in Table 16 presents a negative and significant coefficient for the interaction between the size and the CIT rate differential, thus indicating a negative relationship between the two. The coefficient of the interaction between the CIT rate differential and the square of the size is positive and statistically significant at 1% level. Therefore, the results provide novel evidence of the existence of a non-linear relationship between MNE size and profit shifting. At the same time we observe a negative sign on the coefficient for the interaction between the size and the CIT differential, and a positive sign for the interaction between the differential and the square of the size. This implies that the bigger the MNE, the higher its profit shifting activities; this increase becomes smaller, the larger the size. This further supports the theory that MNEs incur fixed costs in shifting profits that only become sustainable above a certain MNE size. This aspect of course requires deeper investigation.

5 Profit shifting and Revenue loss estimation

In this section, we use the semi-elasticity obtained in the previous section to compute the total amount of shifted profits and calculate the revenue effect associated with profit shifting by country.

As our data contain information on MNEs having at least a subsidiary in Italy, we distinguish between estimated profit shifting within our sample (Section 5.1) and global profit shifting by appropriately augmenting our results to account for MNEs without any presence in Italy (Section 5.2).

5.1 Profit shifting estimation and distribution

We estimate shifted profits by applying the semi-elasticity estimates obtained in the previous section for each subgroup.

Following Huizinga and Laeven (2008), profit allocated by MNE m in country c ($\pi_{m,c}$) can be broken down into a part related to the real activity carried out in the country ($B_{m,c}$), and another related to the tax system, i.e. shifted profits ($S_{m,c}$): $\pi_{m,c} = B_{m,c} + S_{m,c}$.

By applying the definition of the semi-elasticity of profit shifting to tax rate differential, we are able to disentangle within observed profits a part related to real activities and one correlated with tax rate differentials (see Appendix for extensive methodology).

We can therefore estimate shifted profits with the following formulation:

$$S_{m,c} = \frac{\pi_{m,c}\widehat{\beta}\, f(C_{m,c})}{1 + \widehat{\beta}\, f(C_{m,c})} = \frac{\pi_{m,c}(\widehat{\beta_1}C_{m,c} + \widehat{\beta_2}C_{m,c}^2 + \widehat{\beta_3}C_{m,c}^3)}{1 + (\widehat{\beta_1}C_{m,c} + \widehat{\beta_2}C_{m,c}^2 + \widehat{\beta_3}C_{m,c}^3)}$$

Where $C_{m,c}$ is the tax rate differential between the CIT rate of country c and the average rate applied to the subsidiaries of MNE m in all the other countries.

Thus, we will observe positive values of profit shifting if in country c the CIT rate is below the MNE's average, whereas we will observe negative profit shifting if it is above its average.

As profit shifting is a redistribution of profits from one country to another, global shifted profits for each MNE shall be equal to 0. Therefore, once we estimate shifted profits for each MNE in every jurisdiction, we impose the zero-sum condition by ensuring that the total amount of profits being shifted *away* from all countries by an MNE is equal to the sum of all

profits being shifted *into* all countries by the same MNE.[31] We resize shifted profits in proportion to the excess value (negative or positive) among countries with the observed value in order to maintain the direction and prevalence of profit shifting. Through this computation we obtain, for each MNE, the amount of profit being shifted from every country and the amount of profits being shifted into each country with the sum of the two flows being equal to zero. Hence, we are able to estimate profit shifting by subgroup, i.e. by MNE-country pair.

Next, we can group the shifted profits according to the income group of the country. Table 17 reports shifted profits by income group as a share of global profit shifting (first column) and as a share of total profits reported in the income group (second column). The figures refer to the cubic estimation of profit shifting where the independent variable is the statutory CIT rate differential. As to the first column, negative shares identify country groups from which profit is shifted away, while positive shares identify country groups to which profit is being shifted. In terms of aggregated amounts, the figures show that profit is being shifted mainly from high income countries, accounting for 80% of shifted profits, towards investment hubs, which is the only country group receiving shifted profits.

Column 2 in Table 17 presents the incidence of profit shifting over total profits reported in the country group. While high income countries account for the majority of shifted profits (80%), profit shifting only represents 1.2% of the profits reported in these countries. For lower middle income countries profits shifted away account for a relatively small share of globally shifted profits (17%), but is a large share of the total profits reported in the country group, accounting for the highest share among all country groups (8.6%).

[31] It is necessary to apply the zero-sum condition as the application of profit shifting coefficient to MNE profit does not result in the sum being equal to zero when none of these types of conditions are imposed.

Table 17. Aggregated shifted profit by income group

Income group	Shifted profit	
	As percentage of the total shifted profit	As percentage of profit reported in the country
High income	-79.71%	-1.22%
Upper middle income	-3.09%	-0.40%
Lower middle income	-17.16%	-8.64%
Low income	-0.04%	-0.83%
Investment hubs	100.00%	3.62%

The aggregate figures shown in Table 17 may however conceal differences within income groups, namely reflecting the presence within the "high income group" of some countries that are destinations for shifted profits and others that are heavily affected by shifted profits. These results are presented in Table 18, representing the distribution of positive and negative profit shifting separately. While profits are mainly moved from high income countries, the destination of this shifted profit is more heterogeneous among income groups. High income countries are not only a source but also a destination for positive profit shifting, almost accounting for the same share of positive shifted profits as Investment hubs (around 47%), whereas in Table 17 investment hubs appear to be the only destination for shifted profits. This implies that despite the fact that an estimated 80% of shifted profit is moved away from high income countries, within the high income group some countries are likely to be destinations for shifted profits.

Table 18. Positive and negative shifted profits by income group

Income group	Shifted profit	
	As percentage of Positive Shifted Profits	As percentage of Negative Shifted Profits
High income	47.54%	80.66%
Upper middle income	4.88%	6.16%
Lower middle income	0.83%	7.96%
Low income	0.03%	0.04%
Investment hubs	46.73%	5.18%

Ranking the countries by the amount of profits being shifted away, the two countries that have the largest losses from profit-shifting, France and the United States, account for 60% of total profit shifting. The first five countries in the ranking -France, Germany, India, Japan, and the United States- account for almost 80% of total shifted profits.

Examining the jurisdictions that are destinations of shifted profit, the distribution appears slightly less concentrated. The top five jurisdictions by amount of shifted profits account for 60% of profit shifting. However, the distribution still appears skewed as more than 80% of profits are shifted toward only nine jurisdictions: Switzerland, United Kingdom, United Arab Emirates, Ireland, Singapore, Hong Kong, Bermuda, Hungary, and Taiwan.

