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Does Intangible Asset Intensity Increase Profit-Shifting Opportunities of Multinationals?

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Abstract

This paper studies how intangible asset intensity affects multinationals' profit-shifting behavior. Intangible assets reduce the cost of booking profits in low-tax jurisdictions, independently from where profits are generated. Consequently they can be instrumental to implementing tax-avoidance schemes. Using a large firm-level, parent-subsidiaries matched panel data set I test if multinationals characterized by high intangible asset intensity report higher profits in low-tax jurisdictions, respect to corporations with low intangible asset intensity. I find that, intangible asset intensity exacerbates multinationals' profit-shifting behavior. Splitting the sample between tech and non-tech companies, I find that, although tech companies leverage intangible asset intensity for profit-shifting more than the rest of the sample, there is no statistical difference between profit-shifting of tech companies with high intangibles intensity and non-tech companies with high intangibles intensity.

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1 Introduction

Tax-motivated corporate profit-shifting distorts the geographic distribution of economic activity, erodes corporate tax bases, and creates uneven playing fields between multinational firms - able to shift profits to low-tax locations - and companies that cannot. As such, profit-shifting practices not only reduce tax revenues, but are also inefficient.[1] Recent cases reported by the press (e.g. Google's double Irish Dutch sandwich case in 2016) have focused on aggressive tax planning strategies of large "tech" companies (e.g. Google, Facebook, Amazon and Microsoft).[2]

Profits shifting through royalties or other inter-company intangible-assets-related transfers has been identified as the main mechanism through which multinational enterprises artificially allocate global income to low tax jurisdictions. As taxation is based on the location where value-added is created, and it is difficult to define the market value for intangible assets or where these assets are created, multinationals can easily transfer these assets from a location to another. For instance, royalties can be used to charge costs on companies located in a high-tax county and generate profits in low-tax jurisdictions.

The economic literature has provided ample evidence that taxation considerations drive multinational enterprises' (MNEs) location choices (see, among others, Mayer et. al. (2007), Deveruax and Maffini (2007), Barrios et al. (2008), McCorriston et al. (2014)). There is also evidence that profit-shifting to low-tax jurisdictions has increased over the past decades. Zucman (2014) estimates that the percentage of US profits in "tax havens" was approximately 2% in 1984 and increased to above 15% in 2013. Further, recent tax data show that a large amount of American companies' profits are currently booked in the Cayman Islands, Singapore and Switzerland (Figure 1). With respect to the channel through which companies shift profits, Dudar et al. (2015), Karkinsky and Riedel (2012), Ernst and Spengel (2011), Ernst et al. (2014), Griffith et al. (2014), and Baumann et al. (2018), among others., find a positive effect of royalties from patents on profit-shifting to low-tax jurisdictions.

In this paper, I focus on two related questions: (1) do intangibles-intense multi-

[1] Devereux and Vella (2017).

[2] See, for instance, `https://www.ft.com/content/79b56392-dde5-11e8-8f50-cbae5495d92b`. Further, the European Commissioner for Competition, has set tax avoidance of "tech companies" in an illegal state aid framework (`https://www.bloomberg.com/news/articles/2019-09-16/apple-takes-on-eu-s-vestager-in-record-14-billion-tax-battle`).

national groups shift profits relatively more than other multinational groups? (2) Are intangible assets particularly important for profit-shifting strategies in "tech" firms compared to companies in all other sectors?

While the effect of patents on tax avoidance has been studied by several authors, no paper, to my knowledge, has studied how intangible asset intensity affects profit-shifting behaviors. This matters for two reasons. First, since the capital structure of companies is becoming increasingly intangible-intense, understanding how the behavior of intangibles-intense firms differ from more tradition "brick-and-mortar" firms bears policy implications (for instance, in terms of fiscal policy). Second, since non-patent intangible assets (e.g. data, software, know-how, design, among others) have amplified their relevance in production processes of firms in all sectors (Hall (2001) and WIPO (2017)), it is important to assess how these types of assets impact multinational firms' organization.[3]

The allocation of corporate revenues from international activities to national tax-jurisdictions must be based on the arm's length principle, which states that *"entities that are related via management, control or capital in their controlled transactions should agree to the same terms and conditions which would have been agreed between non-related entities for comparable uncontrolled transactions"*. It implies that the value added of an economic activity should be booked in the company (and country) where such value is created. However, it is hard to apply such a concept to income generated by intangible assets. The value of these assets is in fact difficult to measure because there are no public markets for intangible assets. The lack of market prices, in conjunction with the fact that intangible assets can be moved easily, pose significant problems for establishing where the value added produced through these assets is created. As a consequence, the cost of shifting profits shrinks with intangible assets intensity, increasing opportunities for companies to reduce their tax burden.

As mentioned above this is perceived to be particularly true for "tech" companies that are relatively more intangibles-intense than other companies (Figure 2). However, whether intangible asset intensity or other characteristics of tech companies lead them to be more prone to profit-shifting than other firms is an empirical question that this study aims to address.

[3]The full definition of intangible assets by the American Association of University Professors includes inventions, works of authorship, software, data, know-how, experimental designs, technical information, and documentation.

I start by adapting the theoretical framework of Huizinga and Laeven (2008) to include intangible assets. I then bring the resulting model to the data using a large firm-level, parent-subsidiary matched panel data set. I am interested in studying the relationship between reported profits (measured by earnings before interests and taxes, EBIT) in each of the locations where a multinational group operates, with two variables. First, I build a composite tax indicator that measures the relative differences in tax rates between each country and all other countries where a multinational firm has a subsidiary. By construction this indicator captures the relative tax advantage of each location where a subsidiary is located relative to all other locations, identifying cases where a subsidiary is established in a country primarily for tax purposes. Its relationship with reported profits tells how profits are allocated across subsidiaries with respect to tax considerations. The second variable of interest is the interaction term between the composite tax indicator and intangibles intensity, defined as the ratio of intangible assets to total assets in each multinational group. This interaction term captures the extent to which intangibles intensity increases or smooths profit-shifting.

In line with the literature, I find that the coefficient of the tax composite indicator is significant and negatively related to reported profits. This can be interpreted as evidence of profit-shifting: companies report higher profits in locations where taxes are lower.

More importantly, I also find that intangibles-intense multinational groups shift profits relatively more than other multinational groups. The composite tax indicator and the interaction term between this tax indicator and intangible-intensity are both negative and significant. I interpret this result as evidence that intangible assets intensity exacerbates profit-shifting behavior: reported profits are lower when a subsidiary is located in a country where taxes are low *AND* the group's intangibles intensity is high.

On average, for each percentage point increase in intangibles intensity, the relationship between the tax indicator and reported profits is further reduced by 0.104. My estimates show that when intangible asset intensity is 0, changing tax differentials by 1% would lead to a decrease in profits by 1.17%. Instead, when intangible asset intensity is greater than 0, for each 1% increase in intangibles' intensity, the reported profits would decrease by 1.27%.

Further, I study whether the impact of intangible asset intensity on profit-shifting varies across tech and non-tech companies, or across larger and smaller multinationals. I find that although tech companies with high intangibles intensity shift profits more than the average multinational corporation, their tax-avoidance behavior is not statistically different from that of non-tech companies with high intangibles intensity. Hence, it is intangibles intensity that exacerbates profit shifting, not being a tech-company per se.

When it comes to the size of the company, I find that large multinationals with above-median intangibles intensity do not shift profits more aggressively than the rest of the sample. Finally, I test whether large tech companies leverage intangible assets for profit-shifting more than other companies. After having split the sample into four sub-samples ("Big tech"; "Big no-tech"; "Small tech" and "Small no-tech"), I find that intangible asset intensity exacerbates profit-shifting only for the "Big tech" cluster. However, the difference in intangible-assets-driven profit-shifting between the "Big tech" cluster and the rest of the sample is not statistically significant. These results show that intangible asset intensity, rather than size or sector, is the main firm's characteristic that amplifies profit-shifting.

The closest analysis to this study is the work of Dischinger and Riedel (2011), who also find a negative relationship between intangible assets and reported profits. There are two important differences between my work and that of Dischinger and Riedel. First, these authors focus only on European parents and subsidiaries while I cover companies operating in 50 countries worldwide. Second, Dischinger and Riedel study intangibles intensity at a subsidiary level, comparing affiliates located in high-tax jurisdictions and affiliates located in low-tax jurisdictions in the same group. Their objective is to see if multinational companies choose to apportion intangibles assets in subsidiaries located in low-tax jurisdictions. I instead use intangibles intensity at a multinational group level to study if multinationals with high-intangibles intensity are more prone to perform profit-shifting than companies with lower intangible-assets intensity.[4] An example could help to fix ideas: Dischinger and Riedel test if Google's subsidiaries located in tax havens are more intangibles-intense than Google's subsidiaries located in high-tax countries. I test, instead, if intangibles-intense companies like Google shift profits more aggressively than less intangibles-intense companies as, for instance, ExxonMobil.

The remainder of this paper proceeds as follows: Section 2 provides the theoretical

[4]The sum of all intangible assets in all subsidiaries and parent companies divided by the sum of total assets in all subsidiaries and parents.

underpinnings of the empirical methodology; Section 3 describes the data set; Section 4 details the econometric model and illustrates the empirical results on the impact of intangible assets on profit-shifting; Section 5 concludes.

2 Theory

Huizinga and Laeven (2008) provide a simple theoretical model for multinationals' tax planning behavior. Starting from this framework, I innovate by introducing intangible assets and I derive testable predictions on the relationship between reported profits and tax rates, reported profits and intangible assets, as well as reported profits and the interaction term between intangible assets and tax rates.

Consider a multinational group, m, that operates in $n > 2$ countries and denote with j the country where each firm, i, is located. To simplify the notation, I consider one period and I assume that one subsidiary from each multinational group operates in each country j. In such case the country where a subsidiary is located and the subsidiary itself coincide (hence $i = j$).

