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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 analyze profit-shifting behavior of Multinational Enterprises (MNEs) using a novel and unique dataset composed of Country-by-Country Reports (CbCRs) for year 2017 compiled worldwide by all MNEs having at least a subsidiary in Italy. By accessing CbCRs we are able to estimate BEPS - base erosion and profit shifting - using a firm-level data with a better representativeness than commonly used dataset. In fact, many studies are based on available large financial accounts databases that under-represent specific subset of firms and locations such as activities carried out in investment hubs. We provide evidence of this under-representativeness in this work. Our paper, apart from providing an estimation of BEPS as a response to CIT rates by applying the standard linearity assumption, follows recent work into analysing the existence of nonlinear responses to taxation. We go beyond preceding work by exploring non-linearity in a dataset composed of MNEs of all nationalities - thus providing evidence of the existence of a strong non-linear response in a more diversified dataset - and by focussing on the non-linear response of profit shifting to tax rate differentials and not only to CIT rates. We find that profit allocation in a country is non-linearly dependant to the differences in tax rate with respect to the average CIT rate faced by the MNEs in the rest of the world. We further investigate non-linearity pointing out that quadratic estimation presents some issues in countries with high CIT rate. We therefore provide a higher degree, cubic, estimation as a solution to these caveats. We find that the effect of changes in CIT rate differential over profit allocation is statistically and economically significant when allowing for an inverse U shaped semi-elasticity. Finally, we estimate profit shifting and revenue losses. We find that in 2017 a total of € 887 billion of profits was shifted due to differences in tax rates with a global revenue loss of € 245 billion. The distribution of shifted profits is found to be highly concentrated in few countries and this result may have relevant policies implications, suggesting that international tax reforms aimed at guaranteeing a minimum level of taxation may be very effective in reducing the incentive for MNEs to locate profits in these jurisdictions only based on tax reasons, thus may be a very efficient way to reduce BEPS.

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Il lavoro analizza il *profit shifting* delle multinazionali utilizzando un dataset inedito e unico costituito dai *Country-by-Country Report* (CbCR) per l'anno finanziario 2017, compilati a livello mondiale dalle multinazionali che hanno almeno una filiale in Italia. L'analisi dei CbCR consente di stimare il fenomeno BEPS (*base erosion and profit shifting*) utilizzando microdati con una rappresentatività migliore dei dataset comunemente usati. Molti studi sono, infatti, basati su database in cui alcune categorie di imprese e di paesi, quali gli *investment hubs*, sono sotto-rappresentati. Nel paper viene fornita evidenza di questa differenza di rappresentatività. L'analisi, oltre a fornire una stima del *profit shifting* in risposta alle aliquote della tassazione societaria tramite una stima lineare, si colloca nel solco di recenti lavori che analizzano l'esistenza di una risposta non lineare alla tassazione. Rispetto a precedenti lavori, tuttavia, l'assunzione di non linearità è applicata in un dataset costituito da multinazionali di tutti i paesi - fornendo quindi evidenza di una forte risposta non lineare in un dataset più diversificato – e si concentra sui differenziali di aliquota e non solo sul livello delle aliquote. I risultati mostrano che l'allocazione di profitti in un paese è non linearmente dipendente dalla differenza tra l'aliquota del paese e l'aliquota media sostenuta dalla multinazionale nel resto del mondo. La non linearità viene ulteriormente esplorata evidenziando alcune incongruenze dell'assunzione di una risposta quadratica in paesi con aliquota molto elevata. Viene quindi applicata una stima di grado più alto, cubico, al fine di risolvere tali incongruenze. I risultati mostrano che l'effetto di un cambiamento nel differenziale di aliquota sul profitto allocato è statisticamente ed economicamente significativo quando si consente alla funzione di semi-elasticità di assumere una forma a U rovesciata. Viene infine stimato l'ammontare di *profit shifting* e la perdita di gettito ad essa associato. I risultati mostrano che nel 2017, 887 miliardi di euro di profitti sono stati spostati in risposta a differenze nel livello di aliquota societaria, producendo una perdita di gettito globale di 245 miliardi di euro. La distribuzione dei profitti spostati è risultata altamente concentrata in pochi paesi e questo risultato può avere importanti implicazioni di *policy*, suggerendo che riforme fiscali internazionali volte a garantire un livello minimo di tassazione possono essere molto efficaci nel ridurre l'incentivo per le multinazionali a localizzare i profitti in queste giurisdizioni solo sulla base di ragioni fiscali, quindi possono essere un modo molto efficiente per ridurre i fenomeni di BEPS.

Keywords: BEPS, Profit shifting, International taxation, corporate income tax, multinationals

JEL: H25, H26, H32, F23

1 Introduction

Multinational corporations (MNEs) are at the centre of a heated and long-standing debate on the amount of tax liability they effectively pay. In the past decade, the leakage of documents such as the LuxLeaks and the increased media attention on news regarding tax paid by MNEs, have ignited the debate by providing anecdotal evidences that multinational firms are capable of reducing their tax liability up to almost a complete annihilation.

This rising attention to MNEs base erosion and profit shifting (BEPS) behaviour has been accompanied by a crescent heterogeneity among firms. Possibly driven by the exploitation of economy of scale, by the increasing digitalisation and a persistent globalisation reaching every part of the globe, there is plenty of evidence that firms have become larger and sales more concentrated within superstar firms (Van Reenen, 2018).

The contraposition between an increased relevance of multinational enterprises with the corresponding fall in the importance of domestic firms together with evidence of increased mark-ups (Hall, 2018) and fall in labour share of GDP (Autor et al., 2020) has created a perfect environment for the rising widespread social discontent toward the "big ones" not paying "their fair share" of taxes.

From the policy perspective, the OECD, with the BEPS Project, took a major initiative. By identifying the main channels of profit shifting, the 15 Actions within the BEPS project provided guidelines so to curb the use of these channels by the MNEs.

Despite the importance of the issue and the actions undertaken so to limit it, a precise estimation of BEPS has always being difficult to achieve.

This increasing relevance of BEPS within the international taxation debate 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), OECD (2015), Heckemeyer and Overesch (2017) and more recently by Beer, de Mooij and Liu (2020). While methodologies and magnitude of results may vary, the papers provided 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 use macroeconomic data (see Crivelli, de Mooij and Keen 2015, Acciari et al. 2015, Bolwijn et al. 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).

Papers using macro data often use national accounts for measuring gross operating surplus, in combination with FDI, Balance of Payments and trade information used to inform on mispricing and capital flow among jurisdictions. More recently, a new strand of literature is using foreign affiliates statistics (FATS) as they provide better coverage of profits allocation among tax havens (Tørsløv, Wier and Zucman 2018).

Alternatively, papers using micro economic approaches exploit firm-level data to study the effect of tax rate differentials among countries. These papers usually use Orbis database of Bureau van Dijk (Orbis BvD) as it reports financial accounts firm-level data worldwide; other country specific firm-level dataset are sometimes used, however these often lack of data of foreign firms, which are not included.

Each one of the two approaches has positive aspects and drawbacks, the discussion that follows does not intend to be exhaustive and it is meant to provide a useful background against which to assess the strengths and benefits of the approach undertaken in the present paper.

By observing macroeconomic variables and flows among countries, the macro approach is capable of capturing some channels of BEPS, such as interest payments related to debts or royalties flow, that may not be captured in micro estimates due to scarcity of data on debt and royalties at firm-level. One of the drawbacks of using the macro approach, however, consists of the difficulty of disentangling flows related to real economic activities from those related to profit shifting. As macro data report aggregate information on firms, they are inadequate to investigate the profit allocation decisions within each MNE among different branches.

Micro approach uses firm-level data to capture the correlation between allocation of profits by MNE in each jurisdiction with either the corporate income tax in the country or the difference between the rate and the average rate observed abroad by the MNE. By focussing on just corporate income tax rate, the micro approach is not able to capture other profit shifting channels that are not correlated with CIT rate; however, by having information at firm-level, this approach is able to disentangle real from tax-related determinants of profit allocation.

The majority of the literature within the micro-data approach uses Orbis BvD dataset to estimate profit shifting. Despite being one of the most used and complete firm-level dataset that was accessible until now, one of the most relevant caveat of using Orbis is the lack of data for specific subset of countries and firms. More specifically, Orbis shows an important

under-representation of American firms, firms located in United States and firms located in investment hubs or tax havens. Evidences of this under-representativeness have been provided by the literature; see also Tørsløv, Wier and Zucman (2018). Section 2.2 reports additional evidences of this issue. The low coverage of these specific subsets of companies and countries is a major problem in estimating BEPS. As more profit shifting is expected to be conveyed through tax havens or investment hubs, by not observing profits in these countries, estimates obtained may be strongly biased. At the same time, as the American MNEs are an important part of the MNEs worldwide, by providing limited coverage of these firms, BEPS analysis based on Orbis may overlook a significant part of the story.

Our paper first into the micro-based strand of literature by exploiting a new dataset on MNEs: Country by Country Reporting (CbCR).

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, namely presenting global revenues above € 750 million. It provides firm-level information for each MNE in every country in which the company is present.

By using CbCR, we are able to overcome the issues arising with the under-representativeness of Orbis BvD data as firms must file their information in every jurisdiction in which they are present. More detailed information on CbCR is provided in Section 2.

A first contribution to the literature that we make, consists of estimating BEPS using for the first time a firm-level data on MNEs' global structure that does not lack in representativeness of the specific subset of firms and locations under-represented in Orbis. Section 2.2 will describe in more details how representativeness of American firms and investment hubs is different from the Orbis one.

An additional benefit of using CbCR consists in the clearness of the connections among firms within the same multination group. As the perspective of the CbCR is the MNE group, 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 to estimate profit shifting taking into account all locations where the MNE is present. Differently, in Orbis, the recognition of the MNE group and of its operations by country is not immediate, requires multiple steps so to build an ownership matrix that however lacks of precision.

In terms of results found in the literature, econometrics analyses report semi elasticity of pre-tax profit to CIT tax rate differential of around -1, thus implying that a one-percentage point increase in tax rate differential is correlated with a decrease of profits in the country of about -1%. More in detail, the meta-analysis carried out by Heckemeyer and Overesch (2017) found a semi-elasticity of -0.8, while Huizinga and Laeven (2008) observed a -1.3 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 they observe that estimates using micro data are lower, in absolute terms, than the estimates obtained in macro analyses. Furthermore, the recent paper by Dharmapala (2019) examines the differences between micro and macro estimates; while her 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 foreign profits of MNEs are shifted to tax havens (Tørsløv, Wier and Zucman 2018).

