THE MISSING PROFITS OF NATIONS

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<u>ABSTRACT</u>

By exploiting new macroeconomic data known as foreign affiliates statistics, we show that affiliates of foreign multinational firms are an order of magnitude more profitable than local firms in low-tax countries. By contrast, affiliates of foreign multinationals are less profitable than local firms in high-tax countries. Leveraging this differential profitability, we estimate that close to 40% of multinational profits are shifted to tax havens globally. We analyze how the location of corporate profits would change if all countries adopted the same effective corporate tax rate, keeping global profits and investment constant. Profits would increase by about 15% in high-tax European Union countries, 10% in the United States, while they would fall by 60% in today's tax havens. We provide a new international database of GDP, trade balances, and factor shares corrected for profit shifting, showing that the rise of the corporate capital share is significantly under-estimated in high-tax countries.

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Appendix and Data are available at http://gabriel-zucman.eu/missingprofits/

1 Introduction

Perhaps the most striking development in tax policy throughout the world over the last few decades has been the decline in corporate income tax rates. Between 1985 and 2018, the global average statutory corporate tax rate has fallen by about half, from 49% to 24%. In 2018, the United States cut its rate from 35% to 21%.

One reason for this decline is international tax competition. By cutting their tax rates, countries can attract capital and profits from abroad (see Keen and Konrad, 2013, for a survey of the large literature on tax competition). Despite the prominence of tax competition in both the academic literature and the public debate, however, we do not currently have comprehensive estimates of how much profit each country loses or attracts because of international differences in corporate tax rates. Although there are excellent data on U.S. multinationals, which have been used extensively to study the location and tax-optimization choices of U.S. firms,[1] until recently there was no similar data covering the multinationals of other countries. As a result, we do not currently have a clear view of the extent to which globalization and tax competition are redistributing profits across nations.

Our paper attempts to fill this gap by drawing on new data. In recent years, the statistical institutes of most of the world's developed countries—including the major tax havens—have started releasing new macroeconomic data known as foreign affiliates statistics. Following new international guidelines, these statistics record the wages and profits of foreign firms, defined as firms more than 50% owned by foreign shareholders (i.e., typically subsidiaries of foreign multinational companies). By combining these data with existing national accounts aggregates which cover all firms incorporated in a given country, we can estimate the profits made and wages paid in each country by local firms (i.e., all firms incorporated in a given country which are not foreign) and foreign firms separately. This makes it possible to obtain a comprehensive view of where multinational companies book their profits, and in particular to estimate the amount of profit booked in tax havens globally.[2]

Using our new database, we consider the following thought experiment. Imagine that all countries agreed tomorrow to a perfect international tax harmonization, i.e., agreed to apply the same effective corporate income tax rate, keeping global profits and the global capital stock

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[1] See, e.g., Gravelle (2009), Clausing (2009, 2016), Guvenen et al. (2018).

[2] A number of papers attempt to estimate the amount of profits shifted globally (Crivelli, de Mooij and Keen, 2015; Bolwijn et al., 2018, Cobham and Janský, 2018) and the implied tax revenue losses. To our knowledge, however, it is the first time that profits gains and losses for each country are estimated based on directly observable data covering the activities of multinationals in tax havens.

constant. By how much would profits booked in the United States, the European Union, and developing countries increase compared to today's situation—and by how much would they fall in low-tax places like Ireland? And would a lot of capital move back to today's high tax-countries (with potentially significant effect on wages, depending on the elasticity of substitution between capital and labor), or would firms merely change the location of paper profits without many tangible assets moving across borders? In other words, how does tax competition redistribute profits internationally and what is the relative importance of tax competition for tangible capital vs. tax competition for paper profits? Answering these questions is important to better understand the redistributive impacts of globalization, that is, which countries (and social groups) have gained most from it, and which have gained less or lost.

The new foreign affiliates statistics exploited in this paper have a number of strengths to address these questions. They are more comprehensive than financial accounting data on which a lot of the literature is based (see Section 2). They provide direct information on the profits booked in tax havens and do not double-count the profits of indirectly-held affiliates. We stress at the outset, however, that we are well aware of the deficiencies of existing foreign affiliates statistics; in many ways, these statistics are still in their infancy. Despite their limitations (discussed in Section 4.2 below), these macro data are at present the most comprehensive that exist to study the activities of multinational corporations in a global perspective, a question so important that we cannot wait for perfect data before we start addressing it (and which has indeed been addressed in the past by many authors using less comprehensive data than we presently have). In addition, we feel that a useful way for scholars to contribute to future data improvement is to use the existing statistics in a systematic manner, so as to better identify their limits and how these limits could be overcome. Our article, therefore, can also be viewed as an attempt to assess the internal consistency of the foreign affiliates statistics of all the world's countries, and to pinpoint the areas in which progress needs to be made.

Using our new database, we document a simple but striking fact: Foreign firms are systematically more profitable than local firms in low-tax countries, while the opposite is true in high-tax countries. More precisely, for local firms (i.e., firms that are not subsidiaries of a foreign multinational group) the ratio of pre-tax profits to wages is typically around 30%–40% in both high-tax and low-tax countries. For foreign firms, the ratio of pre-tax profits to wages is an order of magnitude higher than 30%–40% in low-tax countries, while it is lower than 30%–40% in high-tax countries. For example, foreign firms in Ireland (a low-tax country) have a profits-to-wage ratio of 800%: for $1 of wage paid to Irish employees, foreign multinationals report $8

in pre-tax profits in Ireland.[3] In the UK by contrast, foreign firms have a profits-to-wage ratio of 26% only. Global macro data thus show a large redistribution of profits within divisions of multinational companies, away from high-tax countries and towards low-tax places.

To better understand the high profits booked in tax havens, we provide decompositions into real effects (more tangible capital used by foreign firms in tax havens) and profit shifting effects (above-normal returns to capital and receipts of interest). This distinction matters because these two processes have different distributional implications. Movements of tangible capital across borders affect wages, to the extent that tangible capital has a finite elasticity of substitution with labor. By contrast, movements of paper profits (i.e., profit shifting) don't: for a given global profitability, whether profit is booked in the United States or in Bermuda has no reason to affect workers' productivity in either of these places. Our results show that the high profits-to-wage ratios of multinationals in tax havens are primarily explained by shifting effects. Tangible capital is internationally mobile—and there is evidence that this mobility has become slightly more correlated with tax rates over the last twenty years—but globally, machines have not massively moved to low-tax places; paper profits have.

Using the differential profitability of foreign firms in high- vs. low-tax countries, and new bilateral balance of payments data recently published by tax havens, we develop a methodology to estimate the amount of profit shifted into each haven and the profit loss for individual high-tax countries. Our computations are relative to a benchmark in which, keeping global profit fixed, all countries had the same effective corporate tax rate (for instance, all countries applied the current global average effective corporate tax rate).[4] Globally, we find that close to 40% of multinational profits—defined as profits made by multinational companies outside of the country where their parent is located—are shifted to tax havens in 2015. The governments of the (non-haven) European Union countries appear to be the prime losers of this shifting, with a reduction in profit of about 20% relative to our benchmark. The governments of tax havens derive sizable benefits from this phenomenon: by taxing the large amount of paper profits they attract at very low rates (typically less than 5%), they generate more tax revenue, as a fraction of their national income, than the United States and non-haven European countries that have much higher rates. We also find that U.S. multinationals shift comparatively more profits than

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[3]This corresponds to a capital share of corporate value-added of 80%–90% in foreign firms operating in Ireland, vs. around 25% in local Irish firms.

[4]We do not have anything to say in this paper about the effect of increasing or cutting the global effective corporate tax rate, a question studied by the large literature on the efficiency costs of capital taxation. Instead, we take the global effective corporate tax rate as given, and ask how the geography of profits and capital would change if all countries applied it.

multinationals from other countries.

Our estimate for the amount of profit shifted globally—close to 40% of multinational profits—is sizable, but it appears to be well founded empirically. In particular, we find similar magnitudes using two fully independent methodologies and data sources: our benchmark "above-normal profitability" methodology, based on the high profits-to-wage ratios recorded in foreign affiliates statistics by foreign firms in tax havens, and an "above-normal cross-border transactions" methodology, based on the high exports of services and receipts of intra-group interest recorded in the balances of payments of tax havens. In 2015, the "above normal profitability" yields an estimate of $616 billion for the amount of profit shifted to tax havens globally, while the "above-normal cross-border transactions" methodology yields an estimate of $646 billion.

We discuss two main implications of these findings. First, our results suggest that the headline economic indicators—including GDP, trade balances, and corporate labor and capital shares—of a number of countries are distorted. The flip side of the profits shifted to tax havens is that output, net exports and profits recorded in non-haven countries are too low. We provide a new database of corrected macro statistics for all OECD countries and the largest emerging economies. Adding back the profits shifted out of high-tax countries increases the corporate capital share significantly. By our estimates, the rise in the European corporate capital share since the early 1990s is twice as large as recorded in the official national accounts (used, e.g., by Karabarbounis and Neiman, 2014). This finding has implications for current debates about the changing nature of technology and inequality.

Second, our results can be used to quantify the tax revenues that individual countries could gain under different corporate tax reform scenarios. We consider one such scenario, the taxation of shifted profits by source countries, and find that corporate tax receipts could increase by up to 15% in the United States and 20% in a number of European countries compared to today. Looking forward, our data could be used to quantify the revenue implications of more fundamental reforms, such as the use of a formulary apportionment system (e.g., Gordon and Wilson, 1986; Avi-Yonah and Clausing, 2007), or a destination-based corporate cash flow tax (Auerbach, 2010). We also plan to update our database and estimates annually, making it possible for researchers and policy-makers to track the effects of ongoing policy efforts aimed at reducing corporate profit shifting, such as the OECD "base erosion and profit shifting" (BEPS) initiative, or the effect of tax changes such as the 2017 US tax reform.[5]

The rest of this paper proceeds as follows. In Section 2 we relate our work to the literature.

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[5] Preliminary updated estimates for 2016 and 2017 are available in Tørsløv et al. (2020).

Section 3 outlines our conceptual framework and methodology, and Section 4 describes the data. We present our estimates of the amount of profits shifted to each tax haven in Section 5, before analyzing the implications of this phenomenon for non-haven countries in Section 6. Section 7 discusses our corrected estimates of factor shares and trade balances. We provide concrete proposals to improve economic statistics and the monitoring of global activity in the conclusion (Section 8). This paper is supplemented by an Online Appendix that enables the reader to reproduce all our estimates step by step starting from publicly available data. All the data used in this research are available online.[6]

2 Related Literature

We start by relating our work to previous attempts to estimate global profit shifting and to the literature on international tax competition.

2.1 Microeconometric Estimates of Profit Shifting

A large body of work studies international profit shifting using accounting micro-data, collected in the Orbis database of Bureau van Dijk.[7] Profit shifting is estimated by running regressions of the following form:

$$log(\pi_{ic}) = \alpha + \beta(\tau_p - \tau_c) + \delta Firm_i + \gamma Country_c + \epsilon_{ic} \tag{1}$$

where π_{ic} denotes the pre-tax profits booked by company i in country c, τ_c the tax rate in country c, τ_p the tax rate in the parent's country (or the average tax rate of foreign affiliates), and $Firm_i$ and $Country_c$ firm and country controls.[8] A positive $\hat{\beta}$ is interpreted as evidence of profit shifting, and the global amount of profits shifted for tax reasons is extrapolated from the estimated β. The OECD (2015) uses this methodology for its official estimate of the size of base erosion and profit shifting (Johansson et al., 2017).

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[6]The Appendix and dataset, as well as updated estimates and visualizations, are available at `http://missingprofits.world`.

[7]See Kalemli-Özcan et al. (2015) for a presentation of these data.

[8]The literature considers four measures for the incentives to shift profits: (1) the differential with the tax rate of the parent's country (e.g., Dharmapala and Riedel, 2013); (2) the weighted tax rate differential with all other subsidiaries (e.g., Huizinga and Laeven, 2008); (3) the unweighted tax rate differential with other subsidiaries (e.g., Johansson et al. 2017), and (4) the statutory corporate tax rate (e.g., Lohse and Riedel, 2013). On a priori ground, it is unclear which of these measures is preferable. Heckemeyer and Overesch (2017) give an overview of 26 studies using this approach; see also de Mooij and Ederveen (2008), Riedel (2018), Wier and Reynolds (2018), and Beer, de Mooij and Liu (2019). A number of studies (e.g., Egger et al. 2010) use the Bureau van Dijk Amadeus database, which is the European subset of Orbis.

Although this methodology has generated important insights, it also faces limitations. First, little micro-data exists about the profits booked by multinationals in low-tax countries. Orbis provides accurate information about the global consolidated profits of most of the world's multinationals (see, e.g., Cobham and Loretz, 2014). Multinational companies, however, are generally not required to publish their profits country by country (or subsidiary by subsidiary). Orbis relies on administrative information in public business registries to record the profits made by multinationals in their various subsidiaries. Because countries such as France maintain comprehensive registries, almost all the profits made by French resident firms (including subsidiaries of foreign multinationals) can be seen in Orbis.[9] But in many countries public registries either do not exist (e.g., Bermuda), or contain no income information (e.g., United States, Ireland, Switzerland).[10] Profits booked by multinationals in these countries are not visible in Orbis.