I distinguish between "true profits" and "reported profits". True profits are those that result from the solution of each subsidiary's maximization process but are not observable, "reported profits" are those booked in financial statements. Each subsidiary firm optimizes B_j - its own pre-tax "true" profit from its commercial activity - independently from all other firms in the group. I assume that each subsidiary produces its output Y_j using a Cobb-Douglass production function with fixed capital (K_j), labor (L_j) and intangible assets (I_j) as inputs, and a productivity parameter (A_j) that reflects cross-country technology and efficiency in input use. I also assume constant returns to scale, hence, the coefficients of each input and the productivity parameter sum to 1. The production function therefore takes the following form:

$$Y_j = cA_j^{\varepsilon}L_j^{\alpha}K^{\gamma}I_j^{\theta}e^{u_j} \tag{1}$$

where c is a constant and e^{u_j} is a random term.

True profits are equal to the output minus the costs of inputs:

$$B_j = Y_j - w_jL_j - r_jK_j - p_jI_j \tag{2}$$

I assume that the factor of productions (L, K, and I) are paid their marginal prices (w, r, and p, respectively). This assumption together with Cobb-Douglass functional form leads to the following optimal true profits (after maximization):

$$B_j^* = c(1-\alpha-\gamma-\theta)A_j^{\varepsilon}L_j^{\alpha}K^{\gamma}I_j^{\theta}e^{u_j} \tag{3}$$

Once each subsidiary has independently determined its optimal allocation of inputs and true pre-tax profits B_j^*, the headquarters maximizes global after-tax profits, by choosing the amount of profits to be shifted across locations, S_j. To be clear, S_j is the total dollar amount to be transferred from/to country j.

To shift profits, firms incur into costs (e.g. paper work, accountancy to modify the books, or concealment costs to justify profit-shifting with tax authorities). Hines and Rice (1994) assume that the marginal cost of profit-shifting increases with the total amount to be shifted S_j to the subsidiary's profits B_j, and Huizinga and Laeven (2008) follow the same approach. I update this assumption by introducing the second and most important innovation to the model: in presence of intangible assets, the cost of shifting profits deceases with intangibles intensity.

I define the intangible assets' intensity of a multinational group as the share of the total book value of intangible assets to total assets in the whole multinational group as:

$$h_m = \frac{\sum_{j=1}^{n} IntangibleAssets_{jm}}{\sum_{j=1}^{n} TotalAssets_{jm}} \tag{4}$$

where n is the number of subsidiaries within a multinational group (m). Notice that I consider the intangibles intensity at group level, not a subsidiary level. This is a significant difference from Hines and Rice (1994): I do not consider the shifting cost to be subsidiary-dependent; instead I assume that these costs are ultimately borne by the multinational groups as a whole. This implies that transfer pricing costs vary only across multinational groups (depending on their intangibles intensity) but do not vary across subsidiaries within the same group.

In this model the parent company does not produce anything, but optimizes international tax planning, by choosing the amount of profits to shift across locations, based on taxation considerations and the cost of shifting these profits, which is sustained at the multinational-group level. Since transferring intangible assets is relatively easy (in some cases the transfer can happen simply by changing a register record), the parent company can observe the profit maximization process of the subsidiaries, and after the production has taken place, can move intangible assets at its own discretion across locations. Once intangible assets have been re-assigned, the parent company artificially books profits to low-tax jurisdictions. Headquarters define how much profits each subsidiary S_j should transfer to other locations, under the constraint that the sum of the transferred profits should be 0. Formally this is: $\sum_{j=1}^{n} S_j = 0$.

Through this mechanism, once fixed set-up costs are paid, the marginal cost to book profits in ad hoc locations falls rapidly close to zero as intangibles intensity increases. This idea incorporates that suggestion of Bilicka (2019) according to which the cost of reducing taxable profits may not be a convex function of firms' profits, and that there are fixed costs associated with profit-shfting.

To formalize this intuition I define the cost of shifting profits as a function of two elements: the multinational's intangible asset intensity h_m and the amount to be shifted (S_j). The profit-shifting cost function therefore is:

$$PScost_{jm} = \frac{(h_m)^{1/\sigma} S_j^2}{2} \tag{5}$$

with $0 > h_m > 1$ and σ (the parameter that defines the concavity of the function) > 1. In other words, I assume that the relationship between intangibles intensity and the profit-shifting cost is non-linear and concave in h_m.

Eq.(5) states that the total cost of shifting profits is zero as long as the parent company does not re-allocate profits across subsidiaries; it jumps up as soon as the parent decides to move some profits, yet this cost remains almost constant as intangibles intensity increases. As a result, the marginal costs of shifting profits decrease as the share of intangible assets to total assets increases. With respect to the second component (S_j), the shifting cost increases more than proportionally with the amount to transfer (as in Hines and Rice (1994)).

Given the "true profits" of each subsidiary and the profit-shifting cost function, the multinational headquarters chooses S_j (the amount of profits to transfer from/to each country) to maximize the global after-tax, post-shifting profits, under the constraint $\sum_{j=1}^{n} S_j = 0$:

$$L = \sum_{j=1}^{n} (1 - \tau_j)[B_j^* + S_j - \frac{(h)^{1/\sigma} S_j^2}{2}] - \lambda \sum_{j=1}^{n} S_j \tag{6}$$

where τ_j is the statutory corporate tax rates in location j and λ is the Lagrange multiplier.

To simplify the notation, since the same Lagrangian applies to each multinational, h_m is noted as simply h (the share of intangible assets to total assets at group level). Eq.(6) states that the pre-tax reported profits are equal to the "true" profits B^* plus the amount transferred to/from that location, minus the cost to transfer that amount. The multinational headquarters optimally chooses the amount to transfer (and where) to reduce the tax burden on the sum of all subsidiaries' profits in the group.

The first n order conditions from Eq.(6) are:

$$(1-\tau_j)(1-h^{\frac{1}{\sigma}}S_j)-\lambda=0 \tag{7}$$

for all $i=1,...n$, and where $(1-\tau_j)(1-h_j^{\frac{1}{\sigma}}S_j)$ is the after-tax, after-marginal-shifting-cost value of additional profits reported in country j.

Solving Eq.(7) for optimal profit-shifting S_j yields:[5]

$$S_j=\frac{1}{h^{\frac{1}{\sigma}}(1-\tau_j)}\frac{\sum_{k\neq j}^{n}\frac{(\tau_k-\tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{n}\frac{1}{(1-\tau_k)}} \tag{8}$$

Where k indicates all countries where the subsidiaries in the group are located, except j. The term $\frac{\sum_{k\neq j}^{n}\frac{(\tau_k-\tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{n}\frac{1}{(1-\tau_k)}}$ is the weighted-average of corporate tax rates differences, with weights $\frac{\frac{1}{1-\tau}}{\sum_{k=1}^{n}\frac{1}{(1-\tau_k)}}$. By construction, the total amount to transfer S_j increases with intangibles intensity h and with the differentials between tax rates across jurisdictions.

Let's define reported profits B_j^r as the sum of "true" (but not observable) profits B_j^* and S_j. Using Eq.(3) and Eq.(8), reported profits ($B_j^r=B_j^*+S_j$) are:

$$B_j^r=c(1-\alpha-\gamma-\theta)A_j^{\varepsilon}L_j^{\alpha}K^{\gamma}I_j^{\theta}e^{u_j}+\frac{1}{h_j^{\frac{1}{\sigma}}(1-\tau_j)}\frac{\sum_{k\neq j}^{n}\frac{(\tau_k-\tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{n}\frac{1}{(1-\tau_k)}} \tag{9}$$

The term $\frac{1}{1-\tau_j}\frac{\sum_{k\neq j}^{n}\frac{(\tau_k-\tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{n}\frac{1}{(1-\tau_k)}}$ is an index of tax differences across the subsidiaries' locations; therefore, re-labelling this term "Tax", the notation simplifies to:

[5] The full details of this calculation are provided in Appendix A.

$$B_j^r = c(1-\alpha-\gamma-\theta)A_j^{\varepsilon}L_j^{\alpha}K^{\gamma}I_j^{\theta}e^{u_j} + \frac{Tax}{h^{\frac{1}{\sigma}}} \tag{10}$$

Log-linearizing Eq.(10) gives:

$$b_j^r = \beta_1 + \beta_2 l_j + \beta_3 k_j + \beta_4 \eta_j + log(1 + \frac{Tax}{h^{\frac{1}{\sigma}}B_j^r}) \tag{11}$$

where $b_j^r = log(B_j^r)$, $l_j = log(L_j)$, $k_j = log(K_j)$, $\eta_j = log(I_j)$, $B_j^* = c(1-\alpha-\gamma-\theta)A_j^{\varepsilon}L_j^{\alpha}K^{\gamma}I_j^{\theta}e^{u_j}$, $B*_j = c(1-\alpha-\gamma-\theta)A_j^{\varepsilon}L_j^{\alpha}K^{\gamma}I_j^{\theta}e^{u_j})$, $\beta_1 = log[c(1-\alpha-\gamma-\theta)]$, $\beta_2 = \alpha$, $\beta_3 = \gamma$, $\beta_4 = \theta$.

While this equation cannot be translated directly into a linear model, it is possible to study its sign. Taking the first order derivative of Eq.(11), with respect to Tax gives:

$$\frac{\partial b_j^r}{\partial Tax} = \frac{1}{Tax + h^{\frac{1}{\sigma}}B_j^r} \tag{12}$$

and taking the first order derivative of Eq.(11), with respect to h gives:

$$\frac{\partial b_j^r}{\partial h} = -\frac{Tax}{\sigma(B_j^r h^{\frac{1}{\sigma}} + Tax)h} \tag{13}$$

Since the variable Tax is the weighted average of tax differentials across jurisdictions where each company operates, it can take a positive or negative value. Tax is positive when the tax rate of a country is higher than the weighted average of the tax rates in all other countries where a company operates, and it is negative otherwise. The sign of Eq.(12) is positive as long as Tax is positive and $|Tax| > h^{\frac{1}{8}}B_j^r$, and negative otherwise. It means that less profits are booked in countries where the tax rate is higher than those of other countries, while more profits are booked in locations where the tax rate is lower than those of other countries where a multinational group operates. Eq.(12) is in line with the findings of the empirical literature and with the intuition. I will test this result empirically in Section 4.