The papers carrying out the micro-based BEPS estimation, assume a linear relationships between profit allocation and taxation. A first deviation from this assumption has been made by Dowd, Landefeld and Moore (2017). While their linear regression shows a semi-elasticity of -1.3, 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, despite providing an estimation of BEPS by applying the standard linearity assumption, is mostly related to Dowd, Landefeld and Moore (2017) in that it analyses non-linearity in MNEs behaviour. Similarly to Dowd et al., we investigate the existence and the magnitude of non-linearity in firms response to changes in CIT rate. We found strong evidence that this phenomenon exists and it is of significant statistical and economic importance.

We further develop this analysis and go beyond Dowd et al. in different directions. Firstly, we provide estimates of 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 behind profit shifting. 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's subsidiaries. Thus, the differential among rates is the best determinant for profit shifting decision. Secondly, we estimate non-linear elasticities on a set of MNEs with different nationality, thus, differently from Dowd et al., we do not restrict our analysis only to the US MNEs. Finally, by recognising that the quadratic relation imposed by Dowd et al. produces counterintuitive results in countries with high enough CIT rates, we propose and test a cubic specification, finding it to

be statistically significant and capable of better performing in countries with higher than average CIT rates.

The assumption of a quadratic relation, despite being an obvious choice as a first step for analysing the existence of non-linearity, produces undesired effects in the elasticity estimation. By assuming the quadratic behaviour, the semi-elasticity will appear as an increasing line; this implies that, for countries with high enough CIT rate, the semi-elasticity becomes positive thus suggesting that increases in CIT rates may induce to higher profit allocation in the country, which appears counterintuitive.

By using a further degree specification, we allow elasticity to be estimated with less functional restrictions and this allows us to overcome the positive-elasticity problem. The cubic specification implies higher negative semi-elasticity, in countries with CIT rate far below the average, an almost zero negative semi-elasticity when countries' CIT rates are near the average and a further increase in negative semi-elasticity, in absolute terms, for countries with a rate way above the average. Those aspects are analysed in detail in Section 4 and in Figure 4 and Figure 5.

Estimating both linear and non-linear elasticity we provide further evidence that the linear approach over-estimate BEPS 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 have a similar CIT rate, and being the majority of profits allocated in high-income countries, linear estimation of BEPS may deliver too big result. Finally, as 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 few low-tax jurisdictions so to minimize profit shifting while at the same time not overburdening tax compliance in countries with average rates. Agreements on the matters of international corporate income taxes may be also easier to reach if their impact is mainly restricted toward a limited, yet significant in terms of profit shifting, subset of countries.

The paper is organised as follows. Section 2 describes the data, provides a comparison between CbCR and Orbis BvD in terms of geographic coverage before showing some descriptive statistics of the dataset. Section 3 describes 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. Section 5 provides an estimation of the amount of shifted profit and of the induced revenue losses. Section 6 concludes.

2 Data

2.1 About the Country by Country Report

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 presenting global consolidated revenues of at least € 750 million.

MNEs must compile CbCR in the jurisdiction of tax residence of the Ultimate Parent Entity (UPE) or, in some circumstances, the report may be filed in another country via a surrogate parent entity or through local filing[2]. Tax administrations exchange the information contained in the CbCR on an automatic basis with all 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 its domestic MNEs and on foreign MNEs that operate in the country.

Within the CbCR, MNEs report information on a set of variables, notably profits, revenues, split in revenues from related and unrelated party, taxes paid, number of employees and tangible assets; all variables are reported broken down on a Country-by-Country basis.

The uniqueness of the CbCR dataset lies in its extensive geographic coverage, in the combination in one single source of financial and tax information and in the possibility to connect the activities of entities carried out in different jurisdictions to the MNE group to which they belong.

CbCR data on which this study is based are CbCRs filed by MNEs that have their Ultimate Parent Entity in Italy and by all MNEs having at least one subsidiary in Italy. Being Italy both a relevant manufacturing country (the second one in Europe) and an important market, the presence of MNEs in Italy is extensive and the coverage of the dataset is quite satisfactory, as described below.

[2] For a more detailed description of the structure of the CbCR, of its comparison with existing data sources and of challenges related to the use of CbCR see Santomartino, Bratta, 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.

The data present some caveats that can be grouped in structural and transitory ones.

As to transitory caveats, they mainly refer to 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 the one carried out by Santomartino, Bratta, Acciari (2020).

As to structural caveats, the main concerns are the possible inclusion by MNEs of intra-company dividends within the profits variable and the absence in the dataset of MNEs with total revenue below €750 million. As regard dividends, the first version of the OECD guidelines on CbCR did not explicitly address if they had to be included or not in the profit variable. Despite "profits before taxes" in financial accounts normally include dividends, the inclusion of dividends into profits might cause problems of double counting when computing effective tax burden of MNEs. As an example, a holding 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 profits. This caveat is addressed in the analysis mainly by using proxies to identify the country where dividend concentration may be more relevant. As regards the €750 million threshold, we address this caveat by applying a correction in the revenue estimation to account for smaller MNEs.

2.2 Comparison with Orbis dataset

In this section, we provide a comparison between CbCR and Orbis BvD data in terms of amounts reported and geographical coverage. As Orbis has been among the most used dataset for micro-founded BEPS estimation, by comparing the two dataset, we provide evidence on the advantages of using CbCR in terms of increased geographic coverage.

As to better align the two dataset, we compare CbCR data with Orbis data referring to MNEs with total revenue of at least € 750 million and having at least one subsidiary in Italy[3].

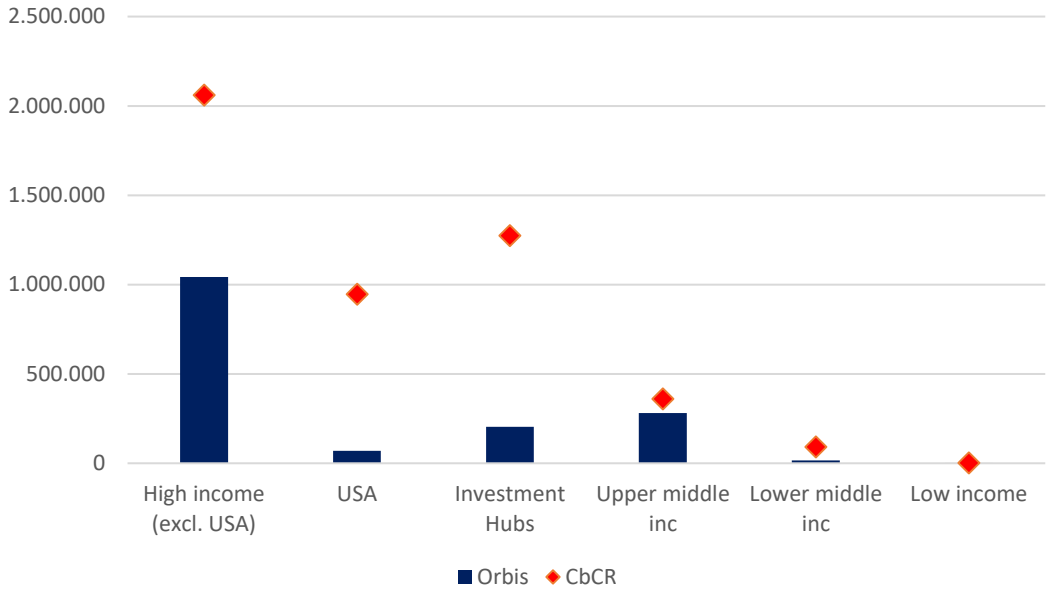
One of the most important caveat of using Orbis data lies in the low geographical coverage of some specific countries and firms from specific nationalities. The low geographical coverage

[3] The dataset has been constructed by connecting Italian tax return information to Orbis data. Using the ownership structure available in Orbis we compute the total turnover by MNE group. Data refers to 2016 due to availability of data issue, however we do not expect that a different reference year would change relevantly the overall distribution and coverage of the dataset.

refers to an under-representation of US MNEs, of non US MNEs located in the United States and to a low coverage of MNEs operating in low-tax and investment hubs countries.

Figure 1 reports pre-tax profits in CbCR and in Orbis across country groups classified by income levels[4]. Table 14 in Appendix lists countries by their income group classification. Data refers to the location of the subsidiaries. The separate representation of the United States from its income level group is intended to provide further insights on the extent of the under-representation of MNEs in US in the Orbis 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 euro reporting at least one subsidiary in Italy.
Notes: Income group classification follow the World Bank classification. We define Investment Hubs the jurisdictions with inward FDI stock over GDP above 150% in line with the OECD approach (OECD, 2020)

Profits reported in United States in Orbis account for around € 70 billion, a value that clearly shows the under-representation of MNEs in US in the BvD dataset, especially if compared with profits reported in the CbCR equal to € 946 billion. Additionally, by reporting € 1.3 trillion of profits in the investment hubs, CbCR provides a better coverage also for these countries. Differently, Orbis, by reporting a total of € 204 billion, does not seem to be a

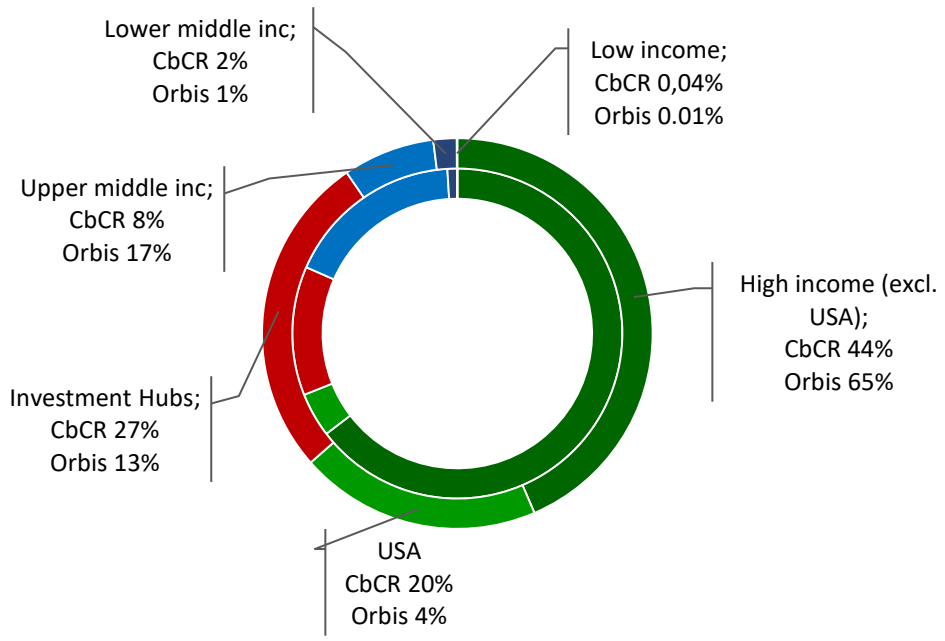
[4] Following OECD (2020), countries included in the Investment Hubs category are British Virgin Islands, Cayman Islands, Cyprus, Malta, Hong Kong, Singapore, Liberia, Ireland, Luxembourg, Mozambique, Anguilla, the Netherlands, Switzerland, Bahamas, Congo, Seychelles, Saint Vincent and the Grenadines, Saint Kitts and Nevis, New Caledonia, Mongolia, Somalia Guernsey and Jersey.

suitable dataset for analysing investment hubs. Profits reported in the CbCR dataset are higher than in the Orbis data also for the other income groups, indicating an overall broader coverage of CbCR data with respect to Orbis data. Results are consistent even when looking at other variables such as total revenue, also in this case CbCR outperform Orbis in terms of data coverage.