We can also observe how shifted profit is distributed among countries according to the average CIT rate differential faced by MNEs in that country. Figure 9 presents the average share of shifted profits over total reported profits for three categories of countries: countries with a very high, in absolute terms, negative CIT rate differential, countries with a very high positive CIT rate differential, and a residual group composed of all remaining jurisdictions in between. The results are displayed both by using the non-linear, meaning cubic, identification strategy (in yellow) and the linear formulation adjusted in order to make it comparable with the non-linear results (in grey). In both specifications, countries with the highest negative CIT rate differential (bars on the left) present a higher share of shifted profits over total profits compared to the other two country groups. Shifted profits account for a greater share of total profits in the non-linear (cubic) specification compared to the linear specification for countries with a CIT rate that is very distant from the average – either lower (bars on the left) or greater (bars on the right). For countries with a CIT rate more in line with the average (bars in the

middle), the linear specification provides a higher share of shifted profits compared to the non-linear (cubic) specification. This supports the finding that the linear specification underestimates the relative magnitude of profit shifting in countries with CIT rate differentials very distant from the average, while over-estimating profit shifting in countries whose CIT rate is closer to the average.[32]

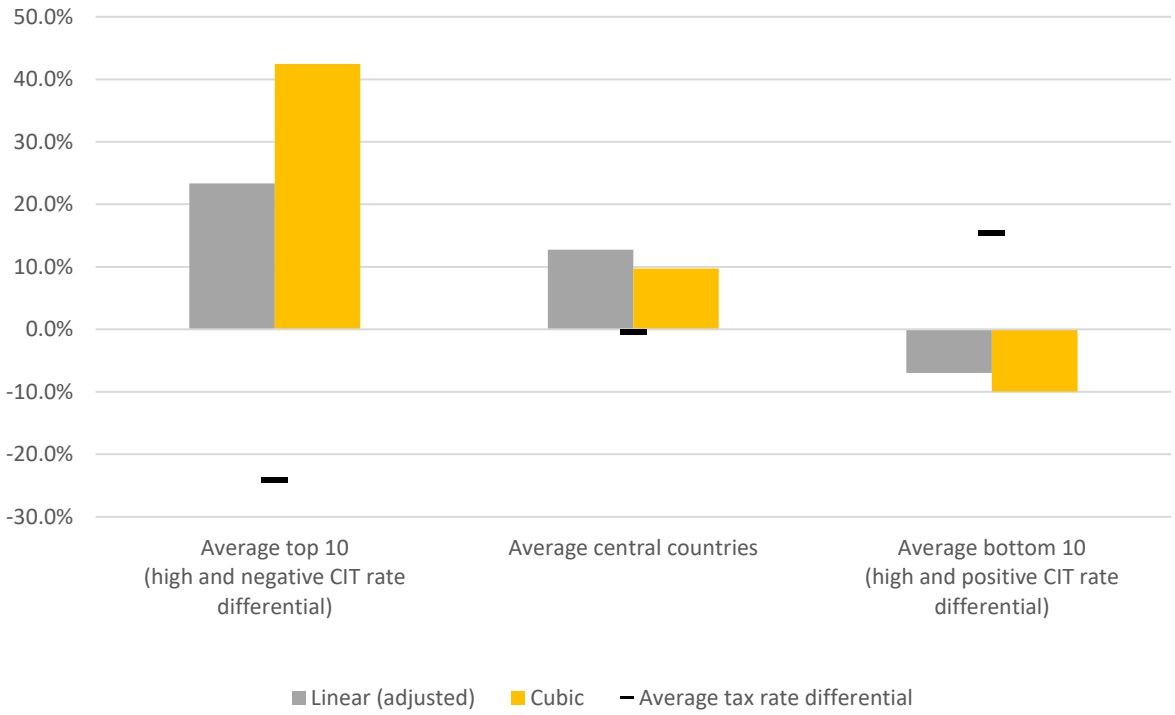

Figure 9. Average share of profit shifting over total profits by average CIT rate differential

Note: In order to make comparable the values resulting from the linear and cubic estimation, the value of profit shifting resulting from the linear estimation has been adjusted proportionally, so that the sum of shifted profits of linear and cubic estimation is the same.

[32] Similar results are obtained if computing average share of profit shifting both as a mean of the shares by country and ratio of total profit shifting over total reported profits.

5.2 Global profit shifting and revenue effect

Several papers have engaged in the estimation of global profit shifting and corporate income tax lost due to shifted profits. The OECD (2015a) estimated a revenue loss between US$100 and 240 billion in 2014, corresponding to 4-10% of global CIT revenue, while Beer, De Mooij and Liu (2020) measured a revenue loss of around 2.6% of global CIT revenue in 2015. Clausing (2016) estimated that in 2012 profit was shifted by an amount around US$1,076 billion while Balwijin et al. (2018) reported an amount of US$700 billion of profit shifted in the same year. Recently, Tørsløv, Wier and Zucman (2018) found that US$616 billion in profits were shifted to tax havens in 2015, corresponding to a global revenue loss of 10% of CIT revenue.

As pointed out in the previous section, our dataset contains information on MNEs having at least a subsidiary in Italy. Assuming that the profit shifting behaviour of non-observed MNEs is the same as the MNEs observed in the dataset, the estimated coefficients will not be affected by the reduced sample. However, by not including firms that do not have any presence in Italy, the total amount of estimated profit shifted will not fully reflect global profit shifting and will not be immediately comparable with worldwide estimates in the literature.

In order to make our results comparable with those estimated in the literature, we re-scale to account for the fact that we only observe MNEs with at least one subsidiary in Italy. Furthermore, we also account for the fact that the data refers to MNEs with a total turnover of at least €750 million. In order to address the first issue, we compare data reported in our dataset with that reported by the OECD in the CbCR section of the Corporate Tax Statistics referring to all MNEs. By comparing our data with the OECD statistics, we can estimate the share of global profits that we cannot observe in our dataset as they are reported by MNEs without a presence in Italy.

As our sample representativeness may change by the country of the UPE, we compare the total amount of positive profits in our dataset with those reported in the OECD dataset for each country-pair that we observe in both datasets. This implies that if both our dataset and the OECD's data report positive profits in a specific country allocated there by MNEs whose UPE is of a specific country, we can directly compute a representativeness percentage. Each percentage is the ratio of profits in our data to those in the OECD statistics.

Not all countries fall between our dataset and the OECD one. This either happens because we have more disaggregated data on jurisdictions or because MNEs included in the OECD dataset are present in countries beyond those we observe in our data.