The sign of Eq.(13) is negative in two cases: (a) if Tax is positive, or (b) if Tax is negative and $|Tax| < B_j^r h^{\frac{1}{\sigma}}$. It implies that the relationship between intangibles intensity and profits depends on taxation: it is negative as long as Tax is positive, which is when a country's tax rate is higher than those of most countries. It turns positive only for cases in which Tax is negative and its absolute value is large, corresponding to a "tax haven case". Loosely speaking, reported profits increases with intangibles intensity when the tax rate is relatively low and decreases when the tax rate is relatively high.

The study of the second order cross-derivative would tell what the model predicts when intangible assets intensity and tax differentials interact:

$$\frac{\frac{\partial b_j^r}{\partial Tax}}{\partial h} = \frac{\frac{\partial b_j^r}{\partial h}}{\partial Tax} = -\frac{B_j^r h^{\frac{1}{\sigma}-1}}{\sigma(Tax + B_j^r h^{\frac{1}{\sigma}})^2} < 0 \tag{14}$$

This term is negative in all circumstances: h and B_j^r are positive by definition, and Tax is comprised into a quadratic term. Based on these results, the theoretical prediction is that the relationship between reported profits and the interaction term between Tax and h is poised to be negative. It implies that companies with high-intangibles intensity would book relatively more profits in low-tax countries. In other words, intangibles intensity exacerbates profit-shifting. In Section 4 I test this prediction estimating an econometric model based on Eq.(11).

3 Data

I use firm-level, parent-subsidiary matched data obtained from Orbis, a commercial data set, compiled by Bureau van Dijk Electronic Publishing, BvD. Orbis is an umbrella product that provides firm data in multiple countries. This data set has two main advantages. First, its ownership information module allows to link each parent to all its subsidiaries; second, the data set contains information on over 295 million companies in over 100 countries worldwide. For each company, the data set reports time series of standard balance sheet information as well as location, sector, and year of incorporation.

Two well-known limitations of the Orbis data set are the unbalanced structure of its financial data, and the skewed distribution of firms by country. With respect to the former, the degree of time-series completion varies by indicator and by firm. For instance, for the same company, turnover time series tends to be more complete than R&D expenditure information. In some cases financial information is missing for the entire time series. In terms of countries coverage, European countries tend to be better represented than non-European ones: 77% of the subsidiaries and 69% of the parent companies in the sample are located in Europe. Nonetheless, the sample of non-European firms is extensive, accounting for over 50,000 subsidiaries and 3,500 parent observations.

In this paper I consider a subset of the Orbis database consisting of companies that are part of an international group. More specifically, I select all parent companies that own at least one foreign subsidiary company. Foreign subsidiaries are defined as companies owned by any ultimate owner with 50% of shares, located in countries different from that of the parent company. I clean the raw data following the approach used in the literature, dropping from the sample observations where a subsidiary's country location is not reported and observation where the subsidiary's identifier (BvDIDnumber) is not reported.[6] I also delete observations of subsidiaries that do not report any financial information. Further, in line with the profit-shifting literature, I drop company groups whenever pre-tax profits are negative for all subsidiaries since firms with negative profits are not subject to tax payments and are therefore irrelevant. Moreover, I discard financial companies, groups with subsidiaries in less than three international locations, and groups that do not report any intangible asset information for any subsidiary. These adjustments help to build a more balanced panel.

Next, I merge firm-level variables from Orbis with country-level variables from several sources. I use KPMG - *Corporate and Indirect Tax Survey* - for tax rates, International Monetary Fund's *World Economic Outlook* (IMF-WEO) for GDP and the World Bank *Development Indicators* database for population data.

After merging the firm-level variables with the country-level variables the sample is further restricted to the set of parent and subsidiaries located in the 50 countries for which taxation information is available. The resulting sample consists of an unbalanced panel of 224,843 subsidiaries and 13,908 parent companies across 50 countries over the period 2006-2017. (Table B.1 provides a detailed distribution of parent and subsidiary firms in the sample by country).

The dependent variable in this paper is the logarithm of the subsidiary's earnings before interest and taxes (EBIT). For estimation, following Huizinga and Laeven (2008), I first sum the financial information across all subsidiaries in a country from the same multinational group, in a given year, then I compute the logarithm of the total reported profits in each country, plus one. This method prevents loss of data

[6] Limitations of the Orbis data set and suggestions on how to overcome them are provided by Kalelmi-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, and Yesilitas (2015).

points when profits are equal to 0. To limit the number of zeros in the distribution of the dependent variable (log of reported profit), I further restrict the sample by dropping all parent companies in a group with more than three missing observations (on the variable reported profits) within a group in a given year. This contains the distribution of zeros in the dependent variable to 36% of the sample. The final sample on which regressions are based consists of 38,175 unique locations of subsidiaries of 4,947 parent companies, each observed an overage 9.7 times over the period 2006-2017, leading to a total panel sample of 369,145 observations. Table B.2 reports the descriptive statistics of the variables used in the estimation, based on this restricted sample.

The key independent variables are the composite tax indicator - labelled as Tax - and the intangibles intensity ratio h. As detailed in Section 2: the former is computed as the weighted average of corporate tax differences across countries where a multinational group operates, the latter is the ratio between the total intangible assets of all companies in a multinational group to the total assets in all companies in the group. This indicator captures how much a multinational's production uses intangible assets. As the underlying intangible asset information is derived from firms' balance sheets, it is reported based on local generally accepted accounting principles (GAAP).[7] The definitions for all the variables used in the paper are reported in Table B.3.

4 The Impact of Intangible Asset Intensity on Profit-Shifting

4.1 Baseline Results

To test the impact of intangible assets on multinationals' profit-shifting behavior I estimate the following econometric model which is an approximation of the solution of the parent company maximization process from Eq.(11):

[7] See, for instance, Alexander et al (2007). Also, as described by Dischinger et al. (2011) the accountancy of intangible assets is defined by three principles: indefinable non-monetary asset without physical substance; asset control as a result of past events (purchase or self-creation); future economic benefit (cash flow). They typically include patent, licenses, copyrights, trademarks, and in some cases the goodwill defined as the price of a firm minus its book value.

$$EBIT_{jmt} = \beta_1 + \beta_2 labcost_{jmt} + \beta_3 fixasset_{jmt} + \beta_4 intgasset_{jmt} + \\ + \beta_5 h_{mt} + \beta_6 Tax_{jmt} + \beta_7 h_{mt} * Tax_{jmt} + \beta_8 GDP_{jt} + \lambda_{jm} + T_t + \nu_{jt} + \epsilon_{jmt} \quad (15)$$

where m identifies the multinational group, j identifies the country where the subsidiaries are located, and t the year.

As mentioned in section 3, I aggregate all establishments in each country by each multinational, in a given year. Thus, $EBIT_{jmt}$ is the sum of profits of all subsidiaries located in country j, from multinational m, at time t. Similarly, $labcost_{jmt}$ is the total labor compensations in country j in all subsidiaries from parent company m, $fixasset_{jmt}$ is the total amount of fixed assets, and $intgasset_{jmt}$ the total amount of intangible assets. h_{mt} is the multinational's intangible assets' intensity defined above and Tax_{jmt} is the tax variable from Eq.(11), computed from the data as $Tax_{jmt} = \frac{1}{(1-\tau_j)} \frac{\sum_{k \neq j}^{n} \frac{(\tau_k - \tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{n} \frac{1}{(1-\tau_k)}}$, where k indicates all countries where the subsidiaries in the group are located, except j. To test if intangibles intensity exacerbates profit-shifting I include the interaction term $h_{mt} * Tax_{jmt}$.

To control for the market size of each subsidiary's location I also include the variable GDP_{jt}, the host country's income. All variables in this equation are expressed in logs. Finally, I include in the model parent group-subsidiary country fixed effects (λ_{jm}), year fixed effects (T_t), and sector-year fixed effects (s_{mt}). Together they absorb most of the unobservable variation; however, the model is not fully saturated. Notably, it does not include country-time fixed effects. This is due to the fact that the variability of one of the key covariates (Tax_{jmt}) is mostly cross-country, hence including country-time fixed effects would limit the estimation of its coefficient. Similarly, I do not include parent-year fixed effects as they would be collinear with the sector-year fixed effects. The model is estimated taking clustering standard errors at parent-company level.[8]

I am mainly interested in the size and magnitude of coefficients β_5, β_6 and β_7. From the theory section, the predicted sign of β_5 depends on the sign of Tax, and the magnitude of h (Eq.(12) and Eq.(13)). Intuitively, I expect β_5 to be negative: the average reported profits across all subsidiaries of a multinational should be lower when the group is intangibles-intense. This is for two reasons. First, if indeed intangibles

[8]The selection of the clustering is based on the indications provided by Abadie et al. (2017).

intensity facilitates the concealment of true profits, intangibles-intense companies are likely to report lower profits in general. Second, since the specification of the model uses logs, if intangibles-intense companies concentrate (most) profits in low-tax jurisdictions, their average profits would be lower than those that report profits evenly across locations.

When it comes to β_6, I also expect its sign to be negative. In line with the literature, companies report higher profits in tax havens or where taxation is low. Recalling that the variable Tax is positive for high-tax countries, and negative for low-tax countries, data should show that companies book high profits in countries where Tax is large and negative, and low profits where Tax is large and positive. Hence, β_6 should be negative.

Finally, based on the prediction of Eq.(14) the sign of β_7 should be negative: companies with high-intangibles intensity should report even higher profits in low-tax countries than companies with low-intangibles intensity. A negative sign of β_7 would indeed provide evidence that intangible assets intensity exacerbates profit-shifting. When the coefficient of the tax variable (Tax) and the coefficient of the interaction term ($h * Tax$) are both negative, the marginal effect of Tax on reported profits is larger for companies with greater h, showing that, the larger the intangibles intensity, the stronger the sensitivity of reported profits to taxation.