More in detail, Figure 2 shows the coverage of the two dataset for different income groups in terms of percentage of the 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 per cent of global profits in the Orbis dataset. Investment hubs account for 27 per cent of total profits in the CbCR dataset, while the coverage is lower – only equal 13 per cent – in Orbis data.

Similar conclusions can be drawn by looking at the comparison between the two dataset when looking at the distribution of profits and revenues by income group of the Ultimate Parent Entity (UPE). In Orbis, profits and revenues of MNEs based in the US account respectively for 18 per cent and 15 per cent of the world total, whereas they account respectively for 30 per cent and 35 per cent 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 fiscal year 2017 and Orbis BvD for 2016. Both the data refer to MNEs with total revenue above €750 million euro reporting at least one subsidiary in Italy.
Notes: Income group classification follow the World Bank classification. We define Investment Hubs the jurisdictions with inward FDI stock over GDP above 150% in line with the OECD approach (OECD, 2020)

Overall, the analysis provided in this Section shows that CbCR dataset appears to provide a better coverage of activities of MNEs; by covering some country groups that were previously under-represented, it also competes to be among the best dataset to be used to analyse multinational activity worldwide and to estimate BEPS.

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).

2.3 Data description and Statistics

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

The descriptive statistics refers to the sample used in the econometrical analysis and, thus, we drop observations for which either we do not know country's number of employees, tangible assets and unrelated party revenues or if their value is zero.

We therefore end up with a dataset composed of 46,563 observations, where each observation contains financial information of an MNE in a jurisdiction.

The observations refer to 2,262 MNEs being located in 221 countries. 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. Clearly, as each MNE may be located in multiple geographical area, the number of MNEs in every area does not sum up to the total number of MNEs in the sample.

In terms of geographical area of the Ultimate Parent Entity, 1,193 are European MNEs, 750 are Americans MNEs, 307 have an UPE in Asia and Oceania and 12 are African MNEs. Additional information on UPE characteristics (i.e. sector and income group of the UPE's country) is reported in the Appendix.

Table 1 reports some descriptive statistics of the data used in the analysis for profits (only positive ones), unrelated parties revenues, total revenues, tangible assets and employees by geographic area of subsidiaries. The table reports both the average value and the totals.

Europe reports the highest values of all variables while the American continent reports the highest averages, thus implying that, on average, MNEs subsidiaries located in the Americas are bigger, in terms of average profits, revenues, tangible assets and number of employees.

Table 1. Descriptive Statistics by geographic area of subsidiaries

		Geographic Area of subsidiaries			
		Europe	Americas	Asia & Oceania	Africa
Positive Profits	Average	101	172	79	21
	Total	2,289,160	1,320,656	1,072,624	51,255
Unrelated Parties Revenue	Average	389	1,006	460	102
	Total	8,857,949	7,746,768	6,270,045	254,661
Total Revenues	Average	666	1,430	692	145
	Total	15,152,153	11,009,032	9,425,283	359,788
Tangible Assets	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

Source: Authors calculations based on CbCR data for fiscal year 2017 and coincides with the sample used in the econometric analysis.
Notes: 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 where they are reported.

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 the ones from Asia and Oceania (Table 2).

Table 2. Descriptive statistics by geographic area of the Ultimate Parent Entity (UPE)

		Geographic Area of the UPE			
		Europe	Americas	Asia & Oceania	Africa
Positive Profits	Average	109	86	112	59
	Total	2,702,032	1,305,465	714,159	12,039
Unrelated Parties Revenue	Average	451	477	727	409
	Total	11,189,441	7,227,440	4,629,478	83,063
Total Revenues	Average	714	721	1,126	550
	Total	17,731,232	10,932,407	7,170,868	111,749
Tangible Assets	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 fiscal year 2017 and coincides with the sample used in the econometric analysis.
Notes: 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 3 reports average profits by income group. 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%[5].

While average profits decline steadily moving from high income to low income countries, investment hubs report extremely high average profits values.

As high profits allocated in a jurisdiction may be correlated by high value of tangible assets and therefore high remuneration, we compare profits allocation with the ratio of tangible assets over profit. Figure 3 shows that the high presence of profits in investment hubs does not seems to correlate with a correspondent high level of tangible assets since the ratio of

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

tangibles over profits is the lowest in investment hubs. This comparison seems to point out that tangible assets do not explain the high profitability in this group of countries.

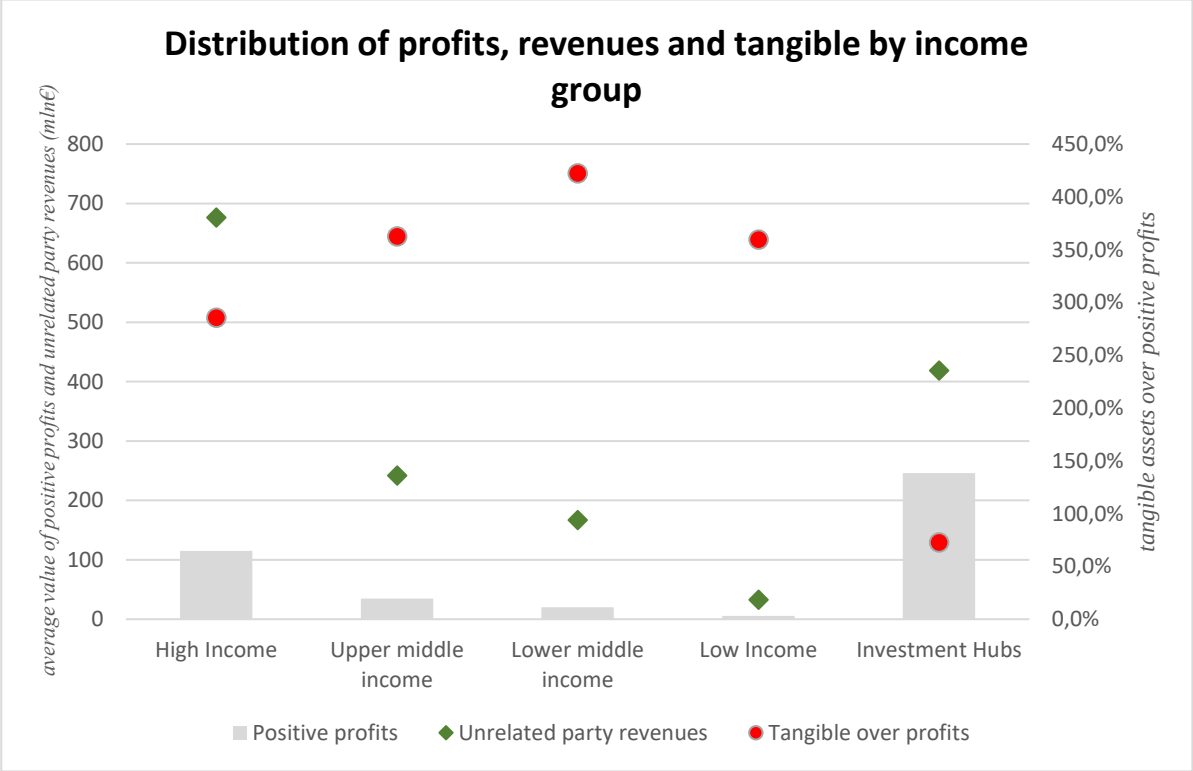
Next we see if the high value may be correlated with extremely high revenues, green rhomboids represents the average unrelated party revenues in each income group. Revenues appear higher in investment hubs than in low and middle-income countries; however, they are lower than revenues reported in high income countries. Despite higher revenues can be found in investment hubs, the difference of profits between investment hubs and high-income countries, does not seem to be explained by the difference in revenues. Similar conclusions can be drawn by looking at number of employees, as they do not explain the high profits in investment hubs.

All the above statistics seem to suggest that further investigation should be done so to analyse profit allocation among countries.
We therefore collect information on statutory CIT rate for all the 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.
We also collect information on the corporate Effective Average Tax Rate (EATR) 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 would not report EATR for a specific country). In absence of the data on EATR in both the datasets, we approximate the EATR as follows. We impose EATR to be zero in countries having zero CIT rate; for the remaining part 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.

Table *17* report for every jurisdiction the statutory and the effective CIT rate.

The next section will describe the econometric analysis undertaken to estimate how taxation affects profits allocation in each country.

Figure 3. Distribution of profits, revenues and tangible by income group



Source: Authors calculations based on CbCR data for fiscal year 2017 and coincides with the sample used in the econometric analysis.
Notes: 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. Income group classification used is the one 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).

3 Methodology

We commence our analysis by examining different proxies for estimating tax treatments effects over profit allocation. We identify three main baseline scenarios and we provide, for each of them, a linear estimation of the effect of taxation on profit allocation.

In the first baseline scenario, we use statutory corporate income tax rate. In the second baseline scenario, we use the tax rate differential, meaning the difference between the statutory CIT rate of the country where the subsidiary is located and the average CIT rate faced by the other subsidiaries of the same group located in all other countries. In the third scenario, we introduce

the forward-looking effective average tax rates (EATRs), therefore estimating the effect of the tax rate differential by using the effective rather than the statutory rates. In this latter case we are able to take into account also the composition of the corporate tax base and not only the tax rate.