Where there are differences in representativeness between our data and the OECD data for a country-pair, we proxy by using the average representativeness of the geographical area of reference for the specific country. For instance, if information on profits allocated by French MNEs to Thailand is missing, we would use the ratio of representativeness of French MNEs in Asia. Whenever this information is not available, we apply the average rate of the geographical area of the UPE's country in the specific country - in our example the representativeness of European MNEs in Thailand. Finally, if no information is available, we apply the average rate observed in the geographical area of the country related to profits allocated there by firms with their UPE in a specific geographical area - in the example above we would use the average representativeness of European MNEs in Asia. By applying this methodology of scaling up the data, we are able to compute profit shifting for all MNEs with a total turnover of at least €750 million.

Finally, we must take into account profit shifting carried out by MNEs that have less than €750 million in total revenue. In order to do so we refer to OECD (2015b), which reported that MNE groups above the €750 million CbCR reporting threshold account for 90% of global corporate income tax revenues. As a further check of this percentage, we use Orbis data on MNEs with at least one subsidiary in Italy and compare profits and loss from MNEs below and above the CbCR reporting threshold. We find similar results: profits of MNEs with a turnover above the threshold account for 91% of total MNE profits.[33]

Once we adjust our estimate of global shifted profits to take into account all MNEs, we resize, as before, the total amount of shifted profit to obtain a zero-sum total. Next, we compute the revenue effect by applying the statutory CIT rate to shifted profits in each country; negative profit shifting is associated with a revenue loss for the country, while positive profit shifting implies a revenue gain.

We estimate that in 2017 a total amount of €887 billion in profit was shifted due to differences in tax rates with a total revenue loss of €245 billion, accounting for 9% of global CIT revenue. Linear estimation would have delivered an estimated total of €1.2 trillion in shifted profits with a consequent revenue loss of €265 billion. The difference in total estimated profit shifting

[33] The data refers to 2016, however it is reasonable to assume the share of profits did not change significantly in one year.

is mainly related to the over-estimation of profit shifting among countries with similar level of CIT and under-estimation of profit shifting in low tax jurisdictions, where the former effect is greater than the latter due to the high presence of MNEs in high income, high tax countries.

In comparing these results with the estimates of previous years, it should be taken into account that in 2017, after the adoption of the BEPS package, MNEs may have begun to reduce their BEPS behaviour and this may reflect in the figures reported in CbCR for the year 2017 - the second year of CbCR implementation. For example, in comparing our work with that of the OECD (2015a), our results appear rather in line with their higher range limit. This outcome, however, could be the result of counterbalancing features: on the one hand our data have greater coverage of investment hubs than Orbis, which was used in OECD (2015a), leading to a higher (and probably more reliable) estimate of global CIT revenue loss. However, the 2017 CbCR data used in our study may capture the first signs of MNE compliance with the BEPS countermeasures adopted by many countries, resulting in lower revenue losses compared to the pre-BEPS project environment.

Table 19 reports the amount of estimated shifted profits by jurisdiction. Global profit shifting appears to be highly concentrated in a few countries, namely 80 percent of total profit shifted involves seven countries of origin and eight jurisdictions of destination. The United States appears to be the country mostly affected by profit shifting, with a total of €320 billion of shifted profits and €124 billion of revenue loss. Our estimate on revenue loss in the United States is in line with that obtained by Clausing (2020a,b) using US CbCRs, thus suggesting that our estimates are solid. Japan is the second most affected country with €123 billion of shifted profits and a total of €36 billion of lost revenue. These two countries together account for half of total shifted profits around the globe. The ranking clearly reflects the importance of these countries in terms of global profits. If we instead ranked countries by share of profit shifting over reported profits, we would find that the most affected countries would be India, Eritrea, France, and South Sudan. The United States still appears in the top ten of most affected countries with 9.2% of reported profits being shifted away by MNEs.[34]

Profits are then shifted from these countries towards the jurisdictions listed in the lower part of Table 19. Five of eight of the destination-jurisdictions are investment hubs and account for 60% of global profit shifting.

[34] As reported profits is the difference between real profits and profit shifted away, this share is equivalent to say that 8.4% of real profits in the USA have been shifted away.

Comparing these with the top ranked jurisdictions in section 5.1 (before the adjustment for MNEs without a subsidiary in Italy), we find that the United States persistently appears as the country with the highest amount of profit being shifted. The second in ranking for global profit shifting appears to be Japan, which overtakes France which in turn is located in a slighter lower position, still in the top five. Our larger dataset covers all firms with a subsidiary in Italy, it provides a better representation of MNEs located in Europe than those located in other continents. This implies that when taking into account firms that do not have any presence in Italy, global profit shifting in the other continents increases.

The jurisdictions that are destinations for shifted profits coincide almost completely with the destinations observed in Section 5.1. The main difference refers to the British Virgin Islands, which increases in ranking to first place. This change is a result of the high profit shifting concentration in that country and the low representativeness of our sample in that jurisdiction.

Table 19. Estimated global shifted profits by jurisdictions

Jurisdiction	Shifted Profits (millions €)
United States of America	-320,807
Japan	-123,240
India	-69,748
Algeria	-68,235
France	-58,595
South Africa	-50,434
China	-32,200
Virgin Islands (British)	315,148
Bermuda	129,235
Singapore	66,361
Switzerland	59,407
Ireland	44,054
United Kingdom	43,507
United Arab Emirates	43,269
Hong Kong	37,317

Analysing profit-shifting by geographical area, the Americas has both the highest estimated loss in profit (€372 billion) and the largest estimated gain in profits (€477 billion). The results for Europe report a net increase in profit allocated to the area by €67 billion. France is the first country of origin of estimated shifted profit in Europe, with an estimated €58 billion in profit

being shifted away and an estimated revenue loss of €26 billion. The distribution of profit shifting appears quite skewed. Germany ranks second with €18.7 billion in shifted profits and a correspondent revenue loss of €5.6 billion. [35] Italy, despite being in fifth position in Europe regarding the amount of shifted profit, reports an estimate of just €5 billion of profits being shifted away, with a correspondent estimated loss of just €1 billion. Switzerland is the first destination for profit shifting among European countries with a total estimate of €182 billion of profit being moved there. Asia and Oceania report an almost balanced loss and gain in profits, with an estimated total net loss of €27 billion. The results for Japan suggest that €123 billion have been shifted from the country, while Singapore turns out to be the first-ranked destination of shifted profits in Asia, with an estimated €66 billion being shifted there. Finally, the estimates for Africa report a net loss of €145 billion in profit, with Algeria losing the most (€68 billion) and Mauritius gaining most with just €2 billion.