To ease the interpretation of coefficients, I center all non-dummy regressors around their means. To do so, I first compute the sample average for each variable, and then I compute the difference between each observation (for each variable) and its sample mean. I then produce estimates of the time-demeaned regressors or profits (the dependent variable, reported profits – EBIT, is not centered around its mean).

The baseline results are presented in Table 1. Column (I) reports the linear regression estimation of Eq.(15) excluding the interaction term. In line with the literature, the coefficient of the composite indicator Tax (the weighted average of tax differentials) is negative and statistically significant at 1% level, providing indirect evidence of profit-shifting: the higher the taxation in a country, the lower the profits booked there. Quantitatively, the estimate indicates that for every 10-percentage points increase in the composite tax indicator, reported pre-tax profits decrease by approximately 11.6%. The size of the coefficient is within the boundaries of the tax variable estimation in the literature and is remarkably close to the coefficient estimated by Huizinga and Leaven (2008).[9]

The estimate of variable intangibles intensity (h) is also negative and significant at 1% level. The value of the coefficient indicates that for every 10-percentage points increase in intangibles intensity, average reported profits across a multinational's locations decrease by 0.25%. However, the coefficient of h does not reveal by itself if companies with higher intangible asset intensity shift profits to low-tax jurisdictions more aggressively than other companies. It simply shows that average reported profits are lower when intangibles intensity is higher. This can be either due to stronger profit-shifting strategies and/or simply by the relatively size of high-intangibles companies. For instance, if high-intangibles companies were for the most part start-ups, they would report lower profits on average.

To test if intangible asset intensity exacerbates profit-shifting, as predicted by Eq.(14), I include the interaction term between Tax and h. Column II of Table 1 reports the estimation of the regression model, including the interaction term, and column III adds both the interaction term and sector-year fixed effects. In line with the prediction, the interaction term is negative and significant at 5% level in both columns. Intuitively, for "sufficiently large" tax differentials, the higher the intangibles intensity the lower the reported profits. In other words, high-intangibles intensity exacerbates profit-shifting behaviors. A simple way to see this is to compute the marginal effect of Tax, which, using the results from column III, is $-1.158 - 0.103$ h. Since h can only assume positive values by construction, any increase in h would make the negative relationship between Tax and reported profits larger. For instance, if h is 0, a 10-percentage points increase in tax differentials would reduce reported profits by 11.6%, and if h goes to, say 0.50, then a 10-percentage points increase in tax differentials would reduce reported profits by 12.1%. This means that all multinationals, on average, report higher profits in low-tax locations (proving that they implement profit-shifting schemes), but companies with high-intangibles intensity report even higher profits in low-tax jurisdictions.[10]

To further clarify this relationship, I plot marginal effects. Figure 3 pictures the first derivative of Eq.(15) with respect to Tax at discrete levels of h. It shows that the marginal effect of Tax on $EBIT$ is negative for any value of h. Yet, as h

[9] It has to be noted that the tax indicator used by these authors is similar to the one used in this paper, except for the inclusion of firms' sales in its computation.

[10] Recall that h is expressed in logs, hence a value of 0.5 corresponds to an intensity of 65%, which is $[exp(0.5) - 1]$.

increases, the (negative) marginal effect of the Tax variable becomes larger. Despite wide confidence intervals, intangible assets further increase the loss of tax revenues (lower reported profits) for each percentage point increase in tax differentials between the rate of the host country and the average tax rate of all other countries.

In a similar fashion, the marginal effect of h on reported profit is $-0.025 - 0.103$ Tax, which implies that the marginal effect of variable h is positive only for relatively large values of $\log(Tax)$ - around -0.24, corresponding to approximately 21% differential across jurisdictions. As the tax differential grows (meaning that the country adopts lower tax rates than most other countries), the marginal effect of h on reported profits is negative and larger in magnitude. For instance, for a value of Tax of approximately 0.1, a 10-percentage point increase in intangibles intensity would reduce reported profits by approximately 3%.

Figure 4 plots marginal effects of h (the first derivative of Eq.(15) with respect to h) at discrete levels of Tax. It shows that h does not impact reported profits only as long as tax differentials (Tax) are at about -0.24; yet, for any value of Tax above that level, any increase in intangibles intensity would negatively affect reported profits.

Another way to see the impact of intangible assets on profit-shifting behavior is to replace the intangibles intensity continuous variable h with binary variables to offer a simpler intuition of the results and run again the econometric model, Eq.(15), using these dummy variables. Table 1.2 reports these results. In columns I-II the dummy variable takes on value 1 if h is above the sample median and 0 otherwise (I call this binary variable AI - Above-median Intangible-intensity); in columns III-IV it takes on the value 1 if h is above the 75th percentile of the sample distribution, and 0 otherwise (I call this variable $A75I$). The results confirm the hypothesis that the effect of intangible assets on profit-shifting is more significant at higher percentiles of variable h's distribution. As expected, the interaction of Tax and AI dummy and the interaction between Tax and *AI75* are both negative and significant at 1%. The marginal effect of Tax on reported profits - when the respective intangible asset dummy variable takes on value 1 - is larger in column IV (-1.47) respect to column II (-1.52). This is another way to see how the larger the share of intangibles, the higher the sensitivity of profits to taxation.

The use of dummy variables in this context facilitates the interpretation of results. Figure 1.5 shows predictive levels of reported profits, for discrete values of Tax. Each line represents predicted reported profits at each specific Tax value for each of these two groups. If all companies in the sample had “high-intangible intensity”, $AI = 1$, (red line) then, for a Tax value of 0.25, their average reported profits would be about 4.6 (or 100 million). If, instead, all companies in the sample had “low-intangible intensity”, $AI = 0$, (blue line), then for the same Tax value (0.25) the average reported profits would be about 4.75 (or 115 million).

Interestingly, this relationship reverses when Tax is below -0.1. Simply put, “high-intangibles” firms report higher profits than “low-intangibles” firms where tax differentials are positive and lower profits when tax differentials are small or negative.

4.2 Intangible asset intensity and Profit-Shifting in Tech Companies

In this section I test if intangible assets are particularly conducive to profit-shifting of companies in the “tech” sector. Anecdotal evidence suggests that tech companies implement particularly aggressive profit-shifting behaviors. The hypothesis is that tech companies can better leverage intangible assets for tax planning than other companies. This may be due, for instance, to the fact that tech companies, not only are particularly intangibles-intense, but also use types of intangibles assets (e.g. algorithms), or business models (e.g. digital platforms) that amplify the disconnect between the location where value added is generated and the location where profits are booked. Another hypothesis is that tech companies are particularly tech-savvy and can therefore better manage their intangible assets and profit-shifting schemes. However, statistical proofs that tech companies behave differently from other intangibles-intense companies are scarce.

Gathering greater evidence on this aspect is important to inform debates on international tax codes reforms. To date, tech companies’ are regarded as special cases that should be targeted with ad hoc measures. For instance, it has been proposed to tax tech companies on the basis of the revenues generated in each country rather than on profits.

To contribute to this debate, I test if there are statistical differences in profit-shifting between tech and non-tech groups with high intangibles intensity with respect to profit-shifting. I will show that, although intangibles-intense tech-companies are more sensitive to tax differentials than the other companies, their profit-shifting behavior is not statistically different from that of intangibles-intense non-tech companies. I estimate the following model:

$$EBIT_{jmt} = \beta_1 + \beta_2 labcost_{jmt} + \beta_3 fixasset_{jmt} + \beta_4 intgasset_{jmt} + \beta_5 Tax_{jmt} + \beta_6 AI_{mt} + \beta_7 AI_{mt} * Tech_m + \beta_8 AI_{mt} * Tax_{jmt} + \beta_9 Tech_m * Tax_{jmt} + \beta_{10} AI_{mt} * Tech_m * Tax_{jmt} + \beta_{11} GDP_{jt} + \lambda_{jm} + T_t + \nu_{jt} + \epsilon_{jmt} \quad (16)$$

where $Tech_m$ is a dummy variable that takes on value 1 if the parent company's sector is reported as Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77, and 0 otherwise;[11] AI_{mt}, is a dummy variable that takes on value 1 for companies with above-median intangibles intensity and 0 otherwise; and the interaction AI_{mt} * $Tech_m$ takes on value 1 for tech companies with above-median intangibles intensity, and 0 otherwise. The coefficient β_{10} captures whether tech companies benefit from high intangible asset intensity for profit-shifting differently than non-tech companies.

The results of Eq.(1.16)'s estimation are reported in Table 1.3. Column I includes only the binary variable AI * $Tech$, and column II adds the triple interaction AI * $Tech$ * Tax. This interaction term is negative and significant at 1% confidence levels, showing that, on average, being a tech company with above-median intangibles intensity leads to greater profit-shifting compared to all other firms.

Quantitatively, the marginal effect of Tax on reported profits is -1.75 for companies in the high-intangibles tech cluster and -1.03 for companies outside this cluster. It implies that for companies within the cluster, an increase of 10 percentage points in the difference between a country's tax rate and the weighted-average international tax rate leads to an additional reduction in reported profits of about 7.2%, respect to the rest of the sample. Since these tax differentials only take into account countries where the multinational group operates, they reflect the international structure of each company and allow for interpreting the results as follows: had the average difference between each country's tax rate and the lowest tax rate among these countries hypothetically increased by 10%, on average, an additional 7.2% of global corporate profits would be shifted in that country.

Figure 1.6 visualizes this result by plotting predictive levels of reported profits, for discrete values of Tax. The red line represents predicted reported profits at each

[11] This selection is based on the sector that Orbis assigns to the Forbes top-20 "tech" firms (e.g. Google, Apple, etc.). I therefore make sure that all these companies are available in the sample and are indeed classified as tech companies. The non-interacted term $Tech_m$ is not included in the model because it is collinear with fixed effects.

specific Tax value for the high-intangibles tech company cluster and the blue line represents predicted reported profits at each specific Tax value for the complementary cluster of companies that are not high-intangibles tech companies. The steeper slope of the red line implies that reported profits of high-intangibles tech firms are more sensitive to taxation than reported profits of all other companies. The lines cross around a value of Tax of -0.1 which corresponds to approximately 1% weighted-average tax differentials.