Once we estimate the linear coefficients, we investigate the role of non-linearity. Firstly, we introduce a quadratic term and later on we assume a cubic relation between tax rates differential and profit allocation.

3.1 Baseline Scenario

We start by estimating the effect of an increase in statutory corporate income tax rate over profits allocated in the country. The first specification is described in the following equation

$$ln(\pi_{c,m}) = \beta_0 + \delta_1 \ln(\mathrm{K_{c,m}}) + \delta_2 \ln(L_{c,m}) + \delta_3 \ln(R_{c,m}) + \beta_1(\tau_c) + \boldsymbol{X}_m + \boldsymbol{\Psi}_c + \epsilon_{c,m} \qquad (1)$$

Where $\pi_{c,m}$ is profit allocated by the MNE m in country c; $\mathrm{K_{c,m}}$, $L_{c,m}$ 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, they control for the economic activity carried out by the MNE in that jurisdiction. Taxation affects profit allocation through the statutory CIT rate in country c (τ_c).

We estimate (1) by controlling for country and MNEs characteristics and by controlling for the effect on profits of the country where the ultimate parent entity (UPE) is located. As one of the caveat of using CbCRs consists of the possible inclusion of intra-company dividends within profits, we use UPE dummy variable to control for this problem, as far as intra-company dividends are allocated mainly to the country of the UPE, we are able to take this issue into account.

MNEs controls consist of total MNE's unrelated party revenues, group's tangible assets (both in logarithm), the total number of employees, a dummy for the nationality of the UPE and sector (4 digits) dummy variables. As mentioned, we also include a dummy variable that is equal to one if the MNE has the UPE in the country, so to take into account possible magnifying effects on profits allocation in the country of the UPE. We control for country's characteristics using the logarithm of GDP, Population and its square.

For a more robust specification, we also include MNE fixed effects to control also for constant unobservable characteristics of the group instead of using observable MNE specific control variables. As every MNE is present in multiple countries, we are able to exploit geographical variation to control for unobservable MNE characteristics through MNE fixed effects. Similarly to Huizinga and Leaven (2008), we depart from the use of the statutory CIT rate and we estimate the effect of the differential between the CIT rate and the average CIT rate of the MNE group. The differential is the best approximation for the tax saving driven by differences in taxation, 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 the profit 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 vastly in the literature on BEPS.

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

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

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 the countries apart from c ($\overline{\tau}_{m,-c}$). Consistently as before, we control for MNE characteristics either using the previously described control variables or by using MNE fixed effects.

Our third baseline linear model includes forward looking EATR in the analysis; we first estimate the effect of an increase in EATR on profit allocation and next we estimate the effect of the tax differential between the country EATR and the average EATR of the countries where the other subsidiaries of the group are located.

3.2 Role of non-linearity

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.

Dowd, Landefeld and Moore (2017) however, found strong evidence of non-linearity in elasticity, finding that an increase in tax rate has a much larger negative effect on reported profits in countries with substantially lower tax rates.

In line with their paper, we start by looking at 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 go beyond Dowd et al. in different directions. Firstly, we provide estimates of elasticity of profit allocation with respect to CIT rate differentials and not just CIT rates. Secondly, we provide evidence that non-linear relation is persistent also when analysing MNEs of multiple nationalities, as, differently from Dowd et al., we do not restrict our analysis only to the US MNEs.

We therefore regress equation (3); $\mathrm{T_{c,m}}$ is either the statutory CIT rate, the forward looking EATR or the difference of each of them with respect to the MNE's average (computed by excluding the country under analysis).

$$ln(\pi_{c,m}) = \beta_0 + \delta_1 \ln(\mathrm{K_{c,m}}) + \delta_2 \ln(L_{c,m}) + \delta_3 \ln(R_{c,m}) + \beta_1 \mathrm{T_{c,m}} + \beta_2 \mathrm{T_{c,m}^2} + \boldsymbol{X}_m + \boldsymbol{\Psi}_c + \epsilon_{c,m} \quad (3)$$

Finally, by recognising that the quadratic relation imposed by Dowd et al. produces puzzling results in countries with high enough CIT rates, we propose and test a cubic specification. We therefore allow for a further general formulation of the role of tax rate over profit allocation by estimating the elasticity of profit allocation with respect to the tax rate differential using equation (4).

$$ln(\pi_{c,m}) = \beta_0 + \delta_1 \ln(\mathrm{K_{c,m}}) + \delta_2 \ln(L_{c,m}) + \delta_3 \ln(R_{c,m}) + \beta_1 \mathrm{T_{c,m}} + \beta_2 \mathrm{T_{c,m}^2} + \beta_3 \mathrm{T_{c,m}^3} + \boldsymbol{X}_m + \boldsymbol{\Psi}_c + \epsilon_{c,m} \quad (4)$$

4 Results

Table 3 reports the results from estimating equation (1). The estimated linear coefficients are in line with the ones observed in the literature. Similar to the results of Heckemeyer and Overesch (2013), who find an average semi-elasticity of -0.8, we find that an increase of one percentage point in statutory corporate income tax rate decreases profit in the country between 0.78% and 0.7%. Column 2 includes group fixed effects to control for unobservable constant characteristics of the MNE.

Table 4 reports the semi-elasticity of profits allocation to changes in tax rate differentials following equation (2). We find that an increase in one percentage point in tax rate differential corresponds to a decrease in profits between 0.68% and 0.83%.

The first two specifications use the statutory corporate income tax rates as a proxy of corporate taxation on profit allocated in the jurisdiction. 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 first extension, we introduce the forward-looking effective average tax rates (EATRs). By computing the corporate income tax rate of each country taking into account also tax credits, tax deductions and tax allowances, EATRs are better suited for having a more comprehensive estimation of a country corporate income taxation. Table 5 reports the coefficients estimated using the EATRs.

The semi-elasticity of profits 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. An increase of one percentage point in EATR corresponds to a reduction of about 1% in profits allocated in the jurisdiction.

Table 3. Baseline linear regression using Statutory CIT rates

VARIABLES	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$
$\boldsymbol{\tau_c}$	**-0.779*** **	**-0.700*** **
	(0.0918)	(0.0849)
$\ln(K_{c,m})$	0.211***	0.186***
	(0.00560)	(0.00612)
$\ln(R_{c,m})$	0.249***	0.253***
	(0.00506)	(0.00495)
$\ln(L_{c,m})$	0.298***	0.352***
	(0.00687)	(0.00796)
Constant	-7.167***	4.026***
	(0.656)	(0.271)
Observations	44,876	46,563
R-squared	0.745	0.788
MNE FE	no	yes

*Notes: Controls for country's characteristics are the logarithm of GDP, Population and its square. We also control for the UPE country for each MNE by applying a dummy variable. For the specification without the MNE fixed effects, MNEs controls include the total unrelated party revenues, group's tangible asset (both in logarithm), the total number of employees, a dummy for the nationality of the UPE and sector (4 digits) fixed effects. Standard errors robust to heteroscedasticity in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels respectively.*

Table 4. Baseline linear regression using differential statutory tax rates

	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$
$\boldsymbol{\tau_c - \overline{\tau}_{m,-c}}$	**-0.831*** **	**-0.684*** **
	(0.0893)	(0.0825)
$\ln(K_{c,m})$	0.210***	0.186***
	(0.00559)	(0.00612)
$\ln(R_{c,m})$	0.249***	0.253***
	(0.00506)	(0.00495)
$\ln(L_{c,m})$	0.299***	0.352***
	(0.00686)	(0.00796)
Constant	-7.415***	3.853***
	(0.656)	(0.260)
Observations	44,874	46,561
R-squared	0.745	0.788
MNE FE	no	yes

*Notes: Controls for country's characteristics are the logarithm of GDP, Population and its square. We also control for the UPE country for each MNE by applying a dummy variable. For the specification without the MNE fixed effects, MNEs controls include the total unrelated party revenues, group's tangible asset (both in logarithm), the total number of employees, a dummy for the nationality of the UPE and sector (4 digits) fixed effects. Standard errors robust to heteroscedasticity in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels respectively.*

Table 5. Baseline linear regression using EATRs both in level and as differential

VARIABLES	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$	(3) $ln(\pi_{c,m})$	(4) $ln(\pi_{c,m})$
$\boldsymbol{\tau_c^{EATR}}$	**-0.999*** **		**-0.924*** **	
	(0.105)		(0.0980)	
$\boldsymbol{\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c}}$		**-1.030*** **		**-0.905*** **
		(0.103)		(0.0955)
$\ln(K_{c,m})$	0.211***	0.210***	0.187***	0.187***
	(0.00560)	(0.00559)	(0.00612)	(0.00612)
$\ln(R_{c,m})$	0.249***	0.249***	0.253***	0.253***
	(0.00506)	(0.00506)	(0.00495)	(0.00495)
$\ln(L_{c,m})$	0.298***	0.299***	0.352***	0.352***
	(0.00687)	(0.00686)	(0.00796)	(0.00796)
Constant	-7.052***	-7.325***	4.104***	3.919***
	(0.658)	(0.657)	(0.285)	(0.284)
Observations	44,876	44,874	46,563	46,561
R-squared	0.745	0.745	0.788	0.788
MNE FE	no	no	yes	yes

*Notes: Controls for country's characteristics are the logarithm of GDP, Population and its square. We also control for the UPE country for each MNE by applying a dummy variable. For the specification without the MNE fixed effects, MNEs controls include the total unrelated party revenues, group's tangible asset (both in logarithm), the total number of employees, a dummy for the nationality of the UPE and sector (4 digits) fixed effects. Standard errors robust to heteroscedasticity in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels respectively.*

Next, similarly to Dowd et al. (2017) we introduce a non-linear quadratic relationship between taxation and profit allocation. We investigate the quadratic relationship further departing from their paper in different directions. Firstly, we provide estimates of elasticity of profit allocation with respect to CIT rate differentials and not just CIT rates. This approach is more in line with the theoretical models behind profit shifting. Secondly, we estimate non-linear elasticities on a set of MNEs with multiple nationalities, thus, differently from Dowd et al., we do not restrict our analysis only to the US MNEs.

Table 6 reports the estimated coefficients from equation (3). The results provide evidence of the existence of non-linearity in the profit allocation behaviour. The quadratic terms are always statistically significant in all four specifications. Additionally, we compute the combined Wald test for our tax related independent variables in all the non-linear specifications. The test suggests a strong combined significance of the variables, by rejecting the null hypothesis with a confidence interval higher than 99%.