The analysis by country groups also confirms the trend already mentioned in section 5.1, showing that profits are mainly shifted from a few high income countries, towards some jurisdictions mainly classified as investment hubs.

Finally, it is important to bear in mind that the results of our paper provide an estimation of profit shifting dependent upon countries' corporate income tax rates - and therefore their differential with respect to other CIT rates. This feature is common within the profit shifting estimation literature, especially in the micro-based literature. However, this has the drawback of disregarding the tax provisions that determine the tax base.

We partially attempt to address this by using EATRs in the estimation of the elasticity of profit allocation. However, effective tax rates cannot account for all other channels of profit shifting that go beyond the reduced tax rate, such as the existence of bilateral tax treaty provisions that effectively lower the tax liability of MNEs, or the existence of special lower tax regimes or lower tax rate special economic zones that are not included within standard effective tax rate calculations. In particular, low elasticities observed in countries with a CIT rate close to the average may be even lower if estimates include the effect of a special lower tax regime. In turn, this may suggest that the current tax system may be almost neutral with respect to profit allocation choices in these countries.

Moreover, MNEs providing digital services can easily avoid the location of profits in medium and high tax rate countries by choosing to operate remotely in those countries, with no or very

[35] Our estimates on revenue loss for Germany are in line with the estimates of Fuest et al. (2021). The consistency of the results suggests that the re-scaling we applied to account for non-observed MNEs is solid.

little physical presence; this tax planning behaviour may not be captured by either financial accounts data or CbCR data. By observing only part of the channels through which profits can be shifted, our estimates can therefore be considered lower-bound estimations of global profit shifting.

5.3 Inclusion of the Tax Cuts and Jobs Act

In 2017, the US Congress passed a series of changes in the tax system within the so-called Tax Cuts and Jobs Acts (TCJA) with the effects beginning in 2018. Among other things, the Act made changes to the CIT system in the United States, reducing the nominal federal CIT rate from 35% to 21% and introducing the Global Intangible Low Tax Income (GILTI).[36]

GILTI refers to income earned by foreign subsidiaries and is defined as a residual part of subsidiaries' global profits in excess of a fixed remuneration of global fixed capital. As GILTI is included, partially, in the CIT base of the US parent entity, the reform aimed at taxing in US part of profits earned abroad that are subject to a low tax rate. More specifically, by allowing a 50% deductibility and an 80% foreign tax credit, the taxation on GILTI effectively happens only if the residual income is taxed at an effective tax rate below 13.125%.

These two changes may have an impact on profit shifting estimation.

First, the reduction in CIT rate may have decreased profit shifting carried out by MNEs located in the United States as the difference in CIT rates, being smaller, reduced the incentive for firms to dislocate profits abroad.

Second, by attracting part of the profits to the United States, the estimated revenue loss due to profit shifting for the United States will be reduced.

In order to assess the impact of both effects, we estimate profit shifting by introducing a lower CIT rate for the US. In a second step, we also estimate the impact of GILTI.

After the national CIT rate has been reduced to 21%, the combined CIT rate for the US was 25.84% in 2018 (OECD CIT database). We therefore modify the CIT rate and compute the

[36] The TCJA introduced several other tax measures, such as the FDII and BEAT. However, for our computation and due to the absence of data on specific expenses carried out by MNEs, we restrict our analysis to the decrease in CIT rate and the introduction of GILTI.

differential CIT rates for every MNE in every country after the change. Next, we apply our semi-elasticity coefficients to estimate profit shifting.

The estimated amount of global profit shifting is now equal to €824 billion and a €219 billion consequent revenue loss. Thus, the reduction in the US CIT rate may have decreased global profit shifting by 7%, and 10.5% in relation to revenue losses associated with profit shifting.

The estimated reduction in profit shifting due to the change in CIT rate is the result of changes in profit shifting not just in US, but also in all the other countries due to the indirect effect on every CIT rate differential.

According to our estimates, the United States would no longer rank as having the highest loss in profit as the new estimated amount of profit being shifted from US would be about €48 billion - a striking reduction by 84.8% of profit shifting. While profit shifting in the US reduces severely, other countries such as Japan and France may observe an increase in profit shifting, by 32% and 88%, respectively. This is due to the higher CIT rate differentials faced by MNEs with respect to the new reduced average. Still, the US appears to rank fifth in the world in terms of profit being shifted away and the sixth in terms of highest revenue loss, as it would still lose €12.6 billion due to profit shifting.[37] When referring to the share of shifted profits over reported profits, the ratio reduces to 1.7%. It would be interesting to check this simulation when post-US reform CbCR microdata will be available.

Next, we introduce GILTI into our analysis to estimate the increase in revenue gain produced by the inclusion of GILTI in the CIT base of the UPE located in the US. In order to compute the tax liability connected to GILTI, we first must estimate GILTI, then a gross-up number to be added to GILTI to take into account the portion of foreign taxes paid on the income, and finally the deemed paid credit for foreign taxes paid. More specifically, GILTI is computed as the difference between the tested income and a fixed remuneration (10%) to tangible assets. Tested income is defined as the excess of the gross income of the corporation over deductions - including taxes - properly allocated to such gross income. As foreign taxes are subtracted to profits, some are added back through the gross-up which represent the share of paid foreign

[37] The overall revenue effect of the reform would also depend on the reduction in CIT revenue caused by the decreased rate applied to reported profits. Using aggregate estimates in our dataset, we would expect the reduction in CIT rate to have cost the US Government about 16% of CIT tax revenue by US multinationals, despite the increase in CIT revenue obtained by taxing profits that are no longer shifted. This means that the reduction in profit shifting does not compensate at all the decrease in revenue caused by the reduced CIT rate applied to reported profits related to real activity. Data from OECD Revenue Statistics show a reduction of around 35% of CIT revenues in the US between 2017 and 2018, including the CIT revenue reduction of purely domestic US corporations.

tax allocated to GILTI. Hence, a deemed paid credit for foreign tax is allowed, this is equal to 80% of the product of the share of GILTI over tested income, multiplied by the aggregate foreign income taxes. In practice, the deemed paid credit can be obtained as the 80% of the gross-up. The computations are described in equation (10).