For instance, as shown by Figure 1, Orbis correctly reports that the worldwide consolidated profits of Apple were 55.3 billion euros in 2016. If one adds up all the profits recorded in Orbis by all of Apple's subsidiaries throughout the world, however, then one finds only 2.0 billion euros. None of the profits made by Apple in the United States or in Ireland, Jersey, or similar tax havens are visible.[11] Similarly large discrepancies are observed for Google Alphabet, Facebook, and Nike. In Figure 2, we compare the consolidated global profits of each multinational in Orbis to the sum of its subsidiary-by-subsidiary profits. In 2012, 17% of the global profits of multinationals could be traced in Orbis. That is, 83% were booked in subsidiaries unknown to Orbis, or for which no profits data was available. The problem is particularly acute for low- and zero-tax countries.[12]

The limited reporting of data in tax havens has two main implications. First, it means that estimating equation 1 with publicly available accounting micro-data can deliver estimates of

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[9]In 2010 for instance, the national accounts of France report that French resident corporations made $240 billion in pre-tax profits after net interest payments. In Orbis one finds a very close figure, $237 billion.

[10]In the Spring of 2017, the United Kingdom announced that it would mandate its overseas territories (e.g., Bermuda, the British Virgin Islands, and the Cayman Islands) to develop public registries of the owners of companies formed there by the end of 2020. It is unclear whether income or balance sheet information will be made available in these registries. This initiative doesn't capture the Crown Dependencies (such as Jersey, Guernsey and Isle of Man).

[11]The use of tax havens by Apple is documented in, e.g., U.S. Senate (2014).

[12]A number of papers study shifting by U.S. multinationals using data from the Bureau of Economic Analysis on the activities of U.S. multinationals abroad (see, e.g., Clausing, 2009; Guvenen et al., 2018) and IRS data (e.g., Altshuler and Grubert, 2005; Grubert, 2013; Dowd, Landefeld and Moore, 2017, and De Simone, Mills and Stomberg, 2017). These data do not suffer from the problems in Orbis, as U.S. multinationals have to (confidentially) report information on all their subsidiaries to the BEA and to the IRS. These data can only be used to study shifting by U.S. multinationals, while we are interested in shifting by all multinationals. See Section 4.2 below for how our data relate to the Bureau of Economic Analysis statistics on the activities of U.S. multinationals abroad.

β that are downwards biased. It is only in the special case where the semi-elasticity of profit shifting with respect to tax rate differentials is constant that the estimated β is unbiased.[13] There is evidence in the literature, however, that the shifting elasticity is nonlinear, with more responsiveness at lower tax rates than at higher ones.[14] One may also imagine that multinational companies try to shift profits in a discreet manner (e.g., for public relation reasons). In the extreme case where they only shift profits to subsidiaries that do not publish income statements, the estimated β in Orbis is zero, while in actual facts it is positive and possibly large.[15] Second, estimating equation 1 with accounting micro-data can lead to biased inferences about the location of shifted profits. If only high-tax countries have public registries, then one can find that all profit shifting takes place between high-tax countries, whereas in actual facts this shifting may be second-order relative to the shifting to low-tax countries.

The main difference between our work and the micro-econometric estimates of global profit shifting is that we rely on direct (macro) data on the profits booked by multinationals in tax havens, namely foreign affiliates statistics. These macro data are more comprehensive than the data available in Orbis or similar databases, for one simple reason. While Orbis has to rely on publicly available corporate registries, statistical authorities have access to a much broader set of information to compile their foreign affiliates and national account statistics: corporate income tax returns, censuses of the activities of domestic and foreign corporations, and private income statements and balance sheets. As a result, the flow of profits recorded in these macro data is much larger than the one in Orbis. These macro data are not perfect however; they have limitations and sometimes need to be corrected, as we discuss in Section 4.2 below.

2.2   Macro Estimates of Profit Shifting

A nascent literature takes a macro perspective to study profit shifting. The OECD (2015) itself, although it used Orbis for its official BEPS estimate, suggested that global macro data be used to estimate profit shifting.

Most of this macro literature uses U.S. statistics, hence focuses on U.S. multinationals only (Clausing, 2009, 2016; Gravelle, 2009; Zucman, 2014; Guvenen et al., 2018). In this paper, we take a global perspective: we estimate profit shifting by all the world's multinationals and the

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[13]Even in this case, extrapolating the global amount of profits shifted from $\hat{\beta}$ requires to be able to observe in which countries multinationals have subsidiaries—which is not possible in Orbis, since subsidiaries in countries with no public corporate registry are not visible.

[14]For instance, using U.S. corporate income tax data, Dowd et al. (2017) find tax semi-elasticities of 4.7 at corporate tax rates of 5 percent and 0.6 at tax rates of 30 percent. See also Wier and Reynolds (2018).

[15]Relatedly, Bilicka (2019) studies profit shifting outside of the United Kingdom using UK tax data, and finds that accounting data underestimate the true size of profit shifting relative to more comprehensive tax data.

implications of this phenomenon for each OECD country, the main emerging economies, and tax havens. This global perspective allows us to estimate how tax competition redistributes profits internationally, thus shedding light on the redistributive effects of globalization. Our database and results are relevant for policy-makers across the world and make it possible to put the United States in an international perspective. For example, we can study whether U.S. multinationals shift more profit than multinationals from other countries.[16]

Two pioneering recent studies, Crivelli, de Mooij and Keen (2015) and Bolwijn et al. (2018), use global macro data to study profit shifting and are the most closely related to our work.[17] The main difference is that we rely on different methodology and data (namely, foreign affiliates statistics and bilateral balances of payments).[18] The foreign affiliates statistics we use allow us to observe the profits booked by multinationals in tax havens and to compute factor shares in foreign vs. local firms across the world. This enables us to produce an estimate of profit shifting based on the abnormally high capital share reported by foreign firms in tax havens.[19] One advantage of this methodology is that it produces estimates of profit shifting that can be easily tracked by policy makers on a year-to-year basis. Moreover, the new bilateral balance of payments we use enable us to provide bilateral estimates of profit shifting (i.e., how much profits are shifted by French firms to Luxembourg, by German firms to the Netherlands, etc.), which was not possible with earlier approaches. Bilateral estimates are a necessary input to calibrate quantitative models of international tax competition and multinational production with profit shifting (e.g., Wang, 2018). Our database, available online at `http://missingprofits.world`, could be used to calibrate such models in the future.

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[16]Methodological similarities and differences with the important work of Clausing (2009) and Guvenen et al. (2018) are further discussed in Section 3.3 below.

[17]These studies are replicated and tested for robustness in Janský and Palanský (2017) and Cobham and Janský (2018).

[18]Bolwijn et al. (2018) rely on the balance of payments and FDI statistics of non-haven countries; Crivelli, de Mooij and Keen use corporate income tax revenue data. A number of papers in international finance (e.g., Lane and Milesi-Ferretti, 2018) use tax havens' international investment positions, but this literature attempts to characterize patterns in international investment, not to estimate the size of profit shifting as we do here.

[19]Crivelli, de Mooij and Keen (2015) infer the tax revenue losses due to international corporate tax avoidance for developing vs. advanced economies from the correlation between corporate tax revenue collected and the statutory tax rates of other countries estimated in a panel model. We view their approach and ours as complementary. Using the methodology in Crivelli, de Mooij and Keen (2015), Cobham and Janský (2018) estimate country-level tax revenue losses due to international corporate tax avoidance. As in Crivelli, de Mooij and Keen (2015), these estimates are based on the estimated cross-country correlation between corporate income tax revenue and foreign countries' tax rates. A systematic reconciliation of their findings with ours is a fruitful avenue for future research.

2.3 Literature on Tax Competition

Our paper is also related to the large theoretical literature on international tax competition. A large body of work focuses on competition for tangible capital (see Keen and Konrad, 2013). A number of studies also consider competition for paper profits, its interaction with competition for tangible capital, the incentives of tax havens, and the costs involved for non-haven countries.[20] Our contribution to this literature is to provide a first empirical quantification of the international redistribution of profits due to tax competition for paper profits vs. capital.

3 Conceptual Framework and Methodology

There are three main steps in our analysis. We first compute the profitability of local vs. foreign firms across countries, including, most importantly, in tax havens. Second, we estimate the extent to which the relatively high profitability of foreign firms in tax havens can be explained by profit shifting to tax havens vs. higher capital intensities in low-tax places. Third we apportion the shifted profits to the countries where they would have been booked absent international differences in tax rates. We discuss each step in turn.

3.1 Macroeconomic Profitability Ratios

In the first step of our analysis, we study the macroeconomic ratio π of pre-tax corporate profits to wages. We are interested in how this statistic varies across countries, and how it varies within countries but across foreign-owned (π_f) vs. local (π_l) firms. The profits-to-wage ratio is easy to compute and closely related to factor shares of output, which allows for straightforward interpretations of the economic forces at play. It is not the only relevant margin to compare local and foreign firms: profits-to-assets and effective tax rates are also relevant and ideally all need to be analyzed together, as we do below.

We define π at the country level as follows. Using standard notations, we denote by Y the corporate output (or value-added) of a country, obtained by combining effective labor AL and capital K.[21] We include in the corporate sector all resident corporations, both non-financial and financial. Part of corporate output is paid to workers, and the rest, operating surplus, accrues to the owners of capital: $Y = F(K, AL) = rK + wL$. In this framework, r includes both the normal return to corporate capital and any above-normal return (i.e., r is not necessarily

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[20]See Slemrod and Wilson (2009); Hong and Smart (2010); Johannesen (2010); the application of the Kanbur and Keen (1993) model of commodity tax competition to profit shifting in Keen and Konrad (2013).

[21]Here and in what follows we consider output at factor cost, i.e., before indirect taxes.

equal to the marginal product of capital). The capital share of corporate output is $\alpha = rK/Y$ and the ratio of operating surplus to wages is $\alpha/(1-\alpha)$. Corporations pay p percent of their operating surplus rK in net interest. We define (pre-tax) corporate profits as $(1-p) \cdot rK$. Our ratio of interest π measures the profits made by resident firms per dollar of wage paid: $\pi = (1-p) \cdot \alpha/(1-\alpha)$.[22] We subtract net interest paid from corporations' operating surplus because interest payments are typically deductible from the corporate tax base while interest received (e.g., by banks) is typically taxable. At the country level, net interest paid by corporations is generally small (interest paid by non-financial corporations is offset by interest received by financial corporations), so π is usually close to $\alpha/(1-\alpha)$. As we shall see, the main exception involves tax havens which receive net interest from foreign countries; for them $\pi > \alpha/(1-\alpha)$. We also subtract capital depreciation from profits, because depreciation is deductible from taxable profits. Thus Y, α, r, and π are all net of capital depreciation.

Our main objective is to study how the profits-to-wage ratio differs for foreign corporations (π_f) vs. local firms (π_l) within each country. We define π_f and π_l analogously to π. That is, π_f is equal to the pre-tax profits (after net interest payments) made by foreign firms divided by the wages paid by these firms: $\pi_f = (1-p_f) \cdot \alpha_f/(1-\alpha_f)$, where α_f is the net-of-depreciation capital share of the net value-added of foreign firms. In the data (described in Section 4.2 below), following internationally-agreed guidelines foreign firms include all firms where foreign investors own more than 50% of shares with voting rights. This condition is sufficient but not necessary: there are a few other ways firms can be classified as "foreign-controlled" (see Eurostat, 2012). Local firms are all firms that are not foreign. By definition, $\pi = s \cdot \pi_f + (1-s) \cdot \pi_l$, where s is the share of wages paid by foreign firms.

3.2   Decomposing Tax Havens Profits: Tangible Capital vs. Shifting

In a perfectly competitive model where factors are paid their marginal product (an assumption we relax below), a high recorded profits-to-wage ratio π in tax havens can have two reasons: either paper profits are being shifted to tax havens, or there's a lot of capital used in production and the elasticity of substitution between capital and labor is greater than 1. We are interested in quantifying the relative contributions of profit shifting vs. movements of tangible capital to the high profit-to-wage ratios π of tax havens.

There are three forms of profit shifting (see Heckemeyer and Overesch, 2017, for a survey),

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[22]Our measure of wage always include non-wage employee compensation (such as retirement benefits, health benefits, payroll taxes, etc.). That is, "wage" in this article always refers to what is called "employee compensation" in the national accounts (SNA code D.1).

and each affects the recorded profit-to-wage ratio π. First, multinational groups can manipulate intra-group exports and import prices: subsidiaries in high-tax countries can try to export goods and services at low prices to related firms in low-tax countries, and import from them at high prices.[23] Such transfer price manipulations increase the recorded π_f (hence π) in tax havens. Second, multinationals can shift profits using intra-group interest payments: affiliates in high-tax countries can borrow money (potentially at relatively high interest rates) from affiliates in low-tax countries, which again increase π_f in tax havens.[24] Last, multinationals can move intangibles—such as trademarks, patents, logos, algorithms, or financial portfolios—produced or managed in high-tax countries to affiliates in low-tax countries. These affiliates then receive royalties, interest, or payments from final customers, which boost π_f.[25] Movements of intangibles can be analyzed like transfer price manipulations and intra-group borrowing because they have the same distributional implications: for a given global stock of intangibles, these movements relocate profits across countries (away from where R&D or financial activity takes place) without affecting wages.[26] By contrast, if the elasticity of substitution between labor and tangible capital is finite, movements of tangible capital across borders affect wages.[27]

To identify what part of the profits reported by foreign firms in tax havens reflects profit shifting vs. movements of tangible capital, it is convenient to start by considering the simple case where all countries—havens and non-havens—have the same aggregate Cobb-Douglas production function $Y = K^\alpha (AL)^{1-\alpha}$ and factors are paid their marginal product. If net interest paid (p) is zero and $\alpha = 25\%$, then all countries have a true $\pi = 33\%$ and any deviation of the recorded π from this value reflects profit shifting (countries with recorded π above 33% attract paper profits from abroad, while countries with recorded π below 33% shift profits abroad). With Cobb-Douglas production, the stock of tangible capital does not affect π, because any

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[23]There is evidence of such transfer price manipulations in the literature; see, e.g., Clausing (2003); Bernard, Jensen and Schott (2006); Vicard (2015); Cristea and Nguyen (2016); Liu, Schmidt-Eisenlohr and Guo (2018).