Columns (1) and (3) in Table 6 provide semi-elasticities for changes in the level of CIT rates, either by using a statutory or an effective tax rate. Columns (2) and (4) show the semi-elasticities computed for changes in differential CIT rates, respectively by using statutory and effective tax rates.

Table 6. Non-linear quadratic estimation

VARIABLES	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$	(3) $ln(\pi_{c,m})$	(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)
$\ln(K_{c,m})$	0.186***	0.186***	0.186***	0.186***
	(0.00612)	(0.00612)	(0.00611)	(0.00611)
$\ln(R_{c,m})$	0.253***	0.253***	0.253***	0.253***
	(0.00495)	(0.00495)	(0.00495)	(0.00495)
$\ln(L_{c,m})$	0.352***	0.352***	0.353***	0.353***
	(0.00796)	(0.00796)	(0.00795)	(0.00795)
Constant	4.067***	3.740***	4.083***	3.741***
	(0.269)	(0.257)	(0.281)	(0.282)
Observations	46,563	46,561	46,563	46,561
R-squared	0.788	0.788	0.788	0.788
MNE FE	yes	yes	yes	yes

*Notes: Controls for country's characteristics are the logarithm of GDP, Population and its square. We also control for the UPE country for each MNE by applying a dummy variable. 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 of the 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 1% to 2% implies a decrease in reported profit by 0.7% or 1.03%, if we consider, respectively, a change in 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 tax rate is high. An increase in one percentage point from 1% to 2% decreases profit by 1.84% or 2.37% if we consider respectively statutory or effective tax rates. The same percentage point increase in tax rate from 29% to 30% would instead imply a reduction in profits by 0.54% or 0.52%.

Table 7 summarizes the percentage change of profit allocation due to an increase in one percentage point in corporate income tax.

The results are in line with what found by Dowd, Landefeld and Moore (2017). Similarly to them we find that, when using the quadratic estimation, a change in one percentage point induces a much larger decrease in profit than the linear formulation when CIT rates are low. Differently, the linear estimation delivers bigger effects than the quadratic one when the rates are high.

Our estimates however appear lower than theirs do. The difference may be partially due to two main reasons. Firstly, there is a difference in the composition of the dataset; while they analyse only US MNEs, we have a more diversified sample of firms of all nationalities, although we cannot observe MNEs not having any subsidiary in Italy. The difference in the magnitude of the results may depend on different propensity to BEPS behaviour in our and their sample. Additionally, to the extent that firms not locating any subsidiary in Italy are correlated with higher degree of profit shifting, the composition of our sample may deliver downward biased estimation. Secondly, Dowd et al. paper estimates profit shifting in the years from 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, finalized in 2015, had a partial effect in reducing profit shifting. Furtherly, part of difference may be due to our data being a cross-section, thus different from panel data used in their study.

Table 7. Semi-elasticities of CIT rates, statutory and effective in linear and quadratic regressions

	Semi-elasticity			
Changes in tax rates	Linear		Quadratic	
	Statutory	EATR	Statutory	EATR
From 1% to 2%	-0.7	-1.03	-1.84	-2.38
From 29% to 30%	-0.7	-1.03	-0.54	-0.52

We further go beyond the analysis of the quadratic effect of CIT rates and we 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 6, in column (2) and (4), reports the estimated coefficients using respectively statutory tax rates and effective average tax rates.

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

Table 8. Semi-elasticities of CIT differentials using statutory or effective rates in linear and quadratic regressions

	Semi-elasticity			
Changes in difference between tax rates	Linear		Quadratic	
	$\tau_c - \overline{\tau}_{m,-c}$	$\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c}$	$\tau_c - \overline{\tau}_{m,-c}$	$\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c}$
From -30% to -29%	-0.684	-0.905	-2.1856	-2.8828
From 1% to 2%	-0.684	-0.905	-0.69698	-0.86284

Table 8 reports the semi-elasticities of an increase in one percentage point in CIT according to the level of tax differential with the rest of the subsidiaries in the same MNE group.

If in country *c* the tax differential is high and negative - e.g. tax rate in country *c* equal to 1% and average rate in other countries 31% - an increase in the tax rate of country *c* by one percentage point will decrease profits in the country by 2.1% or 2.88% (using either statutory rate or EATR respectively).

If in country c the CIT differential is low and positive – e.g. tax rate in country c equal to 20% and average rate in other countries 19% - an increase in the tax rate of country c by one percentage point will decrease profits in country c by 0.69% or 0.86% (using statutory rate and EATR respectively).

This non-linear result might not be surprising for tax planning experts. On the hypothesis that the location of profits in low-tax jurisdiction is strongly driven by tax savings reasons, rather than economic reasons, even a small increase in the tax rate in a low tax country would reduce substantially profits reported there. On the contrary, 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 wold have a smaller effect on the reported profits.

Figure 4 displays the estimated semi-elasticity of changes in statutory CIT and in tax rate differential in panel a and b, respectively. Panel c and d graphically represent the correspondent estimated elasticities. In each graph, the blue dots show the semi-elasticities or the 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 and a linear elasticity of profits. Differently, a quadratic specification allows for a linear semi-elasticity and a non-linear elasticity.

The graphs in Figure 4 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 what the linear estimation models predict. While previous interpretations have suggested that the non-linearity in the level of CIT may be due to the size of CIT, by comparing the CIT and the tax differential graphs, we observe that linear and quadratic estimation coincides when CIT rates is equal to the median average CIT rate (24%). This corresponds on average to a 0 differential tax rate.

This may seem to suggest that the non-linear relation between CIT and profit allocation that was observed by Dowd et al. for US MNEs, and that we observe too 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 choice on profit shifting to the differences in CIT rates.

It is useful spending few words interpreting the results for the differential tax rates. For negative values of differential CIT rates, an increase in one unit of differential rates is equivalent to an increase in one unit of CIT rate, while keeping the average CIT rate of the MNE fixed. If increases in CIT rates induce a decrease in profits, we need to observe a negative semi-elasticity. This is what we observe for linear and for - a part of - quadratic semi-elasticity functions. Differently, elasticity is computed by multiplying the semi-elasticity to the differential CIT rate. When we observe negative tax rate differentials, we obtain a positive elasticity. However, the sign of the elasticity in these cases when the independent variable is negative, must be treated with caution as it does not represent a positive relation of the two variables. The positive elasticity for negative differential observed in panel d, does not suggest that an increase in CIT rates induce a rise in profits, but instead the opposite[6].

Analysing Figure 4, we notice that, similarly to what displayed in Dowd, Landefeld and Moore (2017), the semi-elasticities becomes positive for high enough CIT rates and high CIT differentials. This implies that a further increase in CIT rate of a country having already high CIT rate may induce to higher profit allocation in that country, which appears counterintuitive and not in line with economic literature.

The use of the quadratic form is useful for 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 than average CIT rates.

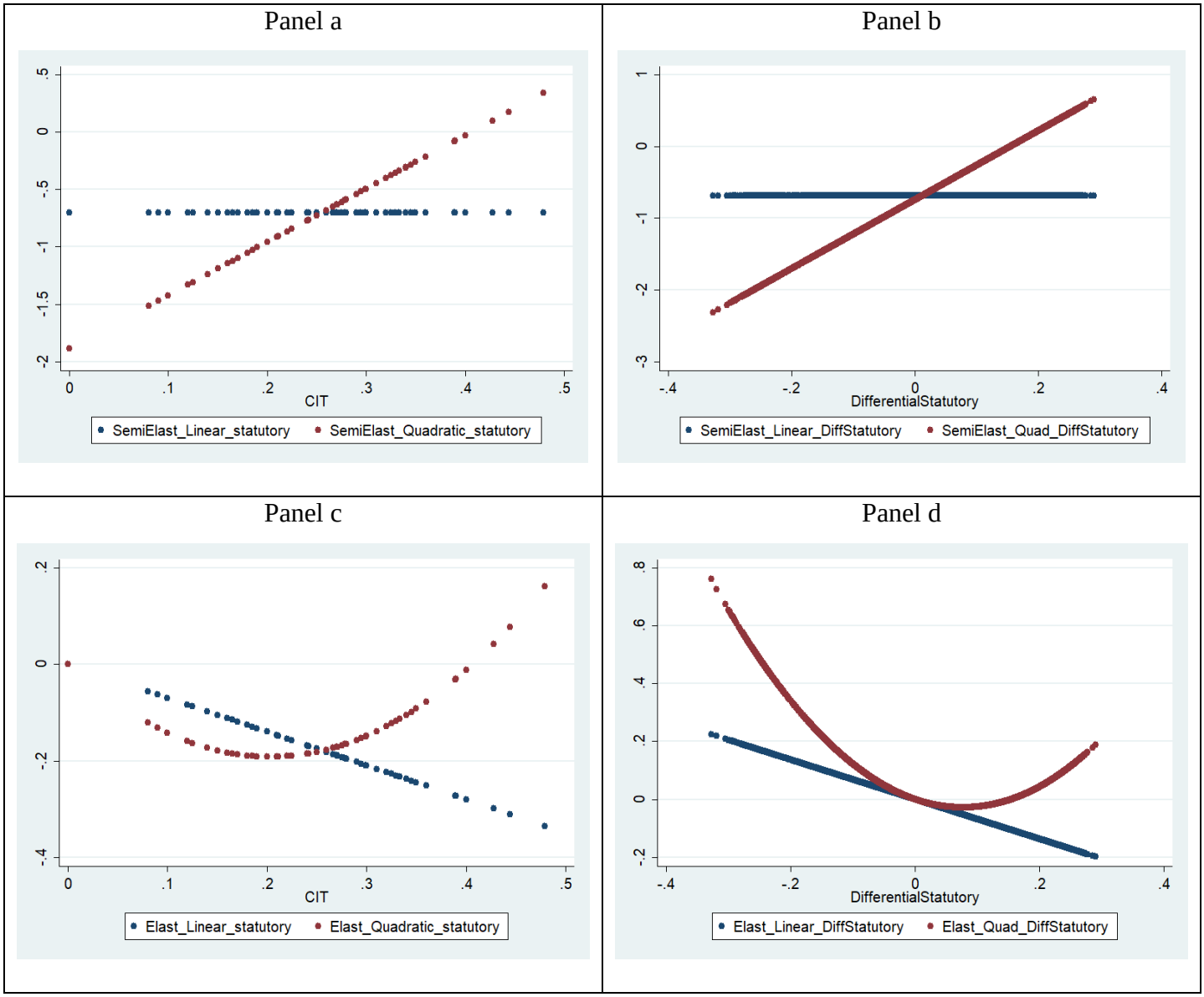
By using a further degree specification, we allow elasticity to be estimated with less functional restrictions and this allows us to overcome the positive-elasticity problem. The cubic specification implies higher semi-elasticity, in absolute value, in countries with CIT rate far below the average, an almost zero semi-elasticity when countries' CIT rates are near the

[6] Semi-elasticity is computed as the partial derivative of profit with respect to the change in tax rate differential multiplied by the inverse of profits. An increase in tax differential corresponds to a positive change in differential and in a negative change in profits, thus leading to a negative semi-elasticity. As the elasticity is defined as the semi-elasticity multiplied by the tax differential, we observe positive elasticity for negative tax rate differentials.

average and a further increase in semi-elasticity, in absolute terms, for countries with a rate way above the average.