$$GILTI = \sum_{c \neq US} \left((\pi_c - tax_c) - 10\% \, Tang_c \right)$$

$$GrossUp = \frac{GILTI}{\sum_{c \neq US} \left(\pi_c - tax_{foreign_c} \right)} \sum_{c \neq US} tax_c \qquad (10)$$

$$Tax_{GILTI} = CIT_{US}\left(50\%(GILTI + GrossUp)\right) - 80\% GrossUp$$

The rationale of the measure is to tax in the United States non-routine profits earned abroad that were not subject to enough taxation. In practice, however, as GILTI is computed on a global basis, low taxes in some countries may be compensated by higher taxes being paid in other countries. We estimate tax liability for every US MNE, finding the total additional tax revenue to be equal to 1.6% of profits reported by US MNEs abroad. Thus, we estimate the overall revenue gain due to GILTI taxation, accounting also for the rescale from unobserved profits in our CbCR sample. Our estimates suggest that the application of GILTI to the foreign profits of US MNEs would result in additional €26.7 billion of tax revenue for the United States.[38]

In principle, GILTI should produce not only additional taxation in the US, but also reduced profit shifting, as the effective tax rate applicable in the country of the subsidiary will ultimately depend not only on the local CIT rate, but also on the GILTI eventually applied on that profit. However, as the GILTI tax liability results only from a global calculation taking into account the activities of all subsidiaries of a US MNE, it is not possible to compute country-pairs profit shifting changes, so it is not possible to assess the GILTI-driven reduction of profits shifted from the US.

[38] Ex-ante estimates of the US GILTI are of around US$10 billion. Our estimates account also for the US sub-national CIT tax rate and do not consider the ownership share of the shareholder since this information is not reported in the CbCR.

5.4 Potential impacts of international reforms

The international discussion about possible policies aimed at curbing aggressive tax planning includes approaches that provide for top-up taxation on profits that are taxed below a minimum level. We refer in particular to the GloBE (Global Anti-Base Erosion) proposal included in the OECD Report on Pillar Two Blueprint (OECD 2020b), currently under discussion by the Inclusive Framework on BEPS. The idea is that if the profits of MNEs are subject to an effective level of taxation below an agreed minimum rate, the MNE will be liable for an incremental amount of tax that will bring the total amount of tax on such profits up to the minimum rate. The rationale is to ensure that all MNEs pay a minimum level of tax irrespective of where they operate, so as to reduce profit relocation driven only by tax reasons.

As a result of the present analysis, shifted profits appear to be concentrated in a few countries, suggesting that policies aimed at guaranteeing a minimum level of taxation may be very effective in reducing the incentive for MNEs to locate profits in these jurisdictions based only on tax decisions. For instance, more than 67% of global shifted profits is allocated within countries with an EATR below 12.5%.

Furthermore, the differences in elasticities suggest that MNEs are especially inclined to modify their profit allocation in low tax countries in response to changes in taxation that occur there. Thus, our results suggest that the introduction of the GLOBE may have greater impacts than what we would expect by using linear models. International tax reforms, providing that profits are taxed at a minimum level, may move in the direction of effectively reducing the incentive for MNEs to relocate profits in countries with an extremely low CIT rate and therefore may be an efficient and effective way to curb profit shifting.

Based on this intuition suggested by the results of our profit shifting analysis, we assess the impact of the implementation of a minimum level of corporate taxation.

Impact of minimum corporate taxation

One of the main benefits of introducing a minimum taxation within the international CIT system consists of a reduction in the incentive to shift profit, due to the decrease in CIT rate differentials.

By applying our estimated semi-elasticity we can simulate the reaction of MNEs to the increase in CIT rate. More specifically, as our estimates refer to the statutory CIT rate rather than backward looking effective CIT rates, we provide an estimation based on the implementation of a minimum statutory CIT rate.

We impose a minimum statutory CIT rate for all countries with a CIT below the minimum, thus, we estimate the new CIT rate differentials for every MNE in each subgroup. Next, we compute the new level of profit shifting carried out by MNEs in response to the lower CIT rate differentials and compare post-reform profit shifting with pre-reform activity.

A minimum tax rate may be implemented as a top-up tax to be applied to profits allocated in a jurisdiction subject to a lower CIT rate than the minimum. Thus, in order to estimate the top-up tax, we estimate the post-reform profit allocated to every subgroup by each MNE by adding, to the reported profit, the difference between pre- and post-reform profit shifting. This enables us to estimate the total profits MNEs would allocate in every jurisdiction in response to the introduction of a minimum taxation. Hence, we estimate the top-up by applying the difference between the minimum tax rate and CIT rate for every jurisdiction to the estimated post-reform allocated profits.

We perform this estimation assuming both a 12.5% and 15% minimum tax rate and surmising that those minimum rates apply in all jurisdictions. Our estimate suggests that by introducing a nominal minimum CIT rate of 12.5%, profit shifting would decrease by 19% from €887 to €715 billion. By applying a 15% minimum statutory CIT rate, profit shifting would decrease by 22.5% to €686 billion. In addition to the increase in revenue due to the decrease in profit shifting, revenue would further increase due to the application of the top-up tax on under-taxed profits.

6 Conclusions

Base Erosion and Profit Shifting carried out by MNEs is one of the most debated topics in international taxation; thus, an increasing number of studies attempt to estimate the elasticity of profit allocation with respect to changes in taxation. Despite the importance of the issue, however, a lack of precise and comprehensive firm-level data is still a major problem with existing estimations.

We use a novel and unique dataset, firm-level Country-by-Country Reports, to estimate profit shifting. Furthermore, we combine this dataset with others. The combination with Orbis BvD allows us to overcome the main limitations of previous micro-founded profit shifting analyses, providing evidence for the better coverage of our data with respect to Orbis BvD on different levels. The combination with tax return data allows us to quantify one of the main issues of the CbCR, which is the possible inclusion of dividends in profits.

With this new data source, we move beyond the classic linear estimation commonly used in the literature and provide evidence of the existence of a strong non-linear response of MNEs' profit allocation to tax rate differentials. To the best of our knowledge, ours is the only paper providing non-linear estimations for MNEs of all major jurisdictions, as the few papers focusing on non-linearity exploit data on domestic-headquartered MNEs only. Furthermore, in contrast with existing papers that take a non-linear approach and, more closely, in line with major theoretical models on profit shifting, we focus on differentials in CIT rates rather than CIT rates themselves. We find that profit allocation in a jurisdiction is non-linearly dependant on the differences between the tax rate in that jurisdiction and the average CIT faced by the MNE group. We further examine non-linearity, pointing to our finding that the effect of changes in CIT rate differences on profit allocation is statistically and economically significant when allowing for an inverse U-shaped semi-elasticity function.