[24]See, e.g., Huizinga, Laeven, and Nicodeme (2008).

[25]See Faulkender et al. (2017) for evidence suggestive of profit shifting by U.S. multinationals through the relocation of intangibles in low-tax countries. See Langenmayr and Reiter (2017) for evidence of profit shifting by German banks through the strategic relocation of financial portfolios in tax havens.

[26]One potential concern with our treatment of intangibles is that some of the intangibles booked in tax havens may not have been shifted there but produced locally, by workers employed in R&D. However the available evidence shows that more than 90% of R&D workers of multinational firms are employed in high-tax countries; see Section 5.3 below.

[27]There is a view among some policy-makers (e.g., underlying "patent box" policies as in the United Kingdom and the related "foreign-derived intangible income" provisions introduced in the 2017 U.S. tax reform) that encouraging companies to locate intangible assets domestically, while benefiting the tax base, may also benefit domestic productivity. One way to rationalize this view is that firms may be more likely to locate tangible assets (office space, headquarters, etc.) in places where they book their intangibles. But it is hard to come up with a plausible reason to believe that the location of intangibles *per se* may significantly affect productivity (for a given stock of intangible assets).

increase in the capital stock is perfectly offset by a corresponding fall in the marginal product of capital.

In the more general case where countries have a constant elasticity of substitution (CES) production function, the effect of the capital stock on the profits-to-wage ratio is ambiguous. Namely, π varies with the capital stock depending on the value of the capital-labor elasticity of substitution σ. If $\sigma > 1$, then countries with a high capital intensity K/AL have high profit-to-wage ratios π. Conversely, if $\sigma < 1$, then countries with high capital intensity have low π, as the marginal product of capital becomes very low. To identify the contribution of capital intensity to the high reported profits-to-wage ratios of tax havens, we decompose the measured π_f of these countries into three components:

$$\pi_f = \left(\frac{K}{wL}\right)_f \cdot r_f \cdot (1 - p_f) \tag{2}$$

where r_f is the measured return to capital used by foreign firms, including any abnormal return (above the marginal product of capital) due to tax-induced profit shifting. We then make assumptions about the value of the elasticity of substitution σ in foreign firms to infer what fraction of the high π_f of tax havens can be attributed to high capital intensities. A large micro literature finds $\sigma < 1$, while a nascent macro literature finds $\sigma > 1$ (Karabarbounis and Neiman, 2014; Piketty and Zucman, 2014).

To form our central estimate of the amount of profit shifted into each tax haven, we make two assumptions. First, we assume that the elasticity of substitution between capital and labor σ is equal to 1 (i.e., Cobb-Douglas production). We do not assume that countries have similar Cobb-Douglas parameters α. That is, we allow for the possibility, for instance, that tax havens have structurally higher α than non-haven countries due, e.g., to pro-capital policies, rents generated by specific institutional features such as financial secrecy or lax regulation, or other deviations from perfect competition. Second, we assume that the reported profitability of local firms in tax havens π_l is not inflated by profit shifting. This assumption is supported by our finding, described in Section 5.2, that local firms in tax havens are generally as profitable as local firms in non-haven countries. Under these two assumptions, within a given tax haven, any excess of π_f over π_l reflects inward profit shifting. In our central scenario we estimate profit shifting by setting π_f equal to π_l in each tax haven.

As we shall see in Section 5.4 below, the results we obtain will be robust to relaxing our two assumptions. First, our estimate of the amount of profits shifted to tax havens will not significantly depend on the assumed capital-labor elasticity of substitution σ, because it turns

out that foreign firms in tax havens have similar capital intensity as local firms (and foreign firms in high-tax countries). As a result, for plausible values of σ, differences in capital intensity cannot explain more than 10% of the high $\pi_f - \pi_l$ gap observed in tax havens. Second, relaxing the assumption that the measured profitability of local firms in tax havens π_l reflects their actual profitability will lead us to find even more profit shifting than in our central scenario— but only slightly so. Although comparing foreign and local firms in tax havens is not perfect, our estimation procedure has the advantage that it can be implemented transparently using readily available macro data which are much more comprehensive than the data used so far to study global profit shifting.

3.3 How we Allocate the Shifted Profits

In the third step of our analysis, we allocate the shifted profits to the countries where they would be booked if all countries had the same effective corporate tax rate. We proceed as follows. First, we collect all existing *bilateral* balance of payments data, which include in particular bilateral service trade flows by type of service, and bilateral foreign direct investment income (including bilateral intra-group interest payments and receipts). We then allocate the shifted profits proportionally to the bilateral service exports and bilateral intra-group interest receipts recorded in the balances of payments of tax havens, summing both of these items. Among services, we only consider the specific types of services which have been found in the literature to be most conducive of profit shifting: exports of the rights to use intellectual property (patents and trademarks), headquarter services (administration, management and advertising), information and communication technology services, and financial services (Hebous and Johannesen, 2016). We disregard goods exports, which according to the existing literature seem to be quantitatively less important than other profit shifting channels.[28]

Our estimation procedure is motivated by the fact that tax havens record very large intra-group interest receipts and exports of services found to be conducive of shifting, way above what could be expected given the size of their economies. As shown by Appendix Figure G.1, these flows amount to 5% of gross national income on average in non-haven European Union countries, but are as large as 350% of GNI in Luxembourg, 78% of GNI in Puerto Rico, and 56% of GNI in Ireland. As with the excess of π_f over π_l in tax havens, we assume that these excess service exports and intra-group interest receipts reflect profit shifting.

A number of remarks about this methodology are in order. First, our procedure is con-

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[28]See Appendix Section D, where we discuss the evidence in the literature on the magnitude of profit shifting through the mis-pricing of intra-group goods trade vs. other channels.

sistent with how profit shifting is perceived by policy-makers globally. Many countries have anti-avoidance policies whereby specific cross-border transactions (such as certain royalty payments, interest, or services) are presumed to be motivated by tax avoidance and taxed accordingly.[29] Second, our procedure is consistent with Clausing (2009), who estimates how much of the profits booked offshore by U.S. multinationals are shifted out of the United States by apportioning the offshore profits of U.S. firms proportionally to the amount of affiliate intra-firm transactions that occur with the United States.[30] Third, our approach does not involve the use of an apportionment formula. We keep the current international tax system of subsidiary-by-subsidiary accounting and arm's length pricing as is, and consider how the geography of global profits would change if all countries applied the same effective corporate tax rate (which would remove incentives to shift profits).[31] Because many of the transactions we consider are intra-group (not to final customers), our allocation of the shifted profits is not equivalent to a sales-based apportionment of shifted profits. Last, and importantly, we find that the amount of intra-group interest received by tax havens plus the amount of services (found in the literature to be conducive of shifting) exported by tax havens (above and beyond what could be expected given the size of their economies) matches our estimate of the amount of global profit shifting obtained by setting $\pi_f = \pi_l$ in tax havens: \$646bn for the former and \$616 billion for the latter in 2015.[32] That is, we have two fully independent estimates of the amount of profit shifting that deliver consistent results: one based on foreign affiliates statistics, setting $\pi_f = \pi_l$ in tax havens; the other based on balance of payments data, tracking tax havens' intra-group interest receipts and service exports. This consistency of findings obtained using completely different data and methodologies lends support to the view that \$600bn–650bn is indeed the correct order of magnitude for the amount of profits shifted to tax havens in 2015.

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[29]For example, residence countries of multinational companies typically have controlled foreign company rules that tax certain forms of income (such as royalties and interest) reported in havens by their multinationals. In 2017, the United States introduced a "base-erosion anti-abuse tax" (BEAT) that presumes that certain services transactions by multinational firms with related parties are motivated by tax avoidance.

[30]We generalize this approach in three ways: (i) we apportion the profits shifted by all (not only U.S.) multinationals; (ii) we use balance of payments data which capture all cross-border transactions (not only transactions within divisions of multinationals); (iii) we focus on the types of transaction identified in the literature as being particularly conducive of shifting.

[31]Our approach differs from Guvenen et al. (2018), who apportion the worldwide profits of U.S. multinationals proportionally to labor compensation and sales to unaffiliated parties in each country. Their allocation approximates how the profits of U.S. firms would be split under a formulary apportionment system (with labor and sales as apportionment factors). We view their benchmark (formulary apportionment) and ours (tax rate harmonization) as both relevant. One advantage of the Guvenen et al. (2018) approach is that the adoption of apportionment formulas by individual countries may be more politically realistic than a full tax harmonization in the short run. One advantage of our approach is that it does not require us to model how firms would change their behavior if countries adopted apportionment systems.

[32]See Appendix C.

In addition to our main allocation of the shifted profits, we also provide an alternative allocation of the profits shifted offshore, in which we assign these profits to the countries where the ultimate parents of the offshore affiliates are incorporated. This allocation makes it possible to estimate what fraction of the globally shifted profits ultimately accrue to the shareholders of U.S. multinationals, European multinationals, etc.[33]

4   Data Sources and Global Summary Statistics

Before presenting and analyzing our results (Section 5), this section describes our three main data sources: national accounts data, foreign affiliates statistics, and balance of payments data. All the data sources, references and step-by-step computations are described in a detailed manner in Appendix A (national accounts and foreign affiliate statistics) and B (balance of payments data); here we focus on the main conceptual and practical issues.

4.1   National Accounts Data

We compute π in all tax havens, all OECD countries, and the main developing countries using harmonized national accounts data that follow the 2008 System of National Accounts (United Nations, 2009). The basic data source is the OECD's detailed national accounts by sector (Table 14A). This source covers all OECD countries (which includes prominent corporate tax havens: Ireland, Luxembourg, Netherlands, Belgium, and Switzerland) and a number of large developing non-OECD countries (Brazil, China, Colombia, Costa Rica, India, Russia, and South Africa). We extend the OECD database to non-OECD tax havens (such as Singapore, Hong Kong, and Puerto Rico) by manually collecting the official national accounts published by tax havens' statistical institutes and central banks. We include all the tax havens listed by Hines and Rice (1994) in our database.

The OECD detailed national accounts include all the necessary inputs needed to compute the profits-to-wage ratio π: corporate operating surplus rK, net interest payments p, and wages paid wL, for both financial and non-financial corporations. A few countries only provide gross-of-depreciation operating surplus series, in which case we impute depreciation based on observed depreciation rates in similar economies.[34] Some also do not isolate the corporate sector from

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[33]Yet another approach to allocate the shifted profits would involve trying to figure where production has "truly" taken place and apportion profits accordingly. However in many cases, it is impossible to determine where production takes place (e.g., the creation of intangibles occurs through the cooperation and interaction of subsidiaries in various countries). See Devereux and Vella (2017) for a discussion.

[34]See Appendix Section A.2.2. Capital depreciation amounts to around 15% of corporate gross value-added with relatively little variation across countries, see Appendix Table A.2.

other sectors of the economy (government and households) official national accounts. In that case, we impute the share of all domestic wages that are paid by corporations based on the share observed in countries with similar level of development.[35]

4.2 Foreign Affiliates Statistics (FATS)

We compute profitability for foreign firms (π_f) within each country using harmonized foreign affiliates statistics (FATS) recently released by the world's largest economic and financial centers.[36] These statistics are based on exhaustive or quasi-exhaustive census-type surveys of multinational enterprises. There are both inward and outward FATS. The inward FATS of, say, France record the value-added Y, operating surplus rK, compensation of employees wL (among other indicators) of foreign firms operating in France and are tabulated by country of the foreign parent company.[37] The outward FATS of France record the value-added, profits, compensation of employees (etc.) of the affiliates of French multinationals operating abroad and are tabulated by country of affiliate.[38] Firms report confidentially to domestic statistical authorities, which then publish tabulated statistics following international guidelines (Eurostat, 2012). Value-added, operating surplus, etc., are defined and constructed like in the national accounts, the only difference being that FATS only capture a subset of firms (e.g., foreign corporations in the case of inward FATS) while the national accounts capture all resident corporations. FATS are disseminated by Eurostat, the OECD, and national statistical agencies. A number of points are worth noting about these data.

Double-counting issues. Although in most European countries the publication of foreign affiliates statistics started only around 2010, in the United States, outward FATS—called "Activities of US Multinational Enterprises"—have been compiled as far back as the mid-1960s

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[35]See Appendix Section A.2.1 and Appendix Table A.1. By definition all profits originate from the corporate sector so generally speaking no imputation is required for profits (see, however, Section 4.2 below for the case of Ireland, Netherlands, and Luxembourg).