Therefore, we move toward a higher degree analysis by regressing equation (4), results are reported in Table 9.

Figure 4. Semi-elasticities and Elasticities of statutory CIT rate and differential statutory CIT rates. Linear quadratic form



Notes: Panel a and b represent the semi-elasticities of profit allocation in a country with respect to respectively statutory CIT rates and the differential of the country CIT with the average CIT of the subsidiaries of the same MNE in all the other countries. Panel c and d represents the correspondent elasticities. Each point in the graph represents an observation. While for the CIT rate 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.

Table 9 reports the cubic estimates for all types of specifications. Column (1) reports the cubic estimates for the statutory CIT rate, column (2) reports the estimates of the tax rate differential, columns (3) and (4) report the results obtained by using EATR instead of statutory tax rate, respectively in level and as a difference to the average.

All the coefficients related to the use of statutory CIT rate are statistically significant at the one percent level. The coefficients obtained by using EATR are also statistically significant, but at a ten percent level. Additionally, Wald tests shows a strong combined significance of the variables. The coefficients remains significant also when removing outliers according to their CIT rate differentials or their profit value[7].

We now compare the results obtained with the three different behaviour assumptions: linear, quadratic and cubic. We plot the semi-elasticities and the elasticities estimated in the three models in Figure 5.

Green dots within Figure 5 display the semi-elasticity and the elasticity obtained from introducing a cubic relationship between taxation and profit allocation. The results are also compared with the previously obtained elasticities to assess the differences. The blue dots represent the results obtained with a linear model while the red dots report the elasticity (and semi-elasticity) by assuming a quadratic relation.

As it can be shown in Panel a and b, allowing for a higher degree in the equation produces a better behaved curve for higher CIT rates. Instead of observing a positive semi-elasticity when CIT rates (or CIT differentials) are high enough, the cubic function provides a negative semi-elasticity, in line with the economic literature.

Allowing for a further degree in taxation implies that in low-tax countries the elasticity of profit allocation is even bigger than the one estimated using the quadratic formulation. At the same time, the changes in CIT rates in countries with a tax rate very similar to the average are associated with almost 0 elasticity. Finally, while the quadratic behaviour predicts that the elasticity becomes smaller, in absolute terms, the higher is the CIT rate with respect to the average CIT (paradoxically becoming positive for high enough values of CIT), our quadratic prediction suggests instead that the elasticity starts to increase (in absolute term) for high tax rates.

[7] As robustness checks we keep the observations between 1st and 99th percentile of CIT rate differentials, or their profits (in logarithm form).

As profit shifting depends upon the difference between the tax rate in the country and the average tax rate to which that profit would be taxed, it is reasonable to expect that a bigger divergence from the average tax rate leads to higher elasticity. Quadratic formulation does not allow for an increase in elasticity (in absolute value) when the divergence is positive, i.e. for high-tax countries. Differently, the cubic formulation suggests that an increase in CIT rate in a country with a tax rate already above the average will be higher the higher is its distance from the average. It would indeed seem not reasonable to assume that increases in tax rate much above the average would not lead to almost any response by the firm's behaviour – or that, paradoxically, would lead to an increase in profit in the country.

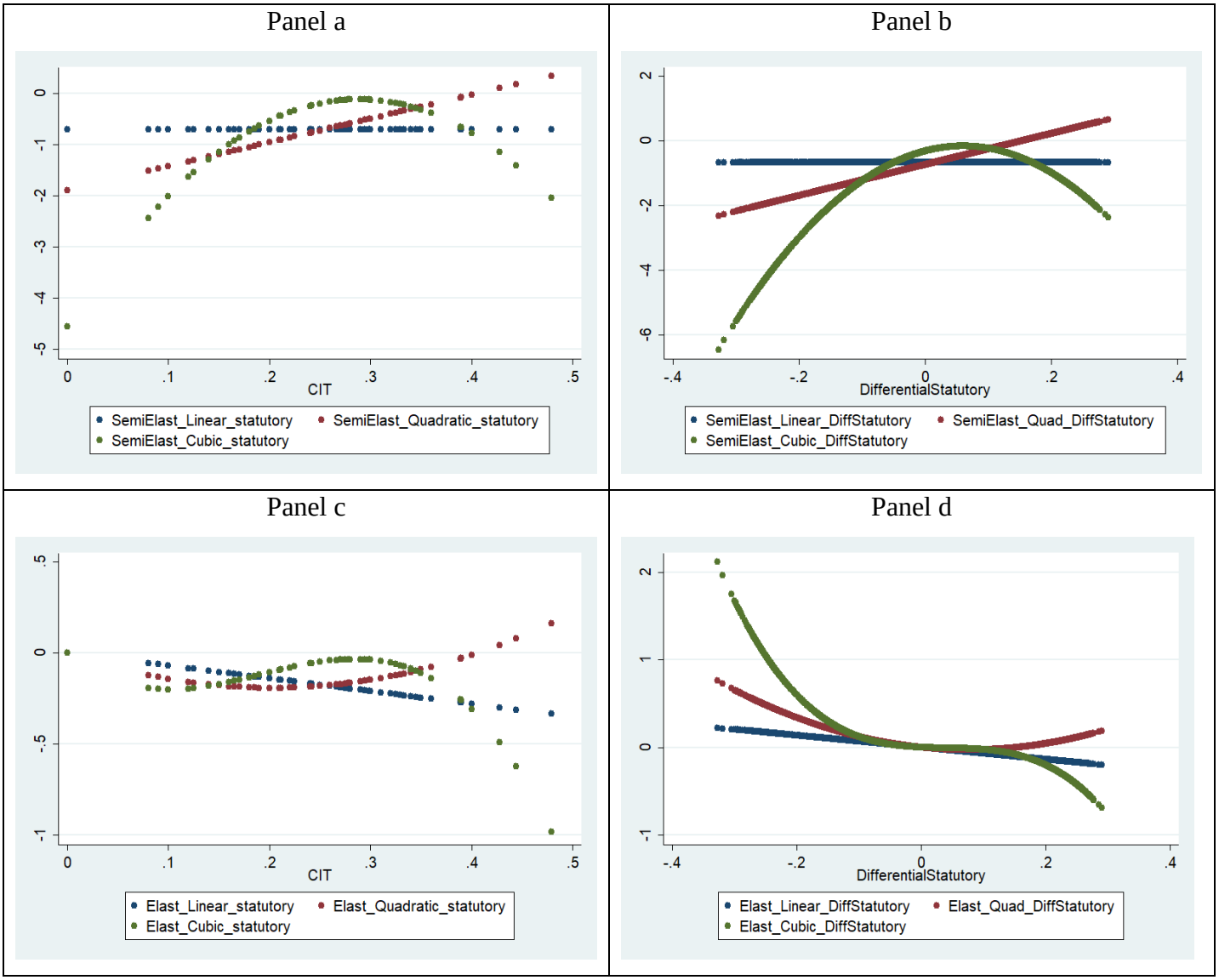
Next, we compute the effect of an increase in one percentage point using the cubic formulation and we compare it with the previously calculated semi-elasticities.

Table 9. Non-linear cubic estimation

VARIABLES	(1) $ln(\pi_{c,m})$	(2) $ln(\pi_{c,m})$	(3) $ln(\pi_{c,m})$	(4) $ln(\pi_{c,m})$
$\boldsymbol{\tau_c}$	**-4.545*** **			
	(0.703)			
$\boldsymbol{\tau_c^2}$	**15.33*** **			
	(2.977)			
$\boldsymbol{\tau_c^3}$	**-17.70*** **			
	(3.822)			
$\boldsymbol{\tau_c - \overline{\tau}_{m,-c}}$		**-0.325** **		
		(0.134)		
$\boldsymbol{(\tau_c - \overline{\tau}_{m,-c})^2}$		**2.516*** **		
		(0.524)		
$\boldsymbol{(\tau_c - \overline{\tau}_{m,-c})^3}$		**-13.91*** **		
		(3.585)		
$\boldsymbol{\tau_c^{EATR}}$			**-3.916*** **	
			(0.748)	
$(\boldsymbol{\tau_c^{EATR}})^2$			**11.11*** **	
			(3.381)	
$(\boldsymbol{\tau_c^{EATR}})^3$			**-11.58** **	
			(4.712)	
$\boldsymbol{\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c}}$				**-0.720*** **
				(0.140)
$\boldsymbol{(\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c})^2}$				**3.256*** **
				(0.654)
$\boldsymbol{(\tau_c^{EATR} - \overline{\tau^{EATR}}_{m,-c})^3}$				**-8.511***
				(4.449)
$\ln(K_{c,m})$	0.185***	0.185***	0.186***	0.186***
	(0.00611)	(0.00611)	(0.00611)	(0.00611)
$\ln(R_{c,m})$	0.252***	0.253***	0.252***	0.252***
	(0.00495)	(0.00495)	(0.00494)	(0.00495)
$\ln(L_{c,m})$	0.354***	0.354***	0.354***	0.354***
	(0.00794)	(0.00795)	(0.00794)	(0.00794)
Constant	4.255***	3.788***	4.214***	3.785***
	(0.282)	(0.269)	(0.290)	(0.284)
Observations	46,563	46,561	46,563	46,561
R-squared	0.788	0.788	0.788	0.788
MNE FE	yes	yes	yes	yes

*Notes: Controls for country's characteristics are the logarithm of GDP, Population and its square. We also control for the UPE country for each MNE by applying a dummy variable. Standard errors robust to heteroscedasticity in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels respectively*.