Our results suggest that low tax countries do not have any incentive to increase their tax rate as this would lead to a reduction in tax base, hence, they may be seen as prisoner of their own low tax rate. Conversely, countries with a higher CIT rate would not benefit from reducing their rate as their attractiveness would still be limited; any effort in tax competition among high tax countries would be then extremely inefficient.

The uniqueness of the dataset also allows us to investigate non-linearities in profit shifting from a novel perspective, finding that the nationality of MNEs matters in terms of the profit

shifting decision. European MNEs carry out on average less profit shifting compared to their American and Asia and Oceania's counterparts. However, MNEs from Europe and the Americas are more inclined to shift profits toward low tax rate countries, being more elastic to changes in these countries. Finally, we find that profit shifting increases with MNE size but at decreasing speed, suggesting that they incur fixed costs when shifting profits that only become sustainable above a certain MNE size.

Our results are substantially different from conventional estimates of profit-shifting elasticities. The estimated semi-elasticity in our approach is up to eight times larger than those yielded by linear estimation approaches for MNEs facing very high negative CIT rate differentials (i.e. in countries with very low CIT rate). At the same time, for MNEs facing similar CIT rates across different countries close to the worldwide average, our estimates are sixty percent lower than for linear ones. Our findings thus suggest that linear specification substantially underestimates the relative magnitude of profit shifting in countries with CIT rate differentials very distant from the average, while substantially over-estimating profit shifting in countries where the CIT rate is closer to the average.

We also provide new estimates regarding the size of profit-shifting and associated revenue loss by country. We find that investment hubs are the main destination of shifted profits and that high income countries lose most profits due to profit shifting. We estimate that in 2017 a total amount of €887 billion in profits was shifted due to differences in tax rates, with a total revenue loss of €245 billion. In terms of gains and losses, we find that profit shifting is very concentrated in a small number of countries. We also investigate how the US Tax Cuts and Jobs Cut policy changes global and country-specific estimates on profit shifting and the consequent revenue gains and losses, finding that the reduction in the US CIT rate would result in a reduction in global profit shifting by 7% and a significant reduction in profit shifting in the US (-84.8%), despite leading overall to a substantial reduction in US CIT revenues. The change in the US CIT rate would also alter profit shifting estimates in other countries by affecting the rest-of-the-world average CIT tax rate. Finally, we estimate the additional revenue for the US arising from the GILTI, finding that it would result in an increase in tax liability as a share of profits for US MNEs in the US equal to 1.6%.

Our results have potentially very significant policy implications. Given that shifted profits appear to be concentrated in a few countries and as the elasticity of reported profit to tax rate in these countries appears to be highest, policies aimed at guaranteeing a minimum level of taxation may be effective and efficient to curb profit shifting. Triggered by this suggestion,

we estimate the impact of implementing a reform providing for a minimum level of corporate taxation and find that it would reduce profit shifting.

Our estimate suggests that by introducing a nominal minimum CIT rate of 15%, profit shifting would decrease by 22.5% to €686 billion. In addition to the increase in revenue due to the decrease in profit shifting, revenue would further increase due to the application of the top-up tax on under-taxed profits.

Further analysis on this should be carried out as these insights may be of help in designing international tax agreements.

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8 Appendix

5.1 A1. Estimated shifted profits by country

As $B_{m,c}$ is not directly observable, we first must compute it by applying a logarithm transformation to the profit equation. Thus, we can rewrite the above equation as follows:

$$\ln \pi_{m,c} = \ln\left(B_{m,c} + S_{m,c}\right)$$

By applying logarithm properties and by rewriting profit shifting as equal to a share $s_{m,c}$ of the profits associated with real activities, we can compute reported profits as follows:

$$\ln \pi_{m,c} = \ln B_{m,c} + s_{m,c}$$

Our identification strategy consists of a log-level estimation of the effect of corporate income tax, defined as a function of tax rate differential between the CIT rate of country c and the average rate applied to the subsidiaries of MNE m in all other countries - $f\left(C_{m,c}\right)$ - on reported profits.

$$ln(\pi_{m,c}) = ln(B_{m,c}) + \widehat{\beta}\, f(C_{m,c})$$

Ceteris paribus, the estimated coefficients of the tax rate differentials, represent the marginal effect of changes in tax rate over profit allocation.

We can now invert the expression and estimate the real-activity profit as follows:

$$\pi_{m,c} = B_{m,c}\left(1 + \widehat{\beta}\, f\left(C_{m,c}\right)\right) \Rightarrow$$

$$B_{m,c} = \frac{\pi_{m,c}}{1 + \widehat{\beta}\, f(C_{m,c})}$$

Once the component of profits related to the activity carried out by the MNE group in each country is estimated, we can approximate shifted profits as the difference between allocated profits and the estimated profits related to real activity.

$$S_{m,c} = \pi_{m,c} - B_{m,c} \Rightarrow$$

$$S_{m,c} = \frac{\pi_{m,c}\widehat{\beta}\, f(C_{m,c})}{1 + \widehat{\beta}\, f(C_{m,c})} = \frac{\pi_{m,c}(\widehat{\beta_1}C_{m,c} + \widehat{\beta_2}C_{m,c}^2 + \widehat{\beta_3}C_{m,c}^3)}{1 + (\widehat{\beta_1}C_{m,c} + \widehat{\beta_2}C_{m,c}^2 + \widehat{\beta_3}C_{m,c}^3)}$$

As $C_{m,c}$ is defined as the difference in the CIT rate of country c and the average CIT rate applied to the other subsidiaries of the MNE m, profit shifting is positive in countries with

CIT rates lower than the MNE's average CIT rate, and negative otherwise.[39] Effectively we will observe for each MNE one value of shifted profit per country where they are present. A negative value of shifted profits indicates that profits are being shifted *away* from that country *into* another country with a positive level of *S*.

[39]As $\widehat{\beta_1}C_{m,c} + \widehat{\beta_2}C_{m,c}^2 + \widehat{\beta_3}C_{m,c}^3$ does not ever reach negative values below -1 and being $C_{m,c} < 1$ by applying the estimated coefficient values, profit shifting is positive when $C_{m,c} < 0$ and negative if $C_{m,c} > 0$.