[36]Once we have π and π_f, the profitability of local firms π_l is obtained as a residual, since by definition, $\pi = s \cdot \pi_f + (1-s) \cdot \pi_l$, where s is the share of wages paid by foreign firms.

[37]Other indicators include, e.g., turnover, number of employees, investments flows, R&D expenditure, and in some countries (such as the United States) tangible capital stocks. When capital stocks are not available, we estimate them by cumulating past investment flows; see Appendix E.

[38]This is in contrast to direct investment income statistics that are tabulated by country of the immediate counterpart. For instance, if a French parent owns a German affiliate through a holding company in Luxembourg, direct investment income received by the French parent is recorded as coming from Luxembourg in the French balance of payment (OECD 2008, Paragraph 218). FATS, by contrast, are tabulated by country of affiliates' primary activity. In the above example, profits are recorded as made in Germany (not Luxembourg).

by the Bureau of Economic Analysis.[39] A large literature has used these data for research purposes.[40]

A concern with some of the BEA data on the activities of US multinational enterprises is that they double-count foreign income (Blouin and Robinson, 2019). More precisely, "net income" as reported in the BEA Income Statement tables (D1–D13) double-counts the income of US affiliates going through chains of holding companies. However, we do not use "net income" in this paper. We use the BEA Value Added tables (F1–F9), which are the tables that report our statistics of interest as defined in Section 3.1: the (net-of-depreciation) value-added Y, employee compensation wL, (net-of-depreciation) operating surplus rK, net interest paid $p \cdot rK$, and (net-of-depreciation) pre-tax profits $(1-p) \cdot rK$ of the majority-owned affiliates of US multinationals abroad. Pre-tax profit in the BEA Value Added Tables (called "profit-type return" by the BEA) does not double-count profits, because in contrast to "net income" it does not count as profit equity income received.[41] As shown in Appendix D.5, the total pre-tax profits made by US multinationals in tax havens recorded in the BEA Value Added tables very closely tracks the preferred estimate of Blouin and Robinson (2019).[42] The foreign affiliates statistics compiled internationally and used in this paper are the analogue of the BEA Value Added Tables. Following common guidelines, pre-tax profit in these statistics always excludes equity income received and does not-double count profits.[43]

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[39]Detailed tabulations starting in 1983 are available online at `https://www.bea.gov/international/di1usdop`, for instance for 2015 at `https://www.bea.gov/international/usdia2015r`

[40]See Section 2 above. See also Wright and Zucman (2018) for an analysis of these data back to the mid-1960s.

[41]Consider for instance the case a US parent that owns a German affiliate through a Bermuda holding company. Assume the German affiliate makes $100 in profit and pays $100 in dividends to the Bermuda holding. In the Income Statement Table D1 (not used in this paper), $100 in "net income" is assigned to Germany and $100 in "net income" is also assigned to Bermuda: foreign income is counted twice. But in the Value-Added Table F1 (used in this paper), $100 in profit is assigned to Germany and $0 profit is assigned to Bermuda. Indeed, to the extent that it has no other activity than to act as a paper intermediary between the US and Germany, the Bermuda affiliate has zero economic value added: for this affiliate, $wL = 0$, $(1-p) \cdot rK = 0$, $Y = 0$. In 2015, the total amount of pre-tax profits $(1-p) \cdot rK$ recorded by the BEA for the majority-owned affiliates of US multinationals operating in Bermuda was only $7.1 billion (Table F1), much less than the "net income" of these affiliates ($72.1 billion, Table D1).

[42]In 2016, according to the BEA Value Added tables, 48% of the pre-tax profit $(1-p) \cdot rK$ of majority-owned affiliates of US multinationals were made in tax havens. The preferred estimate of Blouin and Robinson (2019), "adjusted pre-tax income," is 42% in 2016 (their Figure 3, right panel). Note that the balance of payments data used in Zucman (2014, 2015) tend to overstate the share of profits made by US multinationals in tax havens, because in balance of payments statistics transactions are assigned to the country with which the US has an immediate link (in the above example, $100 in income is assigned to Bermuda and $0 to Germany in the balance of payments); see Wright and Zucman (2018) for a detailed discussion. The FATS used in this paper do not suffer from this bias. Note also that the U.S. FATS under-estimate the share of profits made by U.S. multinationals in tax havens because they exclude Puerto Rico (which is not treated as a foreign country in the BEA data on the activities of US multinational enterprises). Including Puerto Rico, 54% of the pre-tax profit of majority-owned affiliates of U.S. multinationals were made in tax havens in 2016 (Saez and Zucman, 2019).

[43]Paragraph 1.3.4 of the Eurostat (2012) FATS manual states: "Income and expenditure classified as financial

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Imputations for missing countries. The main OECD economies including key havens (such as Ireland, Luxembourg, the Netherlands, and Switzerland) publish foreign affiliates statistics. For these countries, we compute π_f using their inward FATS. For the countries that do not publish FATS yet (which is the case for smaller, non-OECD havens, e.g., Bermuda, the Cayman Islands, Hong Kong), we impute the profits and wages of foreign firms in two steps.

First, we estimate the pre-tax profits of foreign firms using the amount of inward direct investment income reported in the balance of payments and making systematic adjustments. Almost all countries publish direct investment statistics, which follow common international guidelines codified in the OECD (2008) benchmark definition of direct investment. Direct investment income is closely related to the pre-tax profits of foreign firms studied in this paper. Direct investment income is the net-of-depreciation, net-of-corporate income tax profits of firms that are more than 10% owned by foreign investors, pro-rated by the ownership stake of the foreign investor. Pre-tax profits in FATS is the net-of-depreciation, gross-of-corporate-income-tax profit of firms that are more than 50% owned by foreign investors, with no pro-rating. We adjust direct investment income data accordingly.[44]

Second, we estimate the wages paid by foreign firms by applying the wage/profit ratio seen in the outward FATS of counterpart countries. We rely particularly on the outward FATS of the United States which provide data on the foreign operations of US multinationals in small tax havens in isolation, such as Barbados, Bermuda, Panama, etc. We have checked that our procedure closely approximates the true amount of foreign profits and wages by implementing it for the sample of tax havens that publish inward FATS, suggesting that the margin of error involved with these imputations is limited.

Bilateral discrepancies. If foreign affiliates statistics were perfect, the inward FATS of host countries (where affiliates are located) would be fully consistent with the mirror outwards FATS of partner countries (where parents are headquartered). We conducted a systematic comparison of the available data to assess the consistency of existing FATS.[45] We found that while inward and outward data are generally consistent, there is one notable discrepancy. In the inward FATS of Ireland, the Netherlands, and Luxembourg one finds less profit made by US affiliates than in the mirror outwards FATS of the United States. A similar gap (of $95 billion in 2015) is

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in company accounts according to the 4th Accounting Directive (78/660) is excluded from value added."

[44]See Appendix Section A.3 for a step-by-step description of these computations. See Wright and Zucman (2018) for a detailed reconciliation of FATS and balance of payments statistics in the U.S. case.

[45]See Appendix A.4.1 (results summarized in Appendix Table A.8) and Appendix Section B.3.3 (results summarized in Appendix Table B.11).

observed in bilateral balance of payments data, where less direct investment income is paid to the United States by affiliates located in Ireland, Netherlands, and Luxembourg than received by the United States from these havens.

There are two possible reasons for this discrepancy. First, Ireland, Netherlands, and Luxembourg may underestimate the profits that affiliates of US firms book in their territory. In particular, these three countries may miss some of the profits booked in special purpose entities due to a lack of comprehensive enough corporate registries, non-response to surveys, or other data issues (Angulo and Hierro, 2017; Damgaard and Elkjaer, 2017). Alternatively, the United States may overestimate the profits booked by its multinationals in Ireland, Netherlands, and Luxembourg. For example, U.S. statisticians may wrongly assign to Ireland profits that in fact have been booked in other tax havens such as Bermuda (CSO, 2016).

Although it is not possible to settle this issue definitively with the available data, the evidence suggests that Ireland, Netherlands, and Luxembourg under-estimate the profits booked by US multinationals. As shown by Appendix Figure N.4, for non-haven countries, the profits recorded by the US abroad match the data reported by the partner country.[46] It is only for tax havens that US data exceed the estimate of partner countries, so that globally the profits of US affiliates recorded by US statisticians in all foreign countries combined (as measured in the US balance of payments) exceed the profits of US affiliates recorded by all foreign countries combined (as measured in their balances of payments).[47]

In our central scenario, we force global inward investment income to match global outward investment income by upgrading the inward data of Ireland, Luxembourg, and the Netherlands so that they match the counterpart outward data reported by the United States.[48] We discuss two alternative corrections in the Appendix. First, we consider the hypothesis that the inward data of Ireland, Luxembourg, and the Netherlands are correct and that US statisticians over-estimate the total amount of foreign profits made by US multinationals. Taking the Irish,

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[46]For instance, Canada reports $17.9 billion in direct investment income paid to the US in 2015, while the US records $18.5 billion in DI income received from Canada. Japan reports $8.6 billion in DI income paid to the US in 2015, while the US records $9.7 billion in DI income received from Japan. Australia reports $6.1 billion in DI income paid to the US in 2015, while the US records $6.5 billion in DI income received from Australia.

[47]See Appendix Figure A.14. This imbalance is the main driver of the imbalance in global direct investment income recorded in the world balance of payments by the IMF. Globally, more direct investment income is received (in the form of dividends and reinvested earnings) by the parents of multinational firms than paid by affiliates. This direct investment income gap reaches about $200 billion in 2015 (Appendix Figure B.3b). In Appendix B, we decompose this gap by leveraging the bilateral direct investment income data of all the world's countries and find that the bulk of the gap comes from missing payments made by affiliates of US multinationals.

[48]This adds $95 billion in foreign profits to Ireland, Luxembourg and the Netherlands. We allocate the residual inward/outward global income gap (of the order of $100 billion in 2015) by upgrading the inward data whenever the sum of outward profits exceeds reported inward profit; see Appendix A.3.3.

Dutch and Luxembourg data at face value still leaves a difference of an order of magnitude between the profitability of foreign firms (π_f) and the profitability of local firms (π_l) in these three havens and reduces our estimate of global profit shifting by 15%.[49] Second, we consider the hypothesis that the US statistics do not over-estimate the total amount of foreign profits made by US multinationals but wrongly assign to Ireland, Netherlands and Luxembourg profits in fact booked in Bermuda and other havens without inward investment income data. This correction does not affect our estimate of the amount of profits globally shifted, but only their location (with Bermuda featuring more prominently, and Ireland less prominently).

4.3 Bilateral balances of payments

For our main allocation of the shifted profits (i.e., to source countries), we rely on the bilateral balances of payments disseminated by the IMF and Eurostat. While balance of payments statistics traditionally only reported transactions with all non-residents as a total, following the adoption of the 6th edition of the IMF (2009) Balance of Payments Manual, most countries have started publishing bilateral balances of payments. Among tax havens, the data are particularly good for Switzerland and the European Union tax havens (Ireland, Luxembourg, Belgium, Netherlands, Malta, and Cyprus) which must report harmonized statistics to Eurostat.

When two estimates of the same haven-to non-haven flow are available (e.g., exports of services from Luxembourg to Germany as recorded by Luxembourg, and imports of services by Germany from Luxembourg as recorded by Germany), we use the statistics reported by tax havens, because the bilateral data reported by tax havens tend to be more comprehensive than those recorded by counterpart countries. As shown in Appendix B, the service exports recorded by the 6 E.U. tax havens (Ireland, Luxembourg, Netherlands, Belgium, Malta, Cyprus) to the 22 non-haven E.U. countries exceed the recorded imports by more than 30% (and more than 50% for Luxembourg). One likely explanation for this gap is that importers' data miss (at least some of) the services that are exported by tax-haven corporations directly to foreign customers, such as digital music subscriptions, ride-sharing services, and various Internet services (server space, voice over IP, etc.). There is evidence that the typical business structure of digital services multinationals involves shifting intellectual property to tax haven subsidiaries and then directly selling services to final customers without involving any non-haven subsidiary (see, e.g., Pomeroy, 2016). The associated service flows seem at this stage better captured in the tax havens' trade statistics than in the customer countries' statistics.[50]

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[49]See Appendix Figure N.1.