Figure 5. Semi-elasticities and elasticities of statutory CIT rate and differential statutory CIT rates. Linear quadratic and cubic form



Notes: Panel a and b represent the semi-elasticities of profit allocation in a country with respect to respectively statutory CIT rates and the differential of the country CIT with the average CIT of the subsidiaries of the same MNE in all the other countries. Panel c and d represents the correspondent elasticities. Each point in the graph represents an observation. While for the CIT rate 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 represents the cubic estimation results.

Table 10. Semi-elasticities of statutory CIT rates and tax rate differential in linear, quadratic and cubic formulation

Changes in tax rates	Semi-elasticity		
	Linear	Quadratic	Cubic
From 1% to 2%	-0.7	-1.84254	-4.24371
From 24% to 25%	-0.7	-0.77396	-0.24516
From 35% to 36%	-0.7	-0.2629	-0.31875

Changes in difference between tax rates	Semi-elasticity		
	Linear	Quadratic	Cubic
From -30% to -29%	-0.684	-2.1856	-5.5903
From 1% to 2%	-0.684	-0.69698	-0.27885
From 16% to 17%	-0.684	+0.02332	-0.588168

Table 10 shows the percentage change in profit allocated to a country due to increase in one percentage point of the country statutory CIT rate.

The left panel within Table 10 shows that, an increase of one percentage point in CIT rate, decreases profits allocated in the country by -0.7% according to the linear model, by -1.84% with a quadratic formulation and by -4.23% if using the cubic identification. Thus, the cubic formulation estimates a semi-elasticity more than 2 times higher than the one estimated assuming a quadratic relationship and 6 times larger than the constant semi-elasticity.

Differently, when countries approaches to a level of CIT rate near the average, the semi-elasticity estimated with the cubic model is lower than the one estimated using linear and quadratic models. An increase of one percentage point of 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 -0.27% in the cubic model, by -0.69% in the quadratic model and by -0.68% in the linear one.

Further, if a country has a 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. Passing from 35% to 36% CIT rate would imply a semi-elasticity of profit allocation of -0.32% assuming a cubic behaviour and by -0.26% with a quadratic model.

Finally, an increase in 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; it would instead be associated with a decrease in profits by -0.59% in the cubic representation.

When looking at the CIT rate differentials present in the dataset, we find that the cubic identification delivers a semi-elasticity up to 8 times larger than the linear estimation for MNEs facing very high, negative CIT rate differentials, i.e. in countries with very low CIT rate. At the same time, the cubic estimates are one-quarter of the value of the linear ones for MNEs facing similar CIT rates. Finally, the cubic representation delivers also up to 3 times larger elasticity for profit allocated in countries with much higher CIT rate than the average.

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. Next, we calculate the revenue effect associated with profit shifting.

While Section 5.1 describes the methodology for computing profit shifting and provides a description of the results obtained in the data, Section 5.2 goes beyond and computes global profit shifting. 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 in order to include MNEs not having any presence in Italy (Section 5.2).

5.1 Profit shifting estimation and distribution

The first step to compute the total amount of shifted profits consists of applying the semi-elasticity of the quadratic regression to the independent variable.

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

As $B_{m,c}$ is not directly observable, we first 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 real-activities' profits, 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 the other countries - $f(C_{m,c})$ - 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 allocations.

We can now transform inversely the expression, by applying logarithm properties as described above and we can estimate the real-activity profit as follows.

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

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

Once known the part of profits related with the activity carried out by the firm in the country, we can estimate shifted profits as the difference between allocated profits and the estimated real-activities related profits.

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

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

As $C_{m,c}$ is defined as the difference of the CIT rate of country c and the average CIT rate applied to the other subsidiaries of MNE m, profit shifting is positive in countries with lower than the MNE's average CIT rate, and negative otherwise[8]. 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*.

Once we estimate shifted profits for each MNE in every jurisdiction, we impose the zero-sum to the profit allocation among countries. As we do not want our results on revenue estimation to be dependent on a different from zero sum but rather on a redistribution of profits, we impose that the total amount of profits being shifted *away* from all countries by a MNE is

[8]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 $C_{m,c} > 0$

equal to the sum of all profits being shifted *into* all jurisdictions by the same MNE. We resize shifted profits proportioning the excess value (negative or positive) among countries with the observed value so to not change direction and prevalence of profit shifting.

Through this computation we get, 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.

Next, we can group the shifted profits according to the income group of the jurisdiction. The first column in Table 11 reports shifted profits by the income group as a share of global profit shifting. The results refer to the cubic estimation of profit shifting where the independent variable is the statutory CIT differential. Negative percentages identify country groups where profit is shifted away from, while positive values identify country groups where profit is being shifted into.

In terms of aggregated amounts, 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 11 shows 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 reported profits. As to lower middle-income countries, profits shifted from these countries accounts for a relatively small share of globally shifted profits (17%) but when considering profit shifted away as a share of total profits reported in the country, they account for the highest share among all country groups (8.6%).

Table 11. 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 showed in Table 11 may however reflect different situations within income groups, namely reflecting the presence within the "high-income group" of some countries being destination of shifted profits and others being heavily affected by the drawn of capital. This is shown by results in Table 12, representing the distribution of positive and negative profit shifting separately. While capital is mainly moved from high-income countries, accounting for more than 80% of negative profit shifting, the destination of this shifted profit is more heterogeneous among income groups. High-income countries and Investment hubs are destinations of above 90 per cent of total positive shifted profits, almost equally split between the two groups, whereas in Table 11 Investment hubs appear to be the only destination for shifted profits. This implies that, despite confirming that 80% of shifted profits is moved away from high-income countries, within the high-income group some countries are destination of shifted profits.

Table 12. 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%

In terms of distribution of shifted profits among countries, we find higher concentration for negative profit shifting than for positive one.

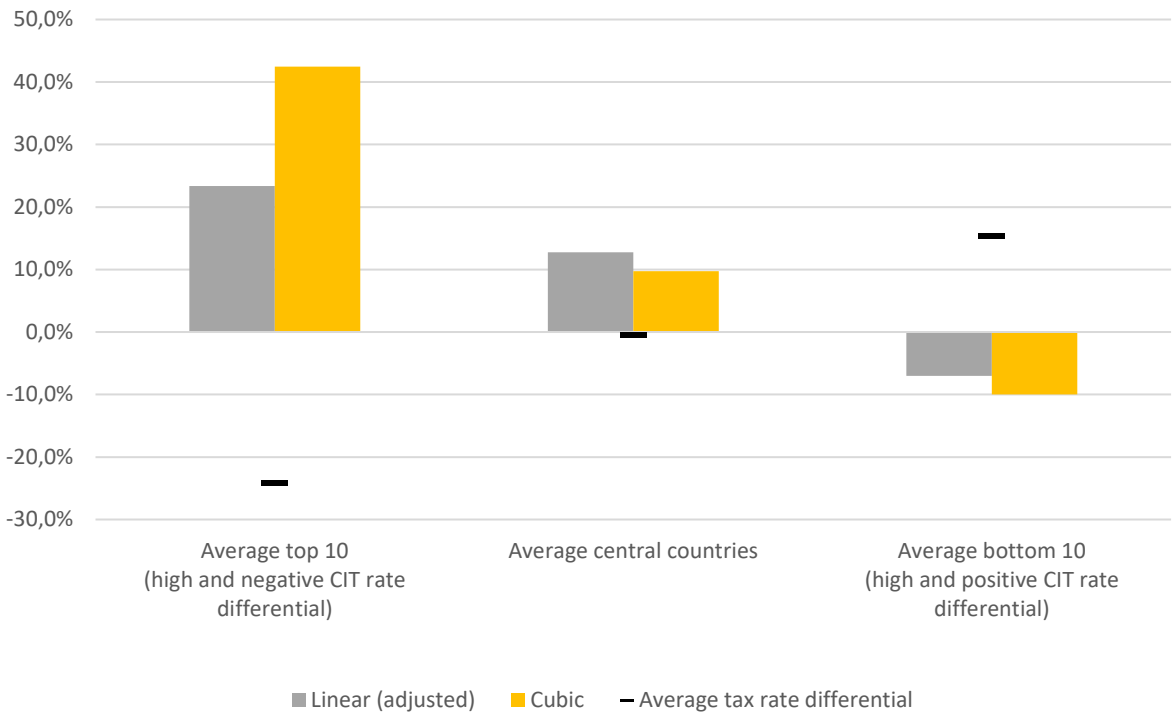
By ranking the countries for the amount of profits being shifted away from there, the first two countries, Unites States and France, account for 60% of total profit shifting. Furthermore, the first five countries in the ranking, United States, France, India, Germany and Japan, account for almost the 80% of total shifted profits.

When looking at the jurisdictions where profit is being shifted to, the distribution appears slightly less concentrated as the first five jurisdictions by amount of shifted profits account

for 60% of profit shifting. However, the distribution appears still skewed as more than 80% of profits are shifted toward only nine jurisdictions: Switzerland, Great Britain, 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 6 reports the average share of shifted profits over total profits for three categories of countries: countries with very high, in absolute terms, negative CIT rate differential, countries with very high positive CIT rate differential and a residual group composed of all remaining jurisdictions in between. Results are shown both by using the non-linear, meaning cubic, identification strategy (in yellow) and by using 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 tax rate differential present a higher share of shifted profits over total profits compared to the other two group of countries. Shifted profits account for a greater share of total profits in the non-linear (cubic) specification compared to the linear specification for countries having a CIT rate very distant from the average – either lower or greater. For countries having a CIT rate more in line with the average, 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.

Figure 6. Average share of profit shifting over total profits by average CIT rate differential



Notes: in order to make values resulting from the linear and cubic estimation comparable, 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.

5.2 Global profit shifting and revenue effect

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 the 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 the literature worldwide estimates.

Several papers engaged in estimation of global profit shifting and of the Corporate Income tax lost due to the shifted profits. OECD (2015) estimated a revenue loss between 100 and 240 billion USD 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 1,076 billion USD while Balwijin et al. (2018) reported an amount of 700 billion USD of profit shifted in the same year. Recently, Tørsløv, Wier and Zucman (2018) found that 616 billion USD in profits were shifted to tax havens in 2015 which correspond to a global revenue loss of 10% of CIT revenue.

In order to make our results comparable with the ones of the literature, we must re-proportionate them to account for the fact that we observe only MNEs having at least one subsidiary in Italy and that data refers on MNEs with total turnover of at least €750 million.

In order to address the first issue, we must augment the estimated shifted profits to take into account MNEs compiling CBCRs that do not have a subsidiary in Italy.