In column III of Table 1.3, I split the interaction effect $AI * Tech * Tax$ into its two components $Tech * Tax$, and $AI * Tax$ which capture the impact on profit-shifting of being a tech company and being a company with above-median intangible asset intensity, respectively. As shown in column III, the interaction term $Tech * Tax$ is negative but not significant, while the interaction term $AI * Tax$ is negative and significant at 5% level. They imply that being a tech company does not drive profit-shifting intensification by its own; instead high intangible asset intensity is sufficient, by its own, to exacerbate profit-shifting.

Finally, column IV reports the results of the fully-specified model, Eq.(1.16). The inclusion of all interaction terms allows to test if the effect of intangibles intensity on profit-shifting is different between tech and non-tech companies. The interaction term $AI * Tech * Tax$ in column IV is negative but not significant. It implies that the difference in profit-shifting between tech companies with high-intangibles intensity and non-tech companies with high-intangibles intensity is non-significant. In other words, although tech companies benefit more from intangibles assets than non-tech companies for profit-shifting, there is no statistical difference between the two types of company.

4.3 Intangible Asset Intensity and Profit-Shifting by Company Size

Company size may also play a role in determining profit-shifting behaviors. Large corporations may benefit from economies of scales in all aspects of their business, including intangible assets, which would reduce the marginal cost of shifting profits. To test if there is a statistical difference in profit-shifting between large and non-large firms with high-intangibles intensity, I estimate the following model:

$$EBIT_{jmt} = \beta_1 + \beta_2 labcost_{jmt} + \beta_3 fixasset_{jmt} + \beta_4 intgasset_{jmt} + \beta_5 Tax_{jmt} + \beta_6 AI_{mt} + \beta_7 Big_{mt} + \beta_8 AI_{mt} * Big_{mt} + \beta_9 AI_{mt} * Tax_{jmt} + \beta_{10} Big_{mt} * Tax_{jmt} + \beta_{11} AI_{mt} * Big_{mt} * Tax_{jmt} + \beta_{12} GDP_{jt} + \lambda_{jm} + T_t + \nu_{jt} + \epsilon_{jmt} \quad (17)$$

Where Big is a dummy variable that takes on value 1 if a parent company's revenue is equal to or above 1 billion USD and 0 otherwise,[12] and AI is again the dummy variable indicating companies with above-median intangible asset intensity. The interaction $AI * Big$, takes on value 1 for large corporations with above-median intangibles intensity and 0 otherwise.

The results of this regression are presented in Table 1.4. Column I includes the interaction $AI * Big$, and Column II adds the triple interaction $AI * Big * Tax$. The coefficient of this interaction term is negative but non-significant, showing that profit-shifting of intangibles-intense large companies is not statistically different from that of intangibles-intense non-large firms.

Figure 1.7 visualizes the results by plotting predictive levels of reported profits for discrete values of Tax of large intangibles-intense companies and non-large intangibles-intense companies. The red line represents predicted reported profits at each specific Tax value if all companies in the sample were large companies with high intangibles, and the blue line represents predicted reported profits to at each specific Tax value if all companies in the sample belonged to the complementary cluster of companies. The slope of the red line is much more similar to that of the blue line in this case, compared to Figure 1.6, suggesting that there is not much difference between the two clusters.

Column III reports the result the full-specified model. Eq.(1.17). The interaction term $AI * Big * Tax$ is positive but insignificant, with a value of 0.125. It implies that large companies do not benefit from intangibles intensity for profit shifting statistically more than non-large companies with high intangibles. Instead, the interacted term $AI * Tax$ is negative and significant at 5% level. These estimates show that size, per se, does not amplify profit-shifting, while intangible asset intensity does.

[12] Variable "Big" is time-variant as companies' revenues change across years. Yet, this only applies to the few companies whose revenue is around the threshold level of 1 billion USD.

4.4 Profit-Shifting by Company Size and Tech Sectors

As shown in Section 1.4.2 and 1.4.3 neither being a tech company, nor being a large company, determines statistically different behaviors in terms of using intangible assets for profit-shifting. One may ask if large tech companies (e.g. GAFAs) may constitute a special group that implements particularly aggressive tax-planning schemes compared to other companies. To explore this question, I proceed in two steps, I first estimate again Eq.(1.15), for each of the following sub-samples: (a) the "Big tech" sub-sample; (b) the "Big no-tech" sub-sample; (c) the "Small tech" sub-sample; (d) the "Small no-tech" sub-sample.[13] In the second step I test if there are statistically differences across these groups in terms of using intangible-intensity for profit-shifting.

Table 1.5 reports the estimates of the baseline model, Eq.(1.15), the four sub-samples: "Big tech", "Big no-tech", "Small tech" and "Small no-tech" defined above. Columns I-II report the estimation results for the first sub-sample, columns III-IV for the second sub-sample; columns V-VI for the third sub-sample, and columns VII-VIII for the fourth sub-sample. The coefficient of the variable Tax is negative for all but the small tech sub-group, indicating again that all types of companies engage in profit-shifting. The fact that the coefficient of the variable Tax is not significant for the small tech sub-sample may be driven by the structure of the sample that includes fewer of these companies and the fact that smaller multinationals are present in fewer locations.

The coefficient of h is negative and significant across all sub-samples, meaning that within each cluster, companies with higher intangible asset intensity report lower profits.

Finally, the coefficient of the interaction term between intangibles intensity (h) and composite taxation (Tax) is significant at 10% level for the big tech sub-sample and non-significant for the other clusters of companies. However, to test if the big

[13] The "Big tech" sub-sample comprises companies with global total sales above 1 billion USD whose sector is reported as Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77; the "Big no-tech" sub-sample comprises companies with global total sales above 1 billion USD whose sector is none of the Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77; the "Small tech" sub-sample comprises companies with global total sales below 1 billion USD whose sector is reported as Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77; the "Small no-tech" sub-sample comprises companies with global total sales below 1 billion USD whose sector is none of the Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77.

tech sub-sample is statistically different from the rest of the sample, I estimate the following model:

$$EBIT_{jmt} = \beta_1 + \beta_2 labcost_{jmt} + \beta_3 fixasset_{jmt} + \beta_4 intgasset_{jmt} + \beta_5 Tax_{jmt} + \beta_6 h_{mt} \\ + \beta_7 BigTech_{mt} + \beta_8 h_{mt} * BigTech_{mt} + \beta 9 h_{mt} * Tax_{jmt} + \beta_{10} BigTech_{mt} * Tax_{jmt} \\ + \beta_{11} h_{mt} * BigTech_{mt} * Tax_{jmt} + \beta_{12} GDP_{jt} + \lambda_{jm} + T_t + \nu_{jt} + \epsilon_{jmt} \quad (18)$$

where $BigTech$ is a dummy variable that takes on value 1 if global total sales are above 1 billion USD whose sector is reported as Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77, and 0 otherwise.

The results of Eq.(1.18)'s estimation are reported in Table 1.6. Column I reports the estimates of the fully-specified model including the continuous variable h and column II reports the estimates of the fully-specified model replacing the variable h with its analogous dummy variable AI (above-median intangible-intensity). In column I, the interaction term h * Tax is negative and significant at 10% level, while the term $BigTech$ * Tax is negative but non-significant. Similarly, in column II the interaction term AI * Tax is negative and significant at 5% level, while the term AI * $BigTech$ * Tax is negative but non-significant. These results show that although big tech companies are more sensitive to tax differentials than other companies, they do not shift profits in a statistically different way from other intangibles-intense firms.

5 Conclusion

Intangible assets represent an increasingly important factor of production, but their evaluation is uncertain. As such, they have become an important vehicle for international profit-shifting. I present a model where intangible assets reduce the cost of shifting profits across jurisdictions, facilitating multinational companies' tax planning. I then take the model to the data and test if intangible asset intensity exacerbates profit-shifting. Using a panel of firm-subsidiary matched data set covering 50 countries globally, I find that: first, in line with the literature, on average all companies report higher profits in low-tax jurisdictions. Second, intangible assets reinforce the negative relationship between tax differentials and reported pre-tax profits and therefore facilitate profit-shifting. Third, comparing intangibles intensity across tech and non-tech multinationals, I find that, although intangibles-intense tech companies shift profits more than all other companies, their profit-shifting behavior is not statistically different from that of intangibles-intense non-tech firms. These findings contribute to the debate on reforming the international tax system, and suggest that policies that aim at curbing profit-shifting behaviors should primarily focus on addressing the intangible assets' measurement problem, rather than targeting specific firms or sectors.

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Table 1: Baseline results

	I	II	III
Dependent variable	EBIT	EBIT	EBIT
Fixed assets (demeaned)	0.468***	0.468***	0.468***
	(0.005)	(0.005)	(0.005)
Labor cost (demeaned)	0.214***	0.214***	0.213***
	(0.004)	(0.004)	(0.004)
Intangible assets (demeaned)	0.059***	0.059***	0.059***
	(0.004)	(0.004)	(0.004)
GDP host country (demeaned)	0.025	0.008	-0.016
	(0.086)	(0.086)	(0.087)
Tax (demeaned)	-1.162***	-1.172***	-1.158***
	(0.206)	(0.206)	(0.206)
h (demeaned)	-0.025***	-0.025***	-0.025***
	(0.005)	(0.005)	(0.005)
Tax * *h* (demeaned)		-0.103**	-0.103**
		(0.044)	(0.044)
Constant	4.844***	4.844***	5.415
	(0.019)	(0.019)	(54.18)
Observations	369,141	369,141	369,141
Number of periods	12	12	12
Host country-parent company fixed effects	Yes	Yes	Yes
Sector-year fixed effects	No	No	Yes
Year fixed effects	Yes	Yes	Yes

Notes: All variables are in logs. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors in parentheses, clustered at parent-firm level. All non-dummy regressors are computed as the difference between a specific variable's observation and its sample mean. The dependent variable has not been transformed.