[50]When a firm incorporated in Luxembourg directly exports digital services to French customers without

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For our alternative allocation of the shifted profits (i.e., to the countries where headquarters are located), we use the bilateral direct investment statistics on an ultimate ownership basis compiled by Damgaard and Elkjaer (2017), who exploit the data made available by OECD countries following the implementation of the 6th edition of the IMF (2009) Balance of Payments Manual.[51]

4.4 Global Summary Statistics

Table 1 presents our database of corporate profits by showing its global totals in 2015, our benchmark year. In 2015, global gross value-added (i.e., global GDP) reached $75 trillion and global net value-added (i.e., after capital depreciation) about $63 trillion. About 54% of global net value-added was produced by corporations; the rest was produced by governments, households, and non-corporate businesses. Within corporations, the capital share of net value-added was about 1/3 and the labor share about 2/3. Out of the $11.5 trillion in net-of-depreciation corporate profits, close to 15% ($1.7 trillion) were made in foreign firms. This $1.7 trillion number includes all the profits made by, say, Apple in France, Germany, Ireland, Jersey, etc., but not by Apple in the United States (where its headquarter is located). It is what we call "multinational profits." That is, multinational profits include all the profits made by multinational companies outside of the country where their parent is located. Our estimate (detailed in Section 5.4 below) is that out of these $1.7 trillion in multinational profits, about 36%, i.e., about $600 billion, were shifted to tax havens.[52]

Table 1 also shows that corporations paid $2.15 trillion in corporate income taxes globally in 2015.[53] Thus the global effective corporate income tax rate was 19% (2.15 trillion divided by

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going through a French subsidiary, French statistical authorities cannot rely on corporate income statements to capture such flows, and have to use other—typically less comprehensive—data sources, such as household consumption surveys. Beginning 2014, value-added taxes have started to be imposed in France (and other E.U. countries) on direct foreign-business-to-consumer sales. In principle, VAT returns could be used as inputs to better estimate French imports of services. Looking forward, systematically using VAT returns could help fix the imports-exports service mismatch between havens and non-havens countries.

[51]See Appendix Section C.2 for a detailed presentation and discussion of these data.

[52]Our list of tax havens is the one in Hines and Rice (1994) to which we add Belgium and the Netherlands. The Netherlands was not considered as a tax haven by Hines and Rice (1994) because U.S. multinationals reported paying relatively high tax rates there in 1982; but as we show in Appendix Table A.11, this is not the case anymore: the tax rate paid by affiliates of U.S. multinationals in the Netherlands was 12% in 2015. Belgium is a borderline case that is sometimes considered a tax haven in the literature (e.g., because of the deductibility of notional interest on equity). As shown in Figure 3 below, Belgium's profitability ratio is only barely higher than that of non-havens, and we estimate that only $13 billion were shifted to Belgium in 2015 (Table 2 below). Hence excluding Belgium from our list of tax havens would not make any significant difference to our results.

[53]Corporate income tax data also come from OECD detailed national accounts (current taxes on income and wealth paid by non-financial and financial corporations, code D.5 in the System of National Accounts) and individual countries' statistical authorities and central banks. Note that some countries include central bank

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net-of-depreciation, pre-tax global profits of \$11.5 trillion). This rate is smaller than the global GDP-weighted statutory tax rate of about 26% because the tax base in most countries is smaller than the full economic base (e.g., due provisions such as accelerated depreciation) and because of tax credits (e.g., for R&D expenditure). If all countries jointly adopted an effective corporate tax rate of 19% (as a fraction of the full economic base), the taxation of global corporate income would be unchanged, hence global investment and the global capital stock would not change, at least to a first-order approximation.[54] What would change is the location of capital and profit—which is what we are concerned with in this paper.

5   The Level and Rise of Global Profit Shifting

We now present and analyze our results. We start by discussing our core results on global profitability in local vs. foreign firms, before turning to the implications of this phenomenon for non-haven countries and tax revenues (Section 6) and for macroeconomic statistics (Section 7).

5.1   Profitability in Tax Havens vs. Non-Haven Countries

Figure 3 shows how the profit-to-wage ratio π varies across countries in 2015. Among the main non-haven countries displayed in Figure 3, π average 36% in 2015. That is, for any dollar of wage paid, corporations made 36 cents in pre-tax profits. This corresponds to a capital share of net corporate value-added $\alpha = 26\%$, and net interest paid $p = $ -3% of net operating surplus. The profits-to-wage ratio π does not vary much across developed, non-haven countries; for instance it is 31% in the United States, 39% in Sweden, 42% in the United Kingdom.[55] These results are consistent with existing studies of corporate capital shares, which find net-of-depreciation corporate capital shares α of about 25% (corresponding to profits-to-wage ratio π of 33% if net

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profits under D.5; we always exclude central bank profits and our series thus only include corporate income taxes paid (see Appendix Table A.3). Business property taxes are treated as taxes on production in the SNA (code D2–D3).

[54]Small changes in investment are possible if elasticities of corporate investment are not constant. In this paper we do not attempt to compute the harmonized effective tax rate that would keep global investment perfectly constant, but simply note that such a rate exists (and is probably close to 19%). The level of the global harmonized tax rate that would keep global investment constant is not relevant for our purposes. Note that this rate could in principle be higher than 19%, for instance if, at the same time they harmonized their tax rates, all countries also increased public investment complementing private capital. Modeling the different ways in which global profits could be kept fixed with a perfect international coordination of economic policies falls outside the scope of this research.

[55]As reported in Appendix Table A.2., profitability ratios are higher in developing countries. This reflects the fact that the capital share of corporate output is typically higher in poorer countries, potentially due, e.g., to the presence of rents generated by natural resources and to lower labor bargaining power (lower unionization rates, low or no minimum wages).

interest p is zero), with modest variation across time and across countries, of the order of 5–10 percentage points (e.g., Blanchard, 1997; Karabarbounis and Neiman, 2014; Cette, Koehl and Philippon, 2019; Gutiérrez and Piton, 2019).

Tax havens, by contrast, are abnormally profitable. In Singapore and Hong Kong, the macroeconomic profit-to-wage ratio exceeds 100%; in Ireland, Puerto Rico, and Luxembourg, it exceeds 200%. That is, tax havens appear to have extraordinarily high profit-to-wage ratios π. As shown by Appendix Table A.2, the high π of tax havens are mostly driven by their high recorded capital shares, not by net interest.[56] For instance, the net capital share of net corporate value-added is 62% in Ireland, 68% in Puerto Rico, 66% in Panama. The main exception is Luxembourg, where net intra-group interest receipts are the key driver of the high recorded π. Overall, 15% of our estimated amount of profits shifted offshore comes from interest, consistent with the literature that suggests that debt-shifting is second-order relative to transfer pricing and the strategic location of intangibles (Heckemeyer and Overesch, 2017).[57]

Next, we analyze how the profitability of tax havens has changed over time. Due to data availability constraints, our global database is for the year 2015, and we cannot yet present time series of π for all countries (future releases of FATS will allow us to build comprehensive time series starting in 2015). However, we can already provide time series of π for specific tax havens. The tax haven for which the longest and highest quality time series exist is Ireland. As shown in the top panel of Figure 4, in Ireland π was around 25–30% in the early 1970s, a level similar to that recorded in the United States. Profitability started rising in the 1980s and then increased sharply in the mid-1990s and then again in the 2010s to reach 250% in 2015.[58] By contrast, in the United States π never dramatically varies. Profitability has tended to slightly increase since the 1980s (from 18% in 1980 to 31% in 2015), driven by the rise in the capital share of corporate value-added; but this increase is small compared to the upsurge in the profitability of tax havens' corporations. Trends are similar for other non-haven countries for which time series

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[56]Throughout this article, we exclude offshore mutual funds (i.e., mutual funds with mostly foreign investors and foreign investments) from our π, π_f, and π_l ratios, because offshore mutual funds otherwise distort the profitability ratios of tax havens. By convention mutual funds have an apparently high profitability as defined in our paper (i.e., after net interest payments), but for purely accounting reasons. All income paid by mutual funds to their shareholders is recorded as dividends in the national accounts, even for mutual funds that only invest in bonds; as a result bond funds are large receivers of net interest. Among OECD countries offshore mutual funds are only significant in Luxembourg, Ireland, and to a much lesser extent the Netherlands. Estimating the net interest received by mutual funds involves a margin of error, but this uncertainty is very small compared to the large π and π_f of tax havens; see Appendix Section A.3 for a discussion.

[57]Intra-group interest received by tax havens amount to $101 billion in 2015 (15.7%) vs. $545 billion for the exports of services most conducive of profit shifting (84.3%); see Appendix Table C.2.

[58]In 2015, the profits-to-wage ratios recorded by Ireland increased particularly strongly. That year, recorded real GDP grew 26.3%—largely reflecting transfers of multinational intangible assets to the island (see e.g., OECD, 2016).

are available.[59]

In the bottom panel of Figure 4, we can see that the rise in the profitability of tax havens over time is not specific to Ireland. When we look at all the majority-owned affiliates of U.S. multinationals throughout the world (using the outward FATS of the United States, which as already noted have been compiled since the 1960s), a similar pattern emerges. In the early 1970s, the haven and non-haven affiliates of U.S. multinationals were as profitable. In both cases, the profits-to-wage ratio was around 50%. Since the 1970s, profitability for haven affiliates has sharply increased. In 2015, the profits-to-wage ratio of US affiliates located in tax havens exceeds 350%, while the profits-to-wage ratio of US affiliates located in high-tax countries has stayed constant since the 1970s (45% in 2015).

5.2   Profitability in Local vs. Foreign Firms

Figure 5 displays the profits-to-wage ratios for foreign firms (π_f) and local firms (π_l) separately within each country in 2015. By construction the aggregate profit-to-wage ratio π shown in Figure 3 for a given country is the average of π_f and π_l shown in Figure 5, with π_f weighted by the share s of wages paid to workers employed by foreign firms and π_l weighted by $1 - s$. A key result emerges: the high overall profits-to-wage ratios π of tax havens are entirely driven by the high profitability of foreign firms (high π_f). Foreign firms in tax havens are an order of magnitude more profitable than local firms in tax havens.

There are three other main take-aways from Figure 5. First, the reported profitability of foreign firms in tax havens is truly exceptional, with π_f ratios of 800% (which corresponds to a capital share of corporate value-added α of close to 90%) in Ireland and as high as 1,625% in Puerto Rico (corresponding to a capital share of more than 94%, i.e., a corporate labor share of less than 6%).[60]

Second, while foreign firms are an order of magnitude more profitable than local firms in tax havens, the opposite is true in high-tax countries: in these countries foreign firms are *less* profitable than local firms. For instance, in the United Kingdom the profits-to-wage ratio is 26% for foreign firms (π_f) vs. 48% for local firms (π_l); in Japan π_f equals 24% while π_l reaches 44%, etc.[61] There are several possible reasons for the low profitability of foreign firms in high-tax

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[59]See, e.g., Karabarbounis and Neiman (2014) and Piketty and Zucman (2014).

[60]Puerto Rico is a U.S. possession, but is treated as a foreign country for purposes of U.S. taxation and in some (but not all) U.S. macroeconomic statistics. In this paper we treat it as a foreign country. Almost all the profits shifted to Puerto Rico accrue to U.S. multinationals. See Suárez Serrato (2018) for an analysis of the evolution of profit shifting by U.S. multinationals to Puerto Rico.

[61]The lower profitability of foreign firms in the United Kingdom compared to local firms, by a factor of about 2, is consistent with Bilicka (2019) who finds that foreign multinational subsidiaries in the UK under-report their

countries (relative to local firms in these countries). For instance foreign firms may be younger, or they could operate in less profitable industries. The fact that $\pi_f < \pi_l$ in high-tax countries while $\pi_f >> \pi_l$ in tax havens (Figure 5) suggests that profit shifting is also part of the reason why foreign firms appear unprofitable in high-tax places. That is, there is a clear trace in global macro data of movements of profits within divisions of multinational groups, away from high-tax affiliates and towards low-tax affiliates. Precisely quantifying the relative importance of profit shifting (vs. other factors such as firm age) in the low π_f observed in high-tax countries falls outside the scope of this research.[62]

Third, local firms in tax havens are generally as profitable as local firms in non-haven countries. The high overall profits-to-wage ratio π of tax havens is entirely driven by the high profitability of their foreign firms π_f. Local firms in tax havens do not seem to be abnormally profitable, which could in principle be the case if low-tax countries also had pro-capital or anti-labor institutions (such as bans on unions or no minimum wage) or if the reported profitability of local haven firms was inflated by inward profit shifting. This suggests that the π_l ratios of tax havens are a useful reference point to estimate what fraction of the large π_f of tax havens can be attributed to profit shifting.

5.3 Decomposing The High Profits of Haven Affiliates

What is the relative contribution of high capital intensities vs. profit shifting to the high recorded π_f of tax havens?

As shown by the top panel of Figure 6, on aggregate firms have similar capital stocks K (relative to wages wL) in tax havens and non-havens. Within tax havens, moreover, foreign firms have similar capital stocks (again relative to wages) as local firms on average. For the main tax havens (Ireland, Puerto Rico, Netherlands, Singapore, Belgium, Luxembourg, Switzerland, and Hong Kong) the ratio of the capital stock to wages averages 274% for foreign firms and 303% for local firms. For the main non-havens countries (US, Italy, Germany, UK, Australia, Spain, France, and Japan) the average capital-stock-to-wage ratios are similar: 291% for foreign firms and 320% for local firms.

These averages conceal some heterogeneity, however. In Ireland and Puerto Rico, foreign firms have large capital stocks, while the converse appears to be true in Switzerland, Hong Kong, and Luxembourg. This suggests that differences in capital intensities could explain some of the

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taxable profits by about 50 percent relative to domestic standalone.