OECD's Corporate Tax Statistics CbCRs aggregated data include information for all MNEs by country of UPE. Differently, MNEs with UPEs from a specific jurisdiction will be present in our dataset only if they have at least a subsidiary in Italy. This implies that, by comparing our data with OECD's one, we can estimate how much profits we cannot observe as they are reported by MNEs not present in Italy.

As our sample representativeness may change by UPE's nationality and by jurisdiction, we compare the total amount of positive profits in our dataset with the one reported in the OECD dataset for each combination of jurisdiction-nationality of UPE that we both possess. This implies that, if both our dataset and the OECD's data report positive profits in a specific jurisdiction allocated there by MNEs whose UPE is of a specific nationality, we compute a representativeness percentage. The percentage is therefore the ratio of profits we observe over the OECD ones.

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

Whenever we would not have a precise representativeness percentage for a jurisdiction-nationality of UPE combination, we proxy it using the average representativeness of profits allocated by MNEs with that nationality in the same geographical area of the jurisdiction. For instance, if information on profits allocated by French MNEs in Thailand would be missing, we would use the ratio of representativeness of French MNEs in Asia. Whenever this information were not available, then we would apply the average rate of the geographical area

of the UPE's nationality 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 jurisdiction related with profits allocated there by firms having UPE in a specific geographical area - in our example 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 total turnover of at least €750 million.

Finally, we must take into account profit shifting carried out by MNEs having less than €750 million of total revenues. Although in principle mainly larger MNEs are expected to engage in profit shifting behaviours, the literature does not consider this size aspect when estimating the global amount of shifted profits. Thus, we also estimate profit shifting undertaken by smaller MNEs in order to make results comparable with previous works. In order to do so, we refer to the OECD Action 13 where it is reported that MNEs group above the 750 threshold account for 90% of corporate revenues. As a further check of this percentage, we use Orbis data on MNEs having at least one subsidiary in Italy and compare profits and loss from MNEs below and above the threshold finding similar results as the OECD ones: profits of MNEs with turnover above the threshold account for 91% of total MNEs profits[9].

Once we adjust our estimated shifted profits taking into account all MNEs – below the threshold and not having a subsidiary in Italy – we resize, similarly as before, the total amount of shifted profit so to obtain a zero-sum total. Next, we compute revenue effect by applying 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, by applying the cubic formulation, in 2017 a total amount of €887 billion of profits was shifted due to differences in tax rates with a total revenue loss of €245 billion. Linear estimation would have delivered a total of €1.2 trillion of shifted profits with a consequent revenue loss of €265 billion. The difference is mainly related to the over-estimation of profit shifting among countries with similar level of CIT.

In comparing these results with estimates of previous years, it should be taken into account that in 2017, after the adoption of the BEPS package, MNEs might have slightly begun to reduce their BEPS behaviour (2017 is the second year of implementation of CbCr). For

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

example in comparing our work with OECD (2015), our results appear rather in line with their higher range limit. This outcome, however, might be the result of counterbalancing features: on one hand our data have a better coverage of investment hubs than Orbis, used in OECD (2015), leading to a higher (and probably more reliable) estimate of global CIT revenue loss. However 2017 CbCr data, that we use, probably capture first signs of compliance of MNEs to the BEPS countermeasures adopted by G20/OECD, with the result of a lower revenue loss vis-à-vis the pre BEPS project environment.

Table 13 reports the amount of estimated shifted profits by jurisdiction. Listed jurisdictions account for 80% of global shifted profits. Global profit shifting appears to be highly concentrated in few countries, namely 80 percent of total profit shifted involves seven countries of origin and eight jurisdictions of destination.

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. Japan is the second mostly affected country with € 123 billion of shifted profits and a total of € 36 billion of lost revenue. The two countries together account for half of total shifted profits in the globe.

Profits are then shifted from these countries towards the jurisdictions listed in the lower part of Table 13. Five in eight of the destination-jurisdictions are investment hubs and they account for 60% of global profit shifting.

Comparing them with the top ranked jurisdictions in 5.1 (before the adjustment for MNEs without any subsidiary in Italy), we find that the United States persistently appear as the country with the highest percentage of profit being shifted. The second in ranking for global profit shifting appears to be Japan, taking the position from France who locates in a slighter lower position, still in the top five. As our dataset covers firms having a subsidiary in Italy, it provides a better representation of MNEs located in Europe than of the ones 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 Virgin Islands increase in ranking up to the first place. This change depends upon the high profit shifting concentration in the country and the low representativeness of our sample in that jurisdiction.

Table 13. 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
Great Britain	43,507
United Arab Emirates	43,269
Hong Kong	37,317

Analysing profit-shifting by geographical areas, Americas result to be both the area with the highest loss in profit (€-372 billion) and the one with the highest gain in profits (€+477 billion). As reported in Table 13, United States and Virgin Islands (British) are the countries with, respectively, the highest loss in profits and the highest gains of shifted profits. Results for Europe report a net increase in profit allocated in the area by €67 billion. France is the first country of origin of shifted profit, with €58 billion of profits being shifted away with a revenue loss of €26 billion. The distribution of profit shifting appears very skewed. Italy, despite being at the fifth position in Europe for amount of shifted profits, reports only €5 billion of profits being shifted away with a correspondent loss of just €1 billion. Switzerland is, instead, the first destination for profit shifting in Europe with a total of €182 billion of profit being moved there. Asia and Oceania report an almost balanced loss and gain in profits, with a total net loss of €27 billion. Results for Japan suggest that €123 billion have been shifted from the country, while Singapore turns out to be the first destination of shifted profits in Asia, with €66 billion of profits being shifted there. Finally, results for Africa report a net loss of €145 billion of

profits, with Algeria losing the most (-€68 billion) and Mauritius gaining most with just €2 billion.

Overall results suggest that profits are mainly shifted from few high-income countries, toward few jurisdictions mainly classified as investment hubs.

The international discussion over possible policies aimed at curbing aggressive tax planning includes approaches that provide for a top-up taxation on profits that are taxed below a minimum level. We refer in particular to the GloBE rules (Global Anti-Base Erosion) included in the Pillar Two blueprint, currently under discussion by countries participating to the Inclusive Framework on BEPS. A similar approach is also at the basis of the US GILTI (Global Intangible Low-Taxed Income), although with certain differences. The idea is that if MNE's profits in a jurisdiction 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 relocation of profits only driven by tax reasons. As a result of the present analysis, shifted profits appear to be concentrated in 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 only based on tax reasons. Further analysis on this should be carried out as these insights might be of help in designing international tax agreements. International tax reforms providing that profits are taxed at a minimum level might go into the direction of effectively reducing the incentive for MNEs to relocate profits in countries with an extremely low CIT rate. More than 67% of global shifted profits is allocated within countries with EATR below 12.5. As elasticity of reported profit to tax rate in these countries appear to be the highest, these reforms may be a very efficient and effective way to curb BEPS.

Before concluding, it is important to remind 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 one and has the drawback of disregarding tax provisions for the determination of the tax base. We partially try to fix this by using effective tax rates in the estimation of elasticity of profit allocation. However, effective tax rates inclusion cannot account for all other channels of profit shifting that goes beyond the reduced tax rate, such as the existence of bilateral tax treaties provisions effectively lowering

MNEs' tax liability, or the existence of special lower tax regimes that are not included within the effective tax rates. Moreover, MNEs providing digital services can easily avoid the location of profits in medium and high tax rate countries by choosing to operate in those country remotely, with no or very little physical presence; that tax planning behaviour might not be captured by both financial accounts data and 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. Finally, by focusing on year 2017, our analysis do not consider the most recent US Tax Cuts and Jobs Act reform. This may change relevantly the results obtained for United States as it is reasonable to assume that a lower amount of profits is to be shifted away from US after the reform.

6 Conclusions

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

We use a novel and unique dataset, the Country-by-Country Reports, to estimate BEPS. This new source of data allows us to overcome the main caveats related to micro-founded BEPS analyses. With this new data source, we go beyond the classic linear estimation, commonly used in the literature, and we provide evidence of the existence of a strong non-linear response of MNEs' profit allocation to tax rate differentials. At the best of our knowledge, we are the only paper providing non-linear estimations for MNEs of all nationalities, as the few papers focusing on non-linearity exploit data on domestic headquartered MNEs only. Furthermore, differently from them and more in line with the theoretical models on profit shifting, we focus on tax rate differentials rather than CIT rates. We find that profit allocation is non-linearly dependant on the differences in tax rate with respect to the average CIT faced by the MNEs. Finally, we further examine non-linearity pointing out that quadratic estimation presents some issues in countries with high CIT rate. We therefore provide a higher degree, cubic, estimation as a solution to these caveats. We find that the effect of changes in CIT rate differential over

profit allocation is statistically and economically significant when allowing for an inverse U shaped semi-elasticity function.

We find that the cubic identification delivers a semi-elasticity up to 8 times larger than the linear estimation for MNEs facing very high, negative CIT rate differentials, i.e. in countries with very low CIT rate. At the same time, the cubic estimates are one-quarter of the value of the linear ones for MNEs facing similar CIT rates, close to the worldwide average. Finally, the cubic representation delivers also up to 3 times larger elasticity for profits allocated in countries with much higher CIT rate than the average.

Our findings suggest that 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.

When estimating profit shifting, we find that investment hubs are the main destination of shifted profits and that high-income countries are the ones losing more profits due to BEPS.

We estimate that in 2017 a total amount of €887 billion of profits was shifted due to differences in tax rates with a total revenue loss of € 245 billion. As regards continents, Africa is the one experiencing the highest net loss, reaching €145 billion. However, we find that profit shifting is very concentrated in few countries. Seven countries experience a loss of profits equal to the 80% of total shifted profits while eight countries are responsible for absorbing the 80% of global shifted profits.

As a result of the present analysis, shifted profits appear to be concentrated in 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 only based on tax reasons. Further analysis on this should be carried out as these insights might be of help in designing international tax agreements. International tax reforms providing that profits are taxed at a minimum level might go into the direction of effectively reducing the incentive for MNEs to relocate profits in countries with an extremely low CIT rate. As elasticity of reported profit to tax rate in these countries appear to be the highest, these reforms may be highly efficient to curb BEPS.

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Appendix

Table 14: 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 15 Number of UPEs by income group of the UPE

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

Table 16 Number of UPEs by sector

Wholesale and retail trade	170
Manufacturing	877
Other industrial activities	64
Private Services	1,054
Not known	97

Table 17: CIT rate and Effective average tax rate (EATR) by jurisdiction, year 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).