Table 20. Jurisdictions classified by income group (World Bank and OECD (2020) for Investment hubs)

High Income																
Andorra	United Arab Emirates	Antigua and Barbuda	Argentina	Austria	Australia	Aruba	Barbados	Belgium	Bahrain	Bermuda	Brunei Darussalam	Canada	Cook Islands	Chile	Curaçao	Czechia
Germany	Denmark	Estonia	Spain	Finland	Faroe Islands	France	United Kingdom of Great Britain and Northern Ireland	Gibraltar	Greenland	Greece	Guam	Croatia	Hungary	Israel	Isle of Man	Iceland
Italy	Japan	South Korea	Kuwait	Liechtenstein	Lithuania	Latvia	Monaco	Saint Martin (French part)	Macao	Northern Mariana Islands	Norway	New Zealand	Oman	Panama	French Polynesia	Poland
Puerto Rico	Portugal	Palau	Qatar	Saudi Arabia	Sweden	Slovenia	Slovakia	San Marino	Sint Maarten (Dutch part)	Turks and Caicos Islands	Trinidad and Tobago	Taiwan	United States of America	Uruguay	Virgin Islands (U.S.)	
Upper middle income																
Albania	Armenia	American Samoa	Azerbaijan	Bosnia and Herzegovina	Bulgaria	Brazil	Botswana	Belarus	Belize	China	Colombia	Costa Rica	Cuba	Dominica	Dominican Republic	Algeria
Ecuador	Fiji	Gabon	Grenada	Georgia	Equatorial Guinea	Guatemala	Guyana	Iraq	Iran	Jamaica	Jordan	Kazakhstan	Lebanon	Saint Lucia	Sri Lanka	Libya
Montenegro	Marshall Islands	Republic of North Macedonia	Mauritius	Maldives	Mexico	Malaysia	Namibia	Peru	Paraguay	Romania	Serbia	Russian Federation	Suriname	Thailand	Turkmenistan	Turkey
Venezuela	Samoa	Kosovo	South Africa													
Lower middle income																
Angola	Bangladesh	Bolivia	Bhutan	Côte d'Ivoire	Cameroon	Cabo Verde	Djibouti	Egypt	Micronesia	Ghana	Honduras	Indonesia	India	Kenya	Kyrgyzstan	Cambodia
Comoros	Lao People's Democratic Republic	Lesotho	Morocco	Moldova	Myanmar	Mauritania	Nigeria	Nicaragua	Papua New Guinea	Philippines	Pakistan	State of Palestine	Solomon Islands	Sudan	Senegal	El Salvador
Eswatini	Timor-Leste	Tunisia	Ukraine	Uzbekistan	Viet Nam	Vanuatu	Zambia	Zimbabwe								
Low income																
Afghanistan	Burkina Faso	Burundi	Benin	Central African Republic	Eritrea	Ethiopia	Gambia	Guinea	Guinea-Bissau	Haiti	North Korea	Madagascar	Mali	Malawi	Niger	Nepal
Rwanda	Sierra Leone	South Sudan	Syrian Arab Republic	Chad	Togo	Tajikistan	Tanzania, United Republic of		Uganda							
Investment Hubs																
Bahamas	Congo (the Democratic Republic of the)	Congo	Switzerland	Cyprus	Guernsey	Hong Kong	Ireland	Jersey	Saint Kitts and Nevis	Cayman Islands	Liberia	Luxembourg	Mongolia	Malta	Mozambique	New Caledonia
Netherlands	Seychelles	Singapore	Somalia	Saint Vincent and the Grenadines	Virgin Islands (British)											
Not classified																
Bonaire, Sint Eustatius and Saba		Falkland Islands [Malvinas]			Guadeloupe	Martinique	Saint Pierre and Miquelon		Réunion							

Table 21. Number of MNEs by income group of the UPE

Income group of the UPE	Number of MNEs
High income	1,915
Investment Hubs	287
Lower middle income	10
Upper middle income	50
Total	**2,262**

Table 22. Number of MNEs by sector

Sector of the reporting entity	Number of MNEs
Manufacture	877
Other services (different from Financial and insurance)	659
Financial and insurance activities	395
Wholesale and retail trade; repair of motor vehicles and motorcycles	168
Other industrial activities	63
Not known	100

Table 23. CIT rate and Effective average tax rate (EATR) by jurisdiction, 2017

Jurisdiction	CIT rate	EATR	Jurisdiction	CIT rate	EATR	Jurisdiction	CIT rate	EATR	Jurisdiction	CIT rate	EATR	Jurisdiction	CIT rate	EATR
Afghanistan	20.00%	18.50%	Bonaire, Sint Eustatius and Saba	25.00%	23.50%	Croatia	18.00%	15.80%	Gambia	31.00%	27.00%	Ireland	12.50%	12.00%
Albania	15.00%	14.50%	Bosnia and Herzegovina	10.00%	8.50%	Cuba	15.00%	13.50%	Georgia	15.00%	13.50%	Isle of Man	0%	0%
Algeria	26.00%	24.50%	Botswana	22.00%	27.30%	Curaçao	22.00%	20.50%	Germany	29.90%	27.50%	Israel	24.00%	22.90%
American Samoa	27.00%	26.60%	Brazil	34.00%	30.10%	Cyprus	12.50%	10.40%	Ghana	25.00%	23.50%	Italy	27.80%	20.20%
Andorra	10.00%	8.90%	Brunei	18.50%	17.00%	Czechia	19.00%	21.20%	Gibraltar	10.00%	8.50%	Jamaica	25.00%	23.30%
Angola	30.00%	28.50%	Bulgaria	10.00%	9.20%	Denmark	22.00%	19.60%	Greece	29.00%	27.90%	Japan	30.00%	27.40%
Antigua and Barbuda	25.00%	23.50%	Burkina Faso	27.50%	26.00%	Djibouti	25.00%	23.50%	Greenland	30.00%	28.50%	Jersey	0%	0%
Argentina	35.00%	35.50%	Burundi	30.00%	28.50%	Dominica	25.00%	23.50%	Grenada	30.00%	28.50%	Jordan	20.00%	18.50%
Armenia	20.00%	18.50%	Cabo Verde	25.00%	23.50%	Dominican Republic	27.00%	25.50%	Guadeloupe	33.30%	31.80%	Kazakhstan	20.00%	18.50%
Aruba	25.00%	23.50%	Cambodia	20.00%	18.50%	Ecuador	22.00%	20.50%	Guam	35.00%	33.50%	Kenya	30.00%	26.20%
Australia	30.00%	29.90%	Cameroon	33.00%	31.50%	Egypt	22.50%	21.00%	Guatemala	25.00%	23.50%	Kosovo	10.00%	8.50%
Austria	25.00%	23.80%	Canada	26.70%	25.20%	El Salvador	30.00%	28.50%	Guernsey	0%	0%	Kuwait	15.00%	13.50%
Azerbaijan	20.00%	18.50%	Cayman Islands	0%	0%	Equatorial Guinea	35.00%	33.50%	Guinea	35.00%	33.50%	Kyrgyzstan	10.00%	8.50%
Bahamas	0%	0%	Central African Republic	30.00%	28.50%	Eritrea	34.00%	32.50%	Guinea-Bissau	25.00%	23.50%	Lao People's Democratic	24.00%	22.50%
Bahrain	0%	0%	Chad	35.00%	33.50%	Estonia	20.00%	17.00%	Guyana	27.50%	26.00%	Latvia	15.00%	13.60%
Bangladesh	25.00%	23.50%	Chile	25.00%	31.10%	Eswatini	27.50%	17.40%	Haiti	42.80%	41.30%	Lebanon	15.00%	13.50%
Barbados	25.00%	23.50%	China	25.00%	23.50%	Ethiopia	30.00%	28.50%	Honduras	25.00%	23.50%	Lesotho	25.00%	23.50%
Belarus	18.00%	16.50%	Colombia	40.00%	38.50%	Falkland Islands [Malvinas]	26.00%	24.50%	Hong Kong	16.50%	15.20%	Liberia	25.00%	23.50%
Belgium	34.00%	26.10%	Comoros	35.00%	33.50%	Faroe Islands	18.00%	16.50%	Hungary	9.00%	10.00%	Libya	20.00%	18.50%
Belize	25.00%	23.50%	Congo	0%	0%	Fiji	20.00%	18.50%	Iceland	20.00%	18.30%	Liechtenstein	12.50%	10.10%
Benin	30.00%	28.50%	Congo (the Democratic Republic of the)	35.00%	31.60%	Finland	20.00%	19.10%	India	47.90%	45.40%	Lithuania	15.00%	13.40%
Bermuda	0%	0%	Cook Islands	28.00%	26.50%	France	44.40%	32.60%	Indonesia	25.00%	22.30%	Luxembourg	27.10%	24.60%
Bhutan	30.00%	28.50%	Costa Rica	30.00%	37.30%	French Polynesia	35.00%	33.50%	Iran	25.00%	23.50%	Macao	12.00%	11.50%
Bolivia	25.00%	23.50%	Côte d'Ivoire	25.00%	24.30%	Gabon	30.00%	28.50%	Iraq	15.00%	13.50%	Madagascar	20.00%	18.50%