[62]See, e.g., Lupo et al. (1978) and Mataloni (2000) for an analysis of the relatively low profitability of foreign firms operating in the United States.

variation in π_l and π_f across countries. The bottom panel of Figure 6 quantifies the contribution of differences in capital intensity to the observed differences in profits-to-wage ratios. The figure shows how applying the capital/labor K/L ratio of foreign firms to local firms would modify the observed profits-to-wage ratio of local firms π_l, for different values of the capital/labor elasticity of substitution σ. For plausible values of σ, differences in capital intensities can explain only a small fraction of the $\pi_f - \pi_l$ gap. For instance in Ireland, if local firms were as capital intensive as foreign firms, then with $\sigma = 1.3$, π_l would equal 100% instead of the observed value of 68%. This would still be almost an order of magnitude less than the observed π_f of 800%. The same conclusion holds true for each other tax haven.

We obtain similar results when we focus on the affiliates of U.S. multinationals throughout the world (using the outward FATS of the United States). Figure 7) decomposes the profit-to-wage ratio of the foreign affiliates of U.S. multinationals following equation 2 above. The haven affiliates of U.S. multinationals have higher capital intensities than non-haven affiliates, but only slightly so. For a given amount of wages paid, haven affiliates use a 1.4 times larger stock of tangible capital than non-haven affiliates in 2015. Haven affiliates also receive slightly more interest in 2015 (1.1 time more than non-haven affiliates, relative to operating surplus), but the difference is not large. By contrast, haven affiliates have much higher recorded rates of return on capital than non-haven affiliates today. In 2015, the recorded rate of return to capital r_f is close to five times higher in haven affiliates than in non-haven affiliates. The bulk of the sevenfold difference in profits-to-wage ratios between havens and non-haven affiliates (bottom panel of Figure 4) is thus due to higher recorded returns to capital in haven affiliates—not high intra-group interest receipts or high capital intensities.

The high rates of return of haven affiliates can be seen as the product of two effects. First, multinationals book intangibles in low-tax affiliates. These intangibles are not included in our measure of corporations' capital stocks, for lack of data about their market value—which in many cases is impossible to assess, given that many of these intangibles are firm-specific and never exchanged on markets between unrelated parties. Second, for a given stock of total capital (tangible plus intangible), haven affiliates can report high profits because of intra-group transfer price manipulations. With the macro data at our disposal, we cannot separate the role of intangibles vs. intra-group transfer prices in explaining the high rates of returns recorded by haven affiliates. This distinction is not relevant for our purposes, however, since both of these techniques have similar redistributive implications: for a given global amount of profits, both redistribute profits across countries without affecting wages.

One potential concern with our treatment of intangibles is that some of the intangibles booked in tax havens may not have been shifted there but produced locally, by workers employed in R&D. To shed light on this question, we use the fact that foreign affiliates statistics include data on R&D personnel. The US outward FATS show that out of the 308,100 employees of the majority-owned foreign affiliates of US multinationals engaged in R&D in 2014, only 8% were employed in tax havens; 92% were employed in non-haven affiliates (primarily in Germany, the U.K., Canada, etc.).[63] The FATS of other countries show similar patterns. By and large, the intangibles booked in low-tax countries have been produced in high-tax countries.[64]

One advantage of using the outward FATS of the United States is that we can study how the contribution of rates of return to capital vs. capital intensity vs. interest payments has changed over time, back to 1966. The main driver of the rise in the profits-to-wage ratio of the haven affiliates of US multinationals since the mid-1960s has been the rise in their rate of return. Up to the late 1970s, affiliates in tax havens had roughly the same recorded rate of return to tangible capital, same capital intensity, and same net interest receipts than other affiliates. Since the 1980s, their relative rate of return has increased by a factor of about 5. By contrast, the relative capital intensity of these two groups of affiliates has remained close to 1, with only a mild rising trend. Some capital has moved towards low-tax places. But what the data suggest is that, so far, profit shifting seems to have swamped tax-driven movements of tangible capital.[65]

5.4   Estimates of Profits Shifted to Tax Havens

To form our estimate of the amount of profits shifted to tax havens, we set π_f equal to π_l in each tax haven. That is, we assume that absent profit shifting, foreign firms in Ireland would be as profitable as local Irish firms, foreign firms in Luxembourg as profitable as local Luxembourg firms, etc. In total, we find that more than $616 billion in profits were shifted to tax havens in 2015, close to 40% of multinational profits ($616 billion out of $1.7 trillion). We present our estimate of the amount of profits shifted into each tax haven in the bottom panel of Table 2. Ireland appears as the number one shifting destination, accounting for more than $100 billion

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[63]See BEA, "Activities of US Multinationals Abroad," Table II-I.1. These tabulations are only made available during benchmark-year surveys (the latest of which was in 2014).

[64]A related issue is that high-tax countries require that intangibles be sold by the parent firm to a low-tax subsidiary at an arm's length price. We do not have data on the prices charged at the time of the transfer. For our main purpose in that paper—quantifying the international mobility of profits—whether fair prices are enforced at the time of the transfer is not relevant. To quantify the tax revenue implications of profit shifting this issue is relevant, however; See Section 6 below.

[65]This conclusion is consistent with the firm-level analysis of Grubert and Slemrod (1998) in the context of US investments in Puerto Rico.

alone. Singapore, the Netherlands, Caribbean tax havens, and Switzerland come next. We stress that due to the complex structures used by multinationals and to the data limitations discussed in Section 4.2, allocating the shifted profits to specific jurisdictions involves a margin of error (for instance, the frontier between Ireland and Bermuda is not always clear). This uncertainty, however, does not affect our estimate of the global amount of profits shifted offshore.

It is worth noting that our estimate of global profit shifting, $616 billion, is at the low-end of the scale of available estimates. Using foreign direct investment data, Bolwijn et al. (2018) estimates that $700 billion in profits where shifted in 2012. Using data from the Forbes Global 2000 list of the world's largest corporations, Clausing (2016) finds $1,076 billion in shifted profits, again for the year 2012. Our estimates of the implied tax revenue losses (described in Section 6 below) are also at the low-end of the scale.[66] We now discuss a number of robustness tests.

Robustness with respect to σ. In our central scenario, the capital/labor elasticity of substitution σ is set to 1 and thus by construction differences in capital intensities explain none of the $\pi_f - \pi_l$ gap within tax havens. With $\sigma = 1.3$, 4% of the abnormal profitability of foreign firms in tax havens (relative to local firms in tax havens) can be explained by differences in capital intensity (and 96% by profit shifting); with $\sigma = 1.7$, the contribution of differences in capital intensity rises to 7%. With an elasticity of substitution less than 1, profit shifting would be even higher than our preferred estimate, for instance $660 billion in 2015 with $\sigma = 0.7$.[67]

Controlling for sectoral composition. One potential concern with comparing profitability in foreign vs. local firms is that foreign firms in tax havens may be in other sectors than local firms, and profits-to-wage ratios may vary across sectors. To address this issue, we use the fact that in some countries, foreign affiliates statistics are available by sector of economic activity. Appendix Figure L.1 focuses on the case of U.S. multinationals, using the outward foreign affiliates statistics of the United States. We find that the haven affiliates of U.S. multinationals are an order of magnitude more profitable than non-haven affiliates in the same sector. In non-haven countries, U.S. affiliates are typically less profitable than local firms operating in the same sector; while in tax havens they are an order of magnitude more profitable than local firms operating in the same sector—consistent with the pattern depicted in Figure 5. Controlling for sectoral differences in local vs. foreign firms does not quantitatively affect our findings.

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[66]See Appendix Table D.1a
[67]See Appendix Table E.3

Another take-away from Appendix Figure L.1 is that profit shifting is not limited to just a few sectors of the economy, such as information and communication technology. Profit shifting appears to be an across-the-board phenomenon, observable even in industries where intangibles play a relatively minor role in the production process (such as manufacturing). There are several potential explanations for this finding. Firms across all industries may shift profits by using intra-group trade and borrowing. It could also be that multinationals in all sectors can create firm-specific intangibles (such as logos), book these in low-tax places, and charge royalties to high-tax subsidiaries for the right to use these intangibles.

Firm size. Another potential concern with our estimation procedure is that local firms in tax havens may be smaller than foreign firms, and smaller firms may have lower profits-to-wage ratios, leading us to over-estimate global profit shifting. Currently available foreign affiliates statistics do not enable us to control for firm size. We note, however, that being a local firm does not imply being small. There are many large multinationals headquartered in tax havens (for instance, after "inverting" from the United States). In our data, such firms are treated as local firms in tax havens, as they are not owned by foreign parents. Looking forward, our estimation procedure could be refined by drawing on more detailed foreign affiliates statistics (e.g., tabulated by firm size) and global micro-data on the operations of foreign firms.

Inward profit shifting by local firms in tax havens. Another concern is that by using the local firms of tax havens as point reference, we may actually under-estimate the extent of global profit shifting, since firms headquartered in tax havens may shift foreign profits inward, inflating π_l. This phenomenon could explain the relatively high profits-to-wage ratio of Irish local firms reported in Figure 5, and suggests that our estimates of global profit shifting should probably be viewed as conservative.[68] We have run robustness tests where we make the profitability of local haven firms vary and assess the impact on our results, and found only second-order effects, however. The reason is that the bulk of our estimated \$616bn in shifted profits comes from tax havens where π_f is an order of magnitude higher than π_l (hence where the exact level of π_l does not matter much). Only a small fraction of our estimated \$616 billion comes from tax havens such as Netherlands and Belgium where π_f is only slightly higher than π_l (hence where the exact level of π_l matters more); see Table 2. If we assumed that local firms in tax havens are

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[68]Ideally we would like to be able to compare the foreign firms of tax havens to local firms of comparable size and without foreign affiliates. Existing foreign affiliates statistics, however, do not currently make it possible to decompose local firms into firms with affiliates abroad vs. firms with only domestic operations.

in reality as profitable as local firms are on average in the OECD ($\pi_l = 41\%$), then our estimate of global profit shifting would rise by about 3%.[69]

Abnormal profitability vs. abnormal cross-border transactions. Last, we compare our estimate of the amount of profit shifted into each tax haven based on setting π_f equal to π_l in each haven to our estimate based on the abnormal level of high-risk cross-border transactions recorded in the balances of payments of tax havens. "High-risk" transactions are service exports found in the literature to be conducive of profit shifting plus intra-group receipts of interest; "excessive" means that we partial out the average transaction level for countries with similar levels of GDP. Figure 8 shows the result of this comparison. Despite being based on totally different and fully independent data, our two methodologies deliver very consistent results. In 2015, the "above normal profitability" methodology yields an estimate of \$616 billion for the amount of profit shifted to tax havens globally, while the "above-normal cross-border transactions" methodology yields an estimate of \$646 billion. Strikingly, the estimates also match almost perfectly at the haven level.

6 The Redistributive Implications of Profit Shifting

6.1 Allocating the Shifted Profits Across Countries

The pink bar in the top panel of Figure 9 allocates the \$616bn in excess profits in tax havens across source countries, proportionally to the bilateral intra-group interest received by tax havens and their bilateral exports of services conducive of profit shifting (such as rights to use intellectual property).

We find that about 35% of the shifted profits come from E.U. (non-haven) countries, close to 30% from developing countries, and about 25% from the United States. European countries are particularly affected. According to our estimates, under a perfect tax harmonization scenario, profits would be 17% higher than they currently are in France (Table 1, col. 4 divided by col. 1), 14% higher in the UK, versus close to 10% higher in the United States. Profits in the main developing countries, by contrast, would be around 5% higher, and profits in Japan only 1% higher. Profits would be reduced by 60% in tax havens. About 80% of the profits shifted out of the European Union are shifted to the E.U. tax havens, primarily Ireland, Luxembourg, and the Netherlands, while the profits shifted out of the United States are primarily shifted to the

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[69]See Appendix Table A.7.

non-E.U. havens.[70]

We also allocate the profits shifted to tax havens to the countries where the parents of the tax haven subsidiaries are located (blue bar in the top panel of Figure 9). Multinationals from all countries shift profits, but we find that U.S. multinationals are the main "shifters": about half of all the shifted profits ultimately accrue to U.S. parents, while about 30% accrue to E.U. parents. The higher shifting intensity of U.S. multinationals can be explained by the specific provisions contained in the U.S. tax code before 2018 and by U.S. policies adopted in the mid-1990s that facilitated shifting from foreign high-tax countries to tax havens (check-the-box regulations); see Wright and Zucman (2018).

6.2   The Redistribution of Tax Revenues

Table 2 presents estimates of the losses of corporate income tax revenues in high-tax countries. These estimates are obtained by applying the statutory income tax rate to the amount of profits shifted outward. At the outset, it is worth stressing two caveats. First, countries attempt to tax profits that are shifted outward through controlled foreign corporations rules. This means that a dollar of lost profit does not necessarily translate into τ cents lost in tax revenue, if τ is the statutory corporate tax rate. Second, it is possible that with better enforcement there would be more real responses to taxation, such as more mobility of tangible capital to low-tax places. Our tax revenue loss computations keep everything else constant, as is standard in the literature on the size of tax evasion (e.g., Johns and Slemrod, 2010; Alstadsæter et al., 2019).

With these caveats in mind, we find that profit shifting reduces the corporate tax revenue of the European Union by around 20%. For the world as a whole, the tax revenue loss is around 10% (bottom panel of Figure 9). The revenue losses vary significantly across countries and are positively correlated with the corporate income tax rate. Within the European Union, higher tax countries (such as France and Italy) experience higher losses than lower tax countries (such as Eastern European countries), consistent with the notion that higher corporate tax rates give more incentives to shift.