Table 2: Baseline results, binary h

	I	II	III	IV
Dependent variable	EBIT	EBIT	EBIT	EBIT
Fixed Assets (demeaned)	0.471***	0.471***	0.471***	0.471***
	(0.005)	(0.005)	(0.005)	(0.005)
Labor cost (demeaned)	0.214***	0.214***	0.214***	0.214***
	(0.004)	(0.004)	(0.004)	(0.004)
Intangible assets (demeaned)	0.065***	0.065***	0.064***	0.064***
	(0.004)	(0.004)	(0.004)	(0.004)
GDP host country (demeaned)	0.013	0.0145	0.0134	0.0138
	(0.087)	(0.087)	(0.087)	(0.087)
Tax (demeaned)	-1.134***	-0.747***	-1.135***	-0.996***
	(0.206)	(0.223)	(0.206)	(0.211)
AI	-0.060***	-0.058***		
	(0.017)	(0.017)		
AI * Tax (demeaned)		-0.719***		
		(0.163)		
$AI75$			-0.0330*	-0.0329*
			(0.019)	(0.019)
$AI75$ * Tax (demeaned)				-0.526***
				(0.173)
Constant	5.448	5.446	5.422	5.419
	(69.14)	(57.24)	(97.45)	(57.24)
Observations	369,145	369,145	369,145	369,145
Number of periods	12	12	12	12
Host country-parent company fixed effects	Yes	Yes	Yes	Yes
Sector-year fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

Notes: All variables are in logs. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors in parentheses, clustered at parent-firm level. All non-dummy regressors are computed as the difference between a specific variable's observation and its sample mean. The dependent variable has not been transformed. AI is a dummy variable taking on value 1 if a parent company's intangible asset intensity is above the sample median and 0 otherwise. $AI75$ is a dummy variable taking on value 1 if a parent company's intangible asset intensity is above the 75th percentile and 0 otherwise.

Table 3: Tech companies by intangible asset intensity

	I	II	III	IV
Dependent variable	EBIT	EBIT	EBIT	EBIT
Fixed assets (demeaned)	0.471***	0.471***	0.471***	0.471***
	(0.005)	(0.005)	(0.005)	(0.005)
Labor cost (demeaned)	0.214***	0.214***	0.214***	0.214***
	(0.004)	(0.004)	(0.004)	(0.004)
Intangible assets (demeaned)	0.064***	0.064***	0.065***	0.065***
	(0.004)	(0.004)	(0.004)	(0.004)
GDP host country (demeaned)	0.014	0.015	0.014	0.014
	(0.087)	(0.087)	(0.087)	(0.087)
Tax (demeaned)	-1.136***	-1.030***	-0.949***	-1.022***
	(0.205)	(0.21)	(0.254)	(0.259)
AI * $Tech$	-0.054	-0.055		0.009
	(0.035)	(0.034)		(0.04)
AI * $Tech$ * Tax (demeaned)		-0.718***		-0.539
		(0.265)		(0.343)
$Tech$ * Tax (demeaned)			-0.0003	0.261
			(0.455)	(0.485)
AI * Tax (demeaned)			-0.407**	-0.241
			(0.163)	(0.2)
AI			-0.061***	-0.064***
			(0.017)	(0.02)
Constant	5.429	5.427	5.44	5.438
	(26.13)	(36.17)	(43.15)	(70.02)
Observations	369,145	369,145	369,145	369,145
Number of periods	12	12	12	12
Host country-Parent company fixed effects	Yes	Yes	Yes	Yes
Sector-year fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

Notes:***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors in parentheses, clustered at parent-firm level. $Tech$ is a dummy variable taking on value 1 if the parent's sector is reported as Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77, and 0 otherwise. AI is a dummy variable taking on value 1 if a parent company's intangible assets intensity is above the sample median and 0 otherwise. All variables are in logs. All non-dummy regressors are computed as the difference between a specific variable's observation and its sample mean. The dependent variable has not been transformed.

Table 4: Big companies with above-median intangible asset intensity

	I	II	III
Dependent variable	EBIT	EBIT	EBIT
Fixed assets (demeaned)	0.471***	0.471***	0.471***
	(0.005)	(0.005)	(0.005)
Labor cost (demeaned)	0.214***	0.214***	0.214***
	(0.004)	(0.004)	(0.004)
Intangible assets (demeaned)	0.064***	0.064***	0.065***
	(0.004)	(0.004)	(0.004)
GDP host country (demeaned)	0.014	0.015	0.012
	(0.087)	(0.087)	(0.087)
Tax (demeaned)	-1.135***	-1.066***	-0.903***
	(0.205)	(0.213)	(0.24)
AI * Big	0.005	0.005	-0.061*
	(0.02)	(0.02)	(0.032)
AI * Big * Tax (demeanded)		-0.249	0.125
		(0.181)	(0.3)
AI			-0.042*
			(0.023)
AI * Tax (demeaned)			-0.468**
			(0.232)
Big			5.397
			(49.49)
Big * Tax (demeaned)			-0.0856
			(0.239)
Constant	5.418	5.418	5.397
	(126.3)	(119.7)	(49.49)
Observations	369,145	369,145	369,145
Number of periods	12	12	12
Host country-parent company fixed effects	Yes	Yes	Yes
Sector-year fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors in parentheses, clustered at parent-firm level. All non-dummy variables are computed as the difference between each observation (in log) and the sample mean (in log). The dependent variable has not been transformed. Large multinationals are defined as firms whose revenues are above 1 billion USD. AI is a dummy variable taking on value 1 if a parent company's intangible asset intensity is above the sample median and 0 otherwise.

Table 5: Tech and size sub-samples

	Big tech		Big no-tech		Small tech		Small no-tech	
	I	II	III	IV	V	VI	VII	VIII
Dependent variable	EBIT	EBIT	EBIT	EBIT	EBIT	EBIT	EBIT	EBIT
Fixed assets (demeaned)	0.495***	0.495***	0.508***	0.507***	0.375***	0.375***	0.358***	0.358***
	(0.012)	(0.012)	(0.008)	(0.008)	(0.014)	(0.014)	(0.009)	(0.009)
Labor cost (demeaned)	0.182***	0.182***	0.197***	0.197***	0.250***	0.250***	0.269***	0.268***
	(0.009)	(0.009)	(0.006)	(0.006)	(0.011)	(0.011)	(0.008)	(0.008)
Intangible assets (demeaned)	0.083***	0.083***	0.053***	0.053***	0.033***	0.032***	0.016**	0.016**
	(0.011)	(0.011)	(0.007)	(0.007)	(0.012)	(0.012)	(0.008)	(0.008)
GDP host country (demeaned)	0.459**	0.430**	-0.214*	-0.217*	0.103	0.067	-0.121	-0.140
	(0.211)	(0.212)	(0.129)	(0.13)	(0.331)	(0.331)	(0.198)	(0.198)
Tax (demeaned)	-1.070**	-1.090**	-1.030***	-1.034***	-0.980	-0.966	-1.495***	-1.508***
	(0.489)	(0.489)	(0.334)	(0.334)	(0.647)	(0.647)	(0.403)	(0.403)
h (demeaned)	-0.011	-0.013	-0.034***	-0.034***	-0.053***	-0.054***	-0.035***	-0.035***
	(0.017)	(0.017)	(0.009)	(0.009)	(0.011)	(0.011)	(0.007)	(0.007)
$Tax * h$ (demeaned)		-0.217*		-0.02		-0.157		-0.098
		(0.126)		(0.09)		(0.111)		(0.066)
Constant	4.934	4.929	4.564	4.564	4.428***	4.433***	4.319	4.316
	(234)	(234)	(2575)	(2575)	(0.464)	(0.463)	(315.4)	(315.4)
Observations	65,606	65,606	143,499	143,499	43,906	43,906	116,130	116,130
Number of periods	12	12	12	12	12	12	12	12
Host country-Parent company fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors in parentheses, clustered at parent-firm level. All non-dummy regressors are computed as the difference between a specific variable's observation and its sample mean. The dependent variable has not been transformed. Tech takes on value 1 if parent's sector is reported as Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77; and 0 otherwise. Big tech is defined as company coded as s tech company with revenues above 1 billion USD. Big no-tech is defined as company coded as non-tech with revenues above 1 billion USD. Small tech is defined as company coded as a tech company with revenues below 1 billion USD. Small no-tech is defined as company coded as non-tech with revenues below 1 billion USD. All variables are in logs.

Table 6: Difference between big-tech and other groups in the use of intangible assets for profit-shifting

	I	II
Dependent variable	EBIT	EBIT
Fixed assets (demeaned)	0.468***	0.471***
	(0.005)	(0.005)
Labor cost (demeaned)	0.213***	0.214***
	(0.004)	(0.004)
Intangible assets (demeaned)	0.058***	0.065***
	(0.004)	(0.004)
GDP host country (demeaned)	-0.015	0.0138
	(0.087)	(0.087)
Tax (demeaned)	-1.143***	-0.962***
	(0.212)	(0.224)
Big Tech	0.0443	0.0314
	(0.05)	(0.058)
Big Tech * Tax (demeanded)	-0.082	0.102
	(0.287)	(0.368)
h	-0.022***	
	(0.005)	
h * Big Tech	-0.034**	
	(0.014)	
h * Tax	-0.090*	
	(0.046)	
h* Big Tech * Tax (demeaned)	-0.124	
	(0.119)	
AI		-0.063***
		(0.018)
AI * Big Tech		0.009
		(0.046)
AI * Tax		-0.383**
		(0.18)
AI * Big Tech * Tax		-0.138
		(0.396)
Constant	5.395	5.425
	(93.59)	(93.59)
Observations	369,145	369,145
Number of periods	12	12
Host country-parent company fixed effects	Yes	Yes
Sector-year fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Standard errors in parentheses, clustered at parent-firm level. All non-dummy variables are computed as the difference between each observation (in log) and the sample mean (in log). The dependent variable has not been transformed. Big tech are defined as firms with parent's total sales above 1 billion USD whose sector is Nace code 26, 47, 49, 58, 61 ,62, 63, 64, 65, or 77. AI is a dummy variable taking on value 1 if a parent company's intangible asset intensity is above the sample median and 0 otherwise.