Malawi	30.00%	28.50%	Niger	30.00%	28.50%	Saint Martin (French part)	30.00%	28.50%	Sweden	22.00%	20.40%	Virgin Islands (British)	0%	0%		
Malaysia	24.00%	22.50%	Nigeria	30.00%	28.50%	Saint Pierre and Miquelon	33.30%	31.80%	Switzerland	21.20%	19.60%	Virgin Islands (U.S.)	35.00%	33.50%		
Maldives	15.00%	13.50%	North Korea	22.00%	20.50%	Saint Vincent and the Grenadines	32.50%	31.00%	Syrian Arab Republic	28.00%	26.50%	Yemen	20.00%	18.50%		
Mali	30.00%	28.50%	Northern Mariana Islands	35.00%	33.50%	Samoa	27.00%	25.50%	Taiwan	17.00%	15.50%	Zambia	35.00%	33.50%		
Malta	35.00%	33.10%	Norway	24.00%	23.30%	San Marino	17.00%	15.50%	Tajikistan	14.00%	12.50%	Zimbabwe	25.00%	23.50%		
Marshall Islands	0%	0%	Oman	15.00%	13.50%	Saudi Arabia	20.00%	18.10%	Tanzania, United Republic of	30.00%	28.50%					
Martinique	33.30%	31.80%	Pakistan	31.00%	29.50%	Senegal	32.50%	26.90%	Thailand	20.00%	22.50%					
Mauritania	25.00%	23.50%	Palau	0%	0%	Serbia	15.00%	16.70%	Timor-Leste	10.00%	8.50%					
Mauritius	15.00%	14.00%	Panama	25.00%	23.50%	Seychelles	30.00%	28.40%	Togo	28.00%	26.50%					
Mexico	30.00%	26.80%	Papua New Guinea	30.00%	26.30%	Sierra Leone	30.00%	28.50%	Trinidad and Tobago	25.00%	23.50%					
Micronesia	0%	0%	Paraguay	10.00%	8.50%	Singapore	17.00%	16.30%	Tunisia	25.00%	23.50%					
Moldova	12.00%	10.50%	Peru	29.50%	27.70%	Sint Maarten (Dutch part)	34.50%	33.00%	Turkey	20.00%	18.20%					
Monaco	33.30%	31.80%	Philippines	30.00%	28.50%	Slovakia	21.00%	22.50%	Turkmenistan	20.00%	18.50%					
Mongolia	25.00%	23.50%	Poland	19.00%	17.80%	Slovenia	19.00%	18.10%	Turks and Caicos Islands	0%	0%					
Montenegro	9.00%	7.50%	Portugal	29.50%	24.00%	Solomon Islands	30.00%	28.50%	Uganda	30.00%	28.50%					
Morocco	31.00%	29.50%	Puerto Rico	39.00%	37.50%	Somalia	35.00%	33.50%	Ukraine	18.00%	16.50%					
Mozambique	32.00%	30.50%	Qatar	10.00%	8.50%	South Africa	28.00%	27.10%	United Arab Emirates	0%	0%					
Myanmar	25.00%	23.50%	Republic of North Macedonia	10.00%	8.50%	South Korea	24.20%	22.50%	United Kingdom of Great Britain and Northern Ireland	19.00%	18.90%					
Namibia	32.00%	30.50%	Réunion	33.30%	31.80%	South Sudan	35.00%	33.50%	United States of America	38.90%	37.50%					
Nepal	25.00%	23.50%	Romania	16.00%	14.30%	Spain	25.00%	25.00%	Uruguay	25.00%	23.50%					
Netherlands	25.00%	22.60%	Russian Federation	20.00%	18.80%	Sri Lanka	28.00%	26.50%	Uzbekistan	8.00%	6.50%					
New Caledonia	25.00%	23.50%	Rwanda	30.00%	28.50%	State of Palestine	15.00%	13.50%	Vanuatu	34.00%	32.50%					
New Zealand	28.00%	27.00%	Saint Kitts and Nevis	0%	0%	Sudan	35.00%	33.50%	Venezuela	34.00%	32.50%					
Nicaragua	30.00%	28.50%	Saint Lucia	30.00%	28.50%	Suriname	36.00%	34.50%	Viet Nam	20.00%	18.50%					

Source: OECD and KMPG for CIT rates. OECD and Oxford University Centre for Business Taxation for EATR. In absence of EATR, authors' approximation (see infra).