Using our estimates of the amount of profits shifted into each haven, we can compute how much tax revenue tax havens have been able to generate by taxing these profits. Although some havens like Bermuda have 0% corporate tax rates, most others, like Ireland, Singapore, and Luxembourg, have low but positive rates. A striking fact, depicted on the top panel of Figure 10, is that tax havens, although they have low statutory tax rates (and even lower effective rates)

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[70]See Appendix Figure C.1

generate much more revenue than non-haven countries (relative to the size of their economy). Malta collects about 8% of its national income in corporate tax revenue, Luxembourg 7%, and Ireland more than 5%. By contrast, in the United States, Germany, and Italy (three of the countries with the highest statutory tax rates in 2015), corporate tax revenue amount to less than 3% of national income. Globally, for each $1 avoided in high-tax countries, about 20 cents in tax revenues are generated in tax havens.

How do tax havens manage to collect so much tax revenue? As shown by the bottom panel of Figure 10, most of their revenue derive from taxes collected on foreign firms. With source taxation and no international coordination, tax havens can generate sizable revenue by taxing the huge foreign profits they attract at low but positive rates. The havens that collect the largest amount of revenue appear to be those that impose the lowest tax rate on foreign profits: the revenue-maximizing tax rate appears to be very low, less than 5%. The low revenue-maximizing rate of tax havens can explain the rise of the supply of tax avoidance schemes documented in the literature—such a favorable tax rulings granted to specific multinationals—and in turn the rise of profit shifting since the 1980s.[71]

Figure 11 considers the case of Ireland, the country that by our estimates attracts the largest amount of shifted profits (more than $100 billion in 2015). As shown in the top panel of this Figure, until the 1990s Ireland used to collect relatively little corporate income tax revenue, about 1.5%–2% of national income—significantly less than the United States. Then, as profit shifting surged (Figure 4), so did tax collection: since the mid-1990s, Ireland has collected significantly more corporate tax revenue (as a fraction of national income) than the United States—about twice as much in 2015. Tax collection is strongly negatively correlated with the statutory corporate tax rate (bottom panel of Figure 11): when the tax rate was high (around 50% until the late 1980s), tax collection was low; since the rate was cut to 12.5% in the 1990s, tax collection has been high. Whenever they choose non-zero rates—even rates effectively quite close to zero—tax havens derive clear benefits from attracting paper profits.

It is worth noting that gains in tax revenue are not the only way tax havens benefit from tax competition. As we have seen a number of tax havens (including Ireland) have high capital intensities, i.e., they also attract capital-intensive industries (which can boost wages). Even when capital intensities are not higher, foreign firms can account for a large share of employment in tax havens and bring important economic benefits.[72] Our analysis does not allow us to

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[71]See for instance the case between the E.U. Commission and Apple in Ireland. The E.U. Commission contends that the Irish tax authorities have allowed Apple to pay particularly low rates, of as little as 0.001%, over years.

[72]One potential explanation is that it may be easier for multinationals to shift profits into the countries where

quantify the complete gains that tax havens derive from international capital mobility. Such an analysis would require an explicit model of how movements of tangible capital affect the host economies, which we leave to future research.

7   Macro Statistics Corrected for Profit Shifting

The flip side of the high profits recorded in tax havens is that profits recorded in non-haven countries are too low. In both cases, core macroeconomic statistics are distorted. In the countries where shifted profits are booked (i.e., tax havens), GDP, corporate profits, the capital share of corporate value-added, and trade balances are over-estimated. In non-haven countries, by contrast, these indicators are under-estimated. In this section, we present macroeconomic statistics corrected for the effect of profit shifting for all OECD countries, all tax havens, and the main emerging economies. All our estimates are available online in Appendix Tables C.5 and C.5b; in this section we focus on discussing the methodology and main results.

To adjust the official statistics, we proceed as follows. We add the profits shifted through transfer prices and the strategic location of intangibles (85% of the total) to the recorded operating surplus rK of their source country. We then correct the full sequence of economic accounts of the source countries accordingly (i.e., we increase the value-added Y of the corporate sector, GDP, exports, and the trade balance by the same amount) and compute corrected corporate capital shares $\alpha = rK/Y$ and labor shares $1 - \alpha$.[73] Profits shifted through the use of intra-group interest payments (15% of the total) do not affect recorded operating surplus rK but only the breakdown of operating surplus into corporate profits $(1 - p) \cdot rK$ and net interest payments p; we adjust corporate profits and net interest payments accordingly.

Table 3 presents our estimates of capital shares and trade balances corrected for profit shifting. A number of results are worth noting. First, accounting for profit shifting increases the capital share of corporate value-added in non-haven countries significantly.[74] Consistent

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they also have sizable real activity. According to our estimates, foreign firms pay 24% of all wages in Ireland (Appendix Table A.4), while they account for as much as 78% of all profits (Appendix Table A.7). Note, however, that there are countries where foreign firms account for an even larger fraction of the total wage bill and yet there was little profit shifting in 2015. This includes most Eastern European countries, where foreign firms account for around 40% of both wages and profits. These countries had corporate tax rates close to 20% in 2015.

[73]Bruner, Rassier, and Ruhl (2018) discuss how the effect of profit shifting cascades through the economic accounts and present US macroeconomic statistics corrected for profit shifting; see also Avdjiev et al. (2018).

[74]Note that it does not necessarily increase the capital share of national income, as the profits of the offshore subsidiaries that belong to domestic shareholders enter national income in the form of direct investment income received from the rest of the world. We focus here on correcting corporate factor shares (which are the focus of most of the literature on the decline of the labor share, e.g., Karabarbounis and Neiman, 2014; Gutiérrez and Piton, 2019).

with our earlier result that European countries are particularly affected, we find that the capital share is under-estimated by about 2 to 2.5 points in the main E.U. countries (Germany, United Kingdom, France, Italy), vs. 1.1 point in the United States. Because there was almost no profit shifting before the 1980s (see, e.g., Figure 4) the higher level of the capital share implies a higher rise in the capital share over the last few decades. By our estimates, the rise in the European corporate capital share since the early 1990s is twice as large as recorded in the official national accounts. This finding is important in light of a recent literature that suggests that after excluding real estate, European labor shares may not have declined much since the 1970s (Gutiérrez and Piton, 2019) relative to the United States. Whether labor shares have declined globally (or only in a few countries) is critical for teasing out the role of technological change (vs. country-specific policies) in driving factor shares and inequality.

Profit shifting also has significant effect on trade balances. For instance, after accounting for profit shifting, Japan, the U.K., France, and Greece turn out to have trade surpluses in 2015, in contrast to the published data that record trade deficits. According to our estimates, the true trade deficit of the United States was 2.1% of GDP in 2015, instead of 2.8% in the official statistics—that is, a quarter of the recorded trade deficit of the United States is an illusion of multinational corporate tax avoidance.[75]

8   Conclusion

What have we learned from this paper? In our view the main finding is that one can obtain a clear picture of global profit shifting by exploiting the foreign affiliates statistics recently made available by many countries. These data show that the capital share of corporate value-added is extremely high in the foreign firms of tax havens, while it is low in the foreign firms of other countries compared to the capital share of local firms. By exploiting this pattern of differential profitability as well as new bilateral balance of payments data recently made available by tax havens, our paper estimates how much each tax haven, each OECD country, and the main emerging economies gain or lose in profits compared to a benchmark of global tax harmonization. We find that the redistributive effects of tax competition are large: by our estimates, close to 40% of multinational profits are shifted to tax havens in 2015. Non-haven European Union countries appear to be the largest losers from this phenomenon.

Our findings have implications for policy. First, they suggest that cutting corporate tax rates, as the United States has done at the end of 2017, is less likely to generate quick positive

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[75]See Sandholtz (2018) for an estimation based on U.S. bilateral trade data.

effects on wages than textbook economic models suggest. For wages to rise, factors of production that complement labor need to increase, which can happen fast if tangible capital flows from abroad, less so if it is mostly paper profits that move across borders. Second, profit shifting raises challenges in a number of policy areas. It reduces the effective rates paid by multinationals compared to local firms, which could adversely affect competition. It reduces the taxes paid by the wealthy—as ownership of these firms is concentrated—which might call for offsetting changes in individual income taxation, or changes in the way multinational companies are taxed.

We stress that our estimates of the amount of profits shifted by multinationals globally is conservative. Our investigation has uncovered statistical gaps that limit our ability to monitor global economic activity and constrain tax enforcement. Statistical improvements are necessary. To solve the asymmetries in bilateral foreign affiliates and direct investment statistics (in particular between the United States and European tax havens), national statistical authorities need to be authorized to exchange micro-data. The foreign affiliates statistics that we exploited in this paper need to be compiled by more countries and expanded to include more information, such as interest payments, corporate income taxes paid, and capital stocks (as the United States, for example, already does). A number of Caribbean tax havens do not currently publish comprehensive enough national accounts. Last and maybe most importantly, many countries—including the United States and a number of tax havens—could improve their public corporate registries so that all firms are included and profit information is made publicly available at the subsidiary level. Altogether, these improvements would significantly improve our ability to study globalization and its distributional effects.

Our analysis has focused on how tax competition redistributes tax bases across countries. In future research, it would be good to introduce the inequality dimension in the analysis, i.e., to quantify how much the various income and wealth groups in each country have gained or lost from tax competition. According to our estimates, about half of the globally shifted profits accrue to the shareholders of U.S. multinationals (a majority of which, but not all, are Americans). Because equity ownership is concentrated (see e.g., Saez and Zucman, 2016, for evidence on equity wealth concentration in the United States), profit shifting tends, everything else equal, to reduce the effective tax rate of the wealthy, which may contribute to increasing inequality. A quantitative analysis of these redistributive effects across income and wealth groups would make it possible to make progress towards a full-fledged macro-distributional analysis of globalization. This raises major conceptual and empirical challenges for future research.

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# Figure 1: Consolidated Global Profits vs. Observable Profits Across Subsidiaries
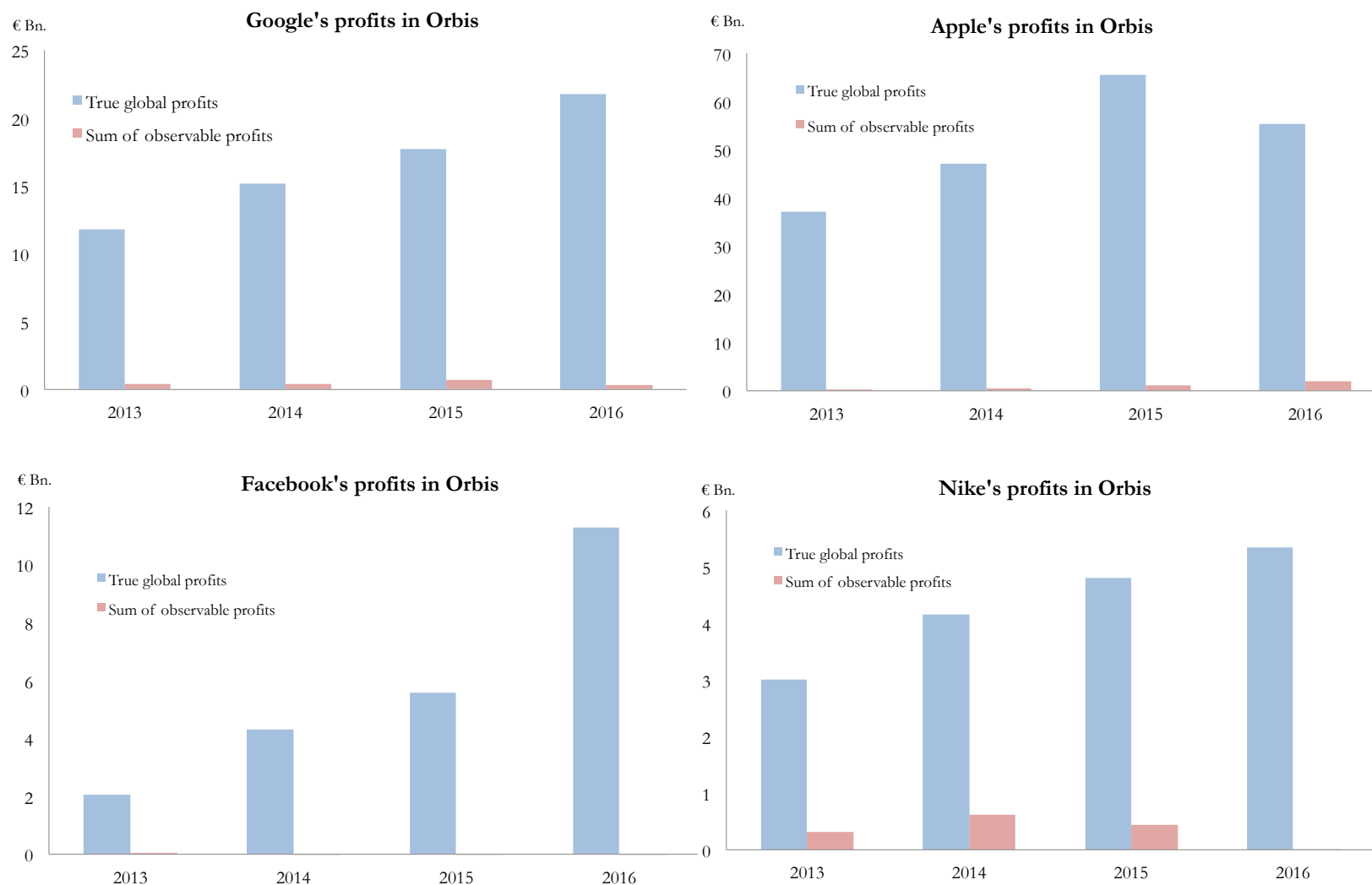
Notes: This graph shows the difference between Apple's, Facebook's, Alphabet's, and Nike's global consolidated profits, and the sum of the profits made by Apple's, Facebook's, Alphabet's, and Nike's subsidiaries, as recorded in Orbis. The difference is due to the fact that the subsidiaries where these firms make the bulk of their profits are not visible in Orbis. Source: authors' computations using Orbis data.