Figure 1: Booking of American corporations' profits abroad

Figure 2: Average intangible asset intensity by sector

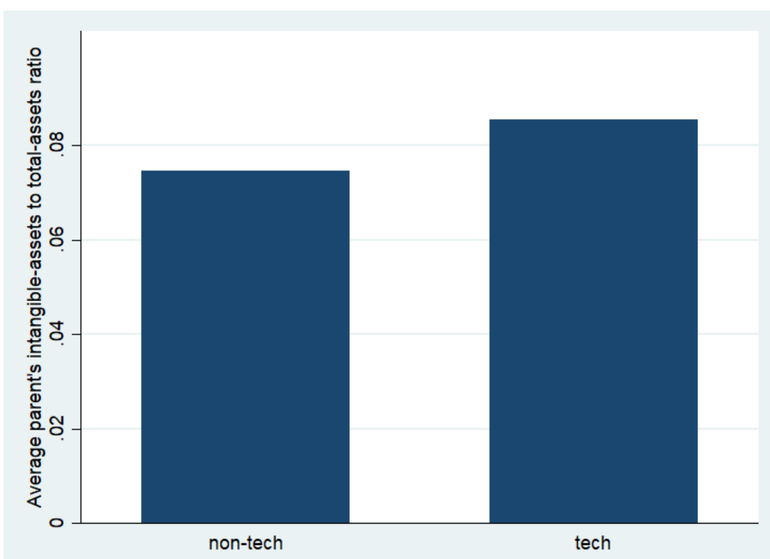


Figure 3: Marginal effect of tax differences at discrete intangible assets levels

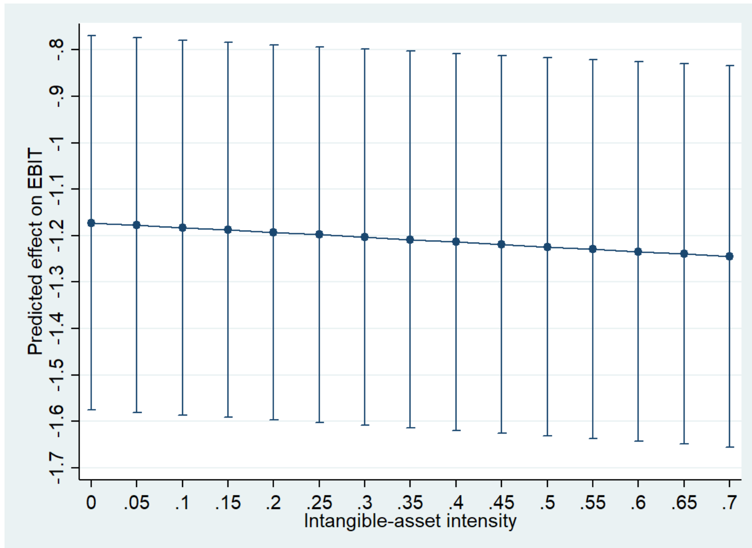


Figure 4: Marginal effect of intangible assets at discrete tax differences levels

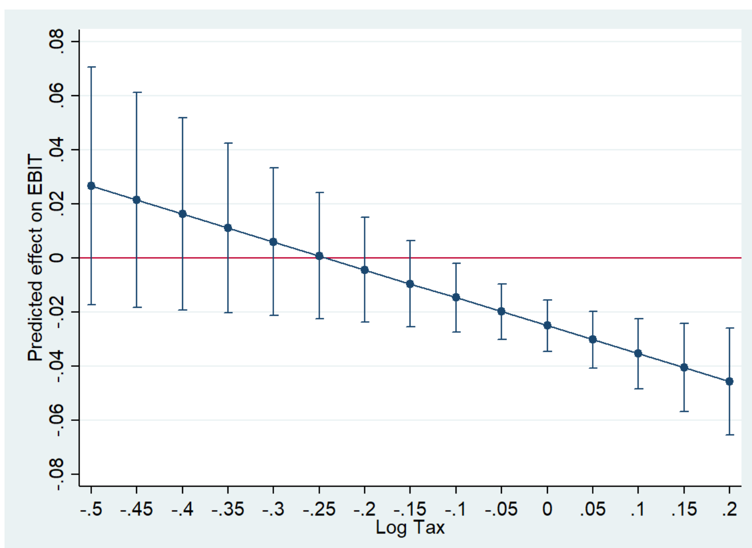


Figure 5: Centered predictions by intangible asset intensity

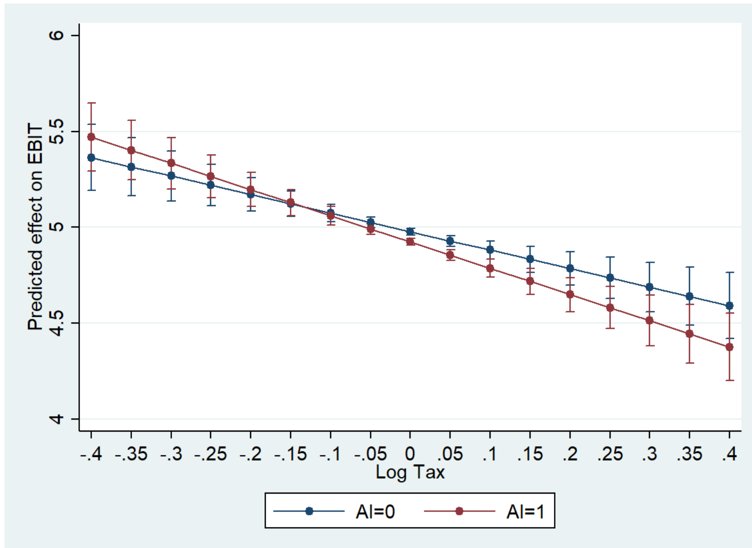


Figure 6: Centered predictions by intangible asset intensity and tech

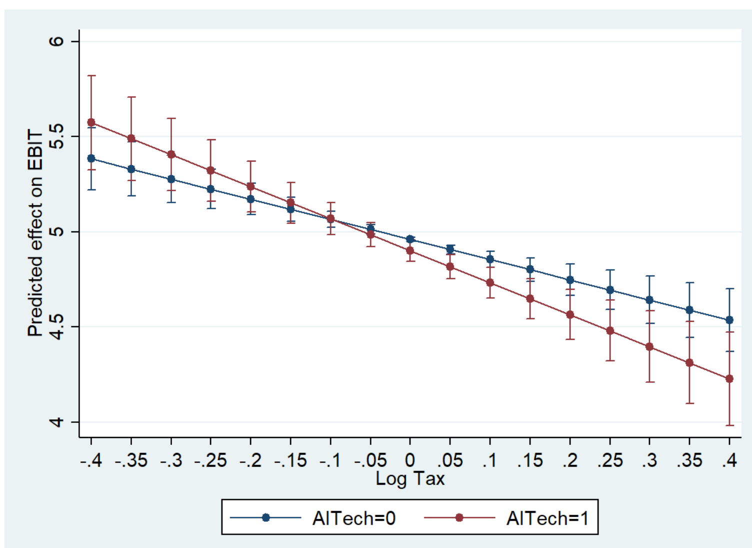
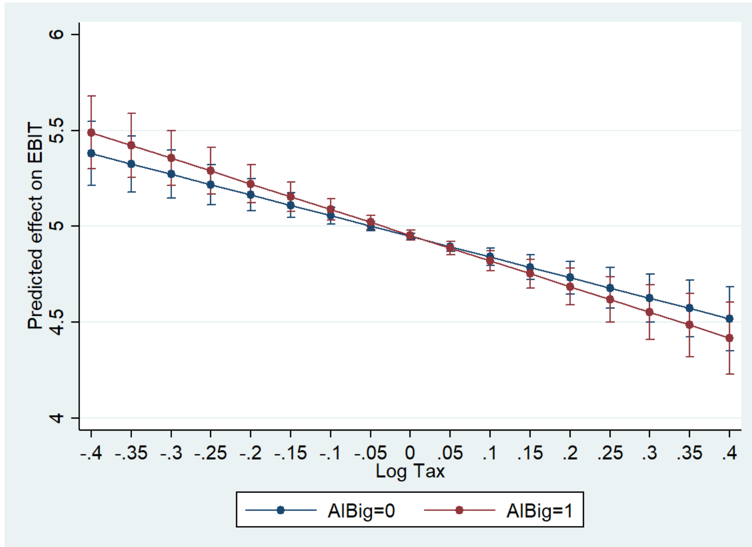


Figure 7: Centered predictions by intangible asset intensity and size



6 Derivation of the Optimal Profit-Shifting Amount

In this section I provide further details for the derivation of Eq.(1.8) from Section 1.2.