# Figure 2: Fraction of Global Profits That Can be Observed in Orbis
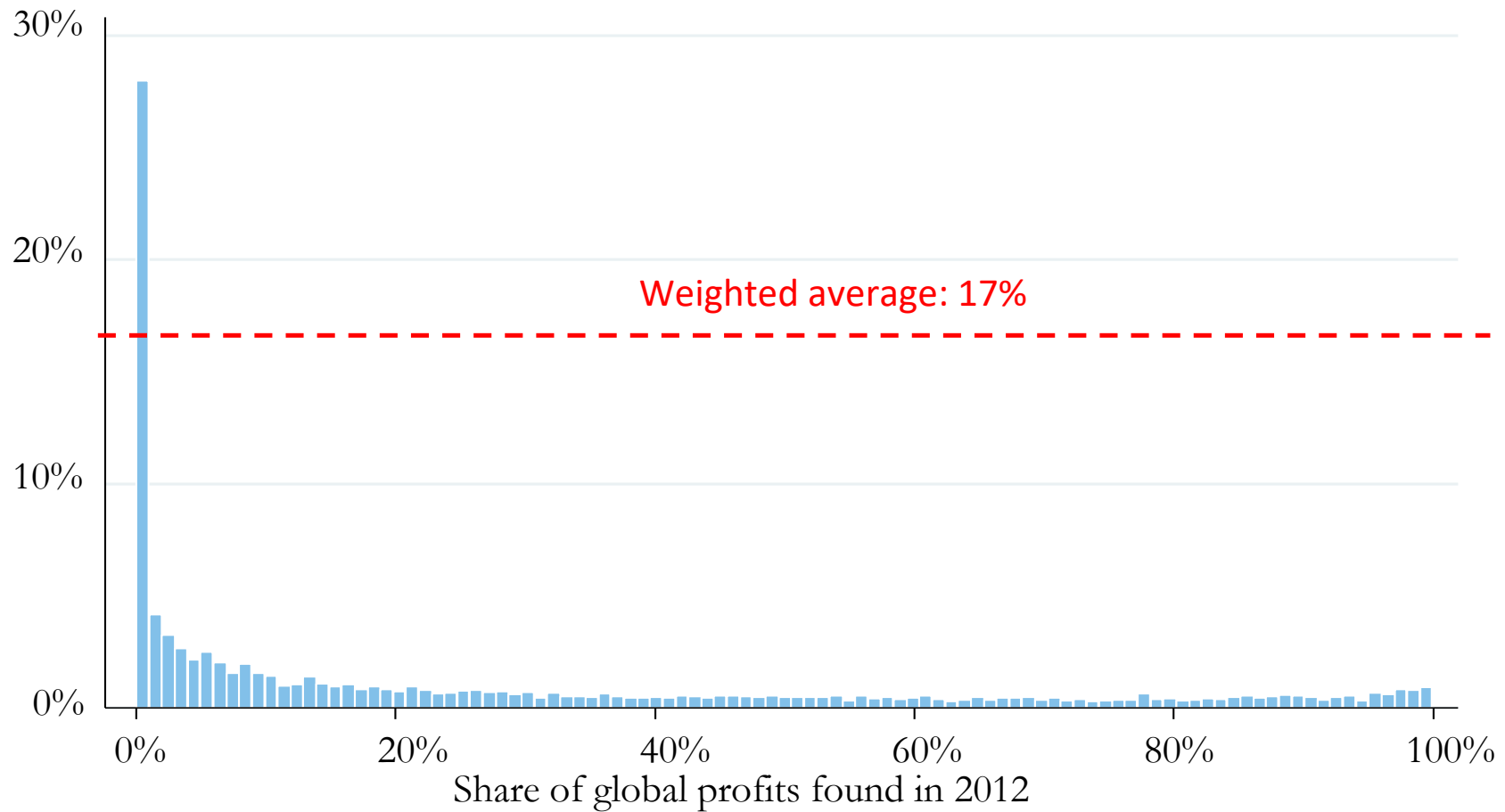
Notes: This graph shows the density of the following ratio. For each multinational firm in Orbis, we compute the sum of the unconsolidated pre-tax profits of all subsidiaries (code U1), and we divide this sum by the consolidated global profits of the firm (code C1). Whenever the ratio is less than 1, this means that only part of the global profits of the firm are visible at the subsidiary level in Orbis. In 28% of the cases, no profits are visible at the subsidiary level. The weighted average of 17% is weighed by profit. Source: authors' computations using Orbis data.

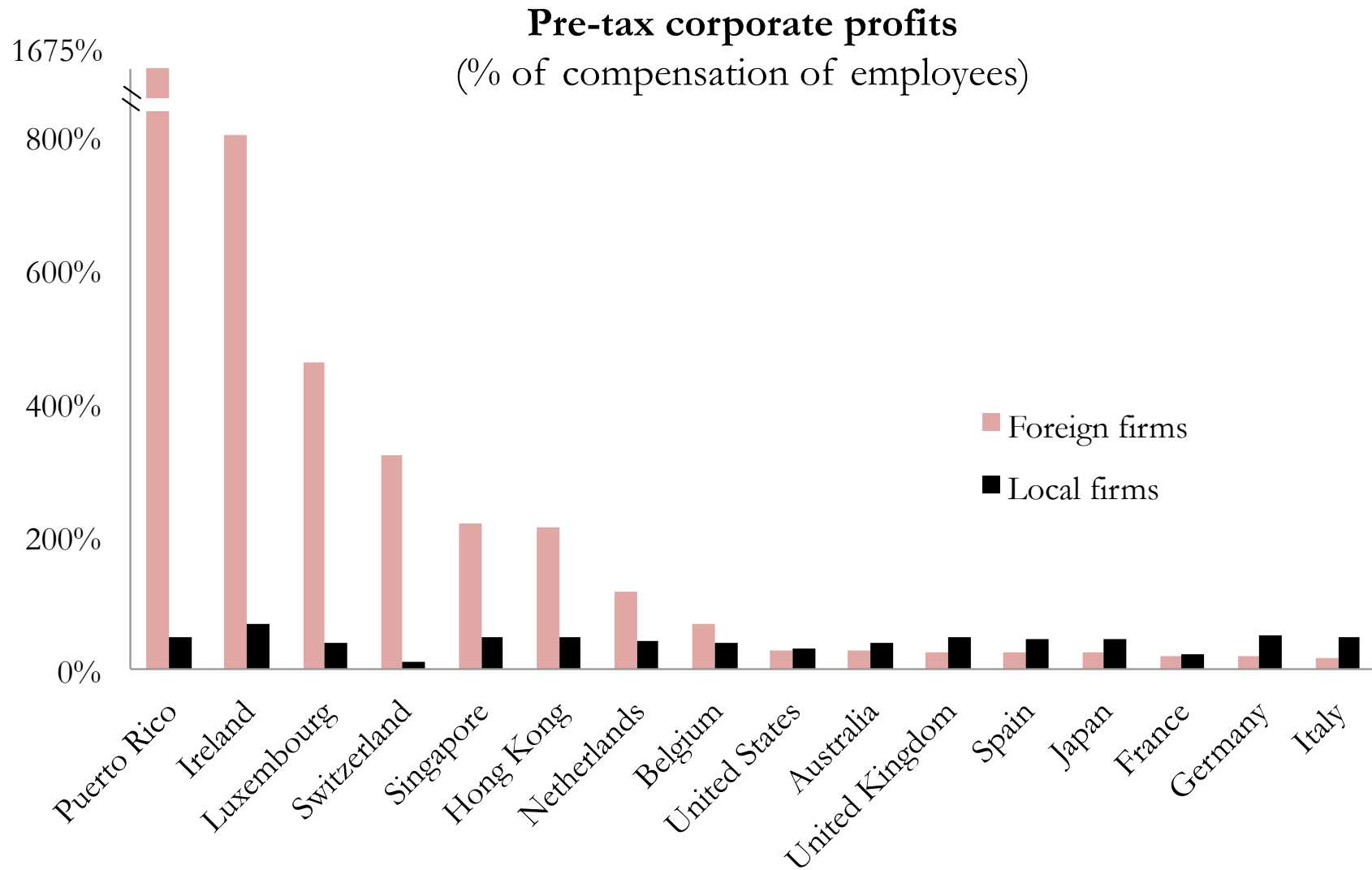# Figure 3: Pre-tax Corporate Profits (% Compensation of Employees)
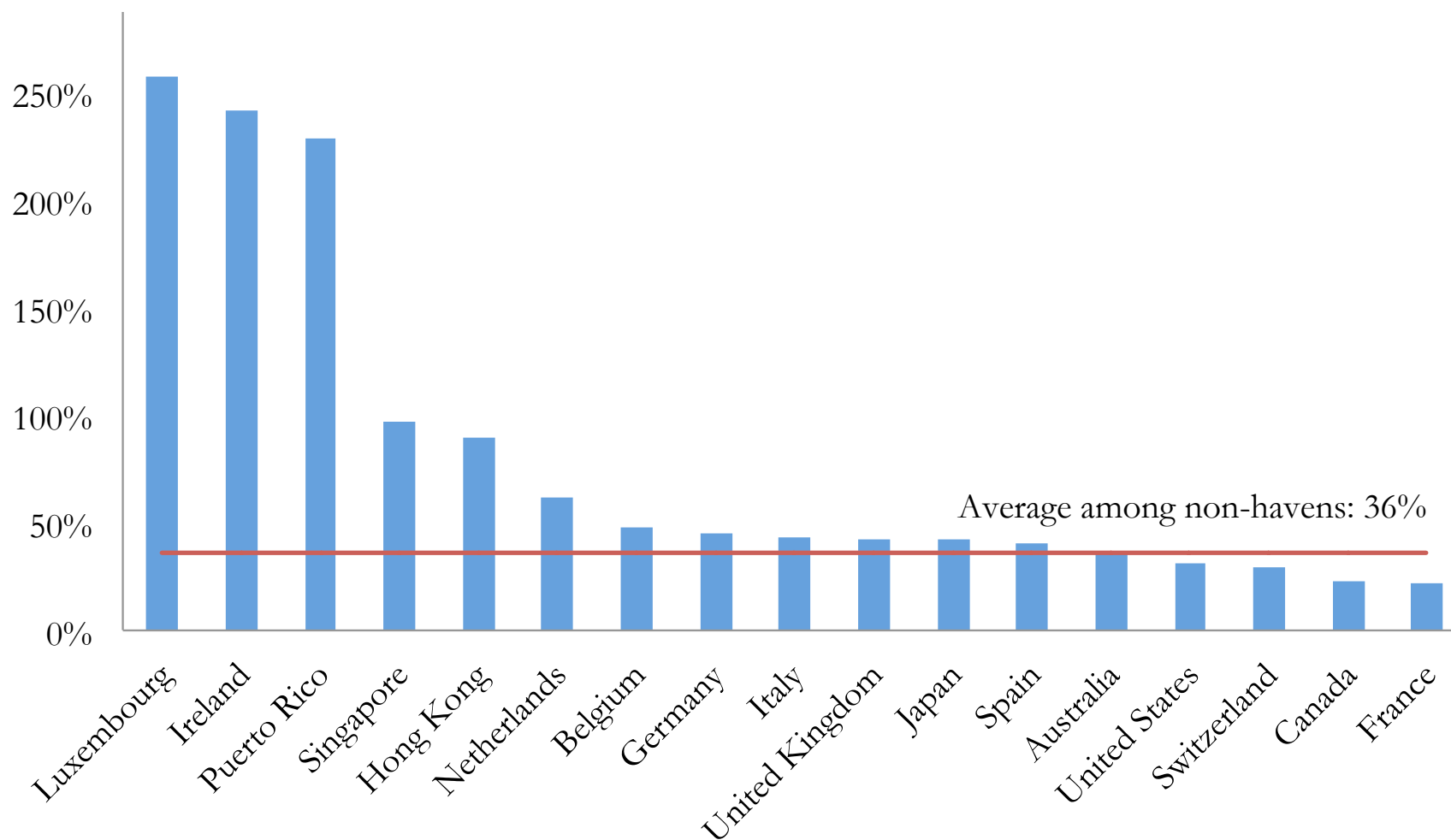
Notes: the bar shows the ratio of pre-tax corporate profits (net of interest and depreciation) to compensation of employees in 2015, as recorded in national accounts data. Source: Appendix Table A.7.

Figure 4: The Rise of Profit Shifting

Pre-tax corporate profits
(% of compensation of employees)

Pre-tax profits of affiliates of U.S. multinationals
(% of compensation of employees)