I start from the first order condition:

$$(1-\tau_j)(1-h^{\frac{1}{\sigma}}S_j)-\lambda=0 \tag{6.1}$$

This condition is the same for all js, which implied that:

$$\lambda=(1-\tau_1)(1-h^{\frac{1}{\sigma}}S_1)=(1-\tau_2)(1-h^{\frac{1}{\sigma}}S_2)....=(1-t_n)(1-h^{\frac{1}{\sigma}}S_n) \tag{6.2}$$

Let's consider the case in which a multinational group consists of three subsidiaries (n=3). In this case we have a system of two equations:

$$(1-\tau_1)(1-h^{\frac{1}{\sigma}}S_1)=(1-\tau_2)(1-h^{\frac{1}{\sigma}}S_2) \tag{6.3}$$

and

$$(1-\tau_2)(1-h^{\frac{1}{\sigma}}S_2)=(1-\tau_3)(1-h^{\frac{1}{\sigma}}S_3) \tag{6.4}$$

By solving each equation for S_1 and S_3 gives:

$$S_1=\frac{1}{(1-\tau_1)h^{\frac{1}{\sigma}}}[(\tau_2-\tau_1)+(1-\tau_2)h^{\frac{1}{\sigma}}S_2] \tag{6.5}$$

and

$$S_3 = \frac{1}{(1-\tau_3)h^{\frac{1}{\sigma}}}[(\tau_2-\tau_3)+(1-\tau_2)h^{\frac{1}{\sigma}}S_2] \tag{6.6}$$

Now, the constraint of the Lagrangian maximization is: $S_1 + S_2 + S_3 = 0$. Plugging Eq.(1.A.5) and Eq.(1.A.6) in this condition yields:

$$\frac{1}{(1-\tau_1)h^{\frac{1}{\sigma}}}[(\tau_2-\tau_1)+(1-\tau_2)h^{\frac{1}{\sigma}}S_2]+S_2+\frac{1}{(1-\tau_3)h^{\frac{1}{\sigma}}}[(\tau_2-\tau_3)+(1-\tau_2)h^{\frac{1}{\sigma}}S_2] = 0 \tag{6.7}$$

Solving for S_2:

$$\frac{(\tau_2-\tau_1)}{(1-\tau_1)h^{\frac{1}{\sigma}}} + \frac{(\tau_2-\tau_3)}{(1-\tau_3)h^{\frac{1}{\sigma}}} + S_2 + \frac{(1-\tau_2)h^{\frac{1}{\sigma}}S_2}{(1-\tau_1)h^{\frac{1}{\sigma}}} + \frac{(1-\tau_2)h^{\frac{1}{\sigma}}S_2}{(1-\tau_3)h^{\frac{1}{\sigma}}} = 0 \tag{6.8}$$

$$S_2\Big[1+\frac{(1-\tau_2)}{(1-\tau_1)}+\frac{(1-\tau_2)}{(1-\tau_3)}\Big] = -\frac{(\tau_2-\tau_1)}{(1-\tau_1)h^{\frac{1}{\sigma}}} - \frac{(\tau_2-\tau_3)}{(1-\tau_3)h^{\frac{1}{\sigma}}} \tag{6.9}$$

$$S_2\Big[\frac{(1-\tau_1)(1-\tau_3)+(1-\tau_2)(1-\tau_3)+(1-\tau_2)(1-\tau_1)}{(1-\tau_1)(1-\tau_3)}\Big] = \frac{(\tau_1-\tau_2)(1-\tau_3)+(\tau_3-t_2)(1-\tau_1)}{h^{\frac{1}{\sigma}}(1-\tau_1)(1-\tau_3)} \tag{6.10}$$

Dividing the numerator and the denominator of each side of Eq.(1.A.10) by $(1-\tau_1)(1-\tau_2)(1-\tau_3)$ gives:

$$S_2\Big[\frac{\frac{1}{(1-\tau_2)}+\frac{1}{(1-\tau_1)}+\frac{1}{(1-\tau_3)}}{\frac{1}{(1-\tau_2)}}\Big] = \Big[\frac{\frac{(\tau_1-\tau_2)}{(1-\tau_1)(1-\tau_2)}+\frac{(\tau_3-\tau_2)}{(1-\tau_2)(1-\tau_3)}}{\frac{h^{\frac{1}{\sigma}}}{(1-\tau_2)}}\Big] \tag{6.11}$$

$$S_2\Big[\sum_{k=1}^{3}\frac{1}{(1-\tau_i)}\Big] = \Big[\frac{\frac{1}{(1-\tau_2)}\Big[\frac{(\tau_1-\tau_2)}{(1-\tau_1)}+\frac{(\tau_3-\tau_2)}{(1-\tau_3)}\Big]}{h^{\frac{1}{\sigma}}}\Big] \tag{6.12}$$

$$S_2\Big[\sum_{k=1}^{3}\frac{1}{(1-\tau_i)}\Big] = \frac{\sum_{k\neq j}^{3}\frac{(\tau_k-\tau_2)}{(1-\tau_k)}}{(1-\tau_2)h^{\frac{1}{\sigma}}} \tag{6.13}$$

$$S_2 = \frac{1}{h^{\frac{1}{\sigma}}(1-\tau_2)}\frac{\sum_{k\neq j}^{3}\frac{(\tau_k-\tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{3}\frac{1}{(1-\tau_k)}} \tag{6.14}$$

This can be generalized to the case with n subsidiaries as:

$$S_j = \frac{1}{h^{\frac{1}{\sigma}}(1-\tau_j)}\frac{\sum_{k\neq j}^{n}\frac{(\tau_k-\tau_j)}{(1-\tau_k)}}{\sum_{k=1}^{n}\frac{1}{(1-\tau_k)}} \tag{6.15}$$

7 Tables Appendix

Table 7: Firms' sample distribution by country

Country	Parents frequency	Parents, %	Subsidiaries frequency	Subsidiaries, %
Australia	133	0.96	3,582	1.59
Austria	244	1.75	2,508	1.12
Bahamas	2	0.01	3	0.00
Belgium	537	3.86	7,466	3.32
Bermuda	186	1.34	453	0.20
Brazil	51	0.37	1,257	0.56
Bulgaria	16	0.12	1,277	0.57
Canada	314	2.26	788	0.35
Cayman Islands	344	2.47	753	0.33
China	286	2.06	7,892	3.51
Croatia	44	0.32	1,290	0.57
Cyprus	24	0.17	155	0.07
Czech Republic	71	0.51	3,223	1.43
Denmark	385	2.77	5,348	2.38
Estonia	34	0.24	730	0.32
Finland	271	1.95	4,005	1.78
France	800	5.75	22,271	9.91
Germany	896	6.44	13,881	6.17
Greece	33	0.24	874	0.39
Hong Kong	260	1.87	1,033	0.46
Hungary	76	0.55	3,282	1.46
Iceland	14	0.10	449	0.20
India	161	1.16	5,089	2.26
Indonesia	33	0.24	185	0.08
Ireland	117	0.84	2,152	0.96
Italy	706	5.08	20,002	8.90
Japan	799	5.74	20,094	8.94
Latvia	14	0.10	661	0.29
Lithuania	14	0.10	358	0.16
Luxembourg	103	0.74	2,242	1.00
Malta	6	0.04	867	0.39
Mexico	33	0.24	162	0.07
Netherlands	687	4.94	6,487	2.89
Norway	92	0.66	6,824	3.04
Panama	3	0.02	24	0.01
Poland	42	0.30	4,753	2.11
Portugal	298	2.14	4,235	1.88
Romania	13	0.09	3,340	1.49
Russian Federation	13	0.09	4,034	1.79
Singapore	14	0.10	694	0.31
Slovakia	29	0.21	1,655	0.74
Slovenia	46	0.33	846	0.38
Spain	849	6.10	15,275	6.79
Sweden	781	5.62	10,232	4.55
Switzerland	1,015	7.30	1,706	0.76
Taiwan, Province of China	287	2.06	1,444	0.64
Turkey	48	0.35	514	0.23
United Arab Emirates	31	0.22	70	0.03
United Kingdom	943	6.78	24,594	10.94
United States	1,710	12.30	3,784	1.68
Total	13,908	100.00	224,843	100

Table 8: Summary statistics

Variable name	Obs	Mean	Std. Dev.	Min	Max
EBIT (USD, th)	369,145	86,863	1,186,749	0	97,300,000
EBIT (log)	369,145	5.0	4.3	-11.2	18.4
Intangible assets (USD, th)*	369,145	168,899	2,704,882	0	243,000,000
Intangible assets (log)*	369,145	3.3	4.3	-12.6	19.3
Intangible asset shares**	369,141	0.08	0.11	0.00	0.88
Fixed assets (log)	369,145	5.69	4.55	-11.45	20.51
Fixed assets (USD, th)	369,145	392,484	6,592,331	0	807,000,000
Labor compensations (USD, th)	369,145	97,622	11,800,000	0	7,150,000,000
Labor compensations (log)	369,145	5.37	4.49	-6.71	22.69
Tax***	369,145	1.35	0.13	0.90	1.76
Corporate tax rate	369,145	0.26	0.07	0.00	0.41
Host country GDP (log)	369,145	27.41	1.49	21.75	30.69
Tech company	369,145	0.3	0.5	0.0	1.0

Note: *Aggregate subsidiaries' intangible assets by country and multinational group. **Share of total group intangible assets to group total asset. ***As defined in section 1.2.

Table 9: Variables descriptions

Variable	Definition	Source
EBIT	Log of USD value of subsidiary's earnings before interests and taxes in a given year.	Orbis
Fixed assets	Log of USD value of subsidiary's fixed assets stock in a given year.	Orbis
Total assets	Log of USD value of subsidiary's total assets stock in a given year.	Orbis
Intangible assets	Log of USD value of subsidiary's intangible assets stock in a given year.	Orbis
Labor cost	Log of USD value of subsidiary's total labor compensation in a given year.	Conference Board
Tech parent	Dummy variable taking the value of 1 if the parent's sector is "electronics manufacturing" or "communication and ict services" sectors, 0 otherwise. These sectors correspond to Nace Rev. 2. sector codes: 26, 47, 49, 58, 61 ,62, 63, 64, 65, 77.	Orbis
Intangibles group share	Ratio of a total multinational group's value of intangible total asset stock (in USD) within the same multinational group. It varies by multinational group and year.	Orbis
Intangibles group share dummy	Dummy variable that takes on value 1 if the Intangibles Group Share is above median, 0 otherwise.	Orbis
Corporate tax rate	Statutory corporate tax rate in the country where a subsidiary is located.	KPMG, corporate and indirect tax survey
Withholding tax	Withholding tax rate between the country where a subsidiary is located and the country where the parent company is located.	KPMG, corporate and indirect tax survey
GDP host country	Log of GDP of the country where a subsidiary is located in a given year.	IMF, *World Economic Outlook*, October 2018 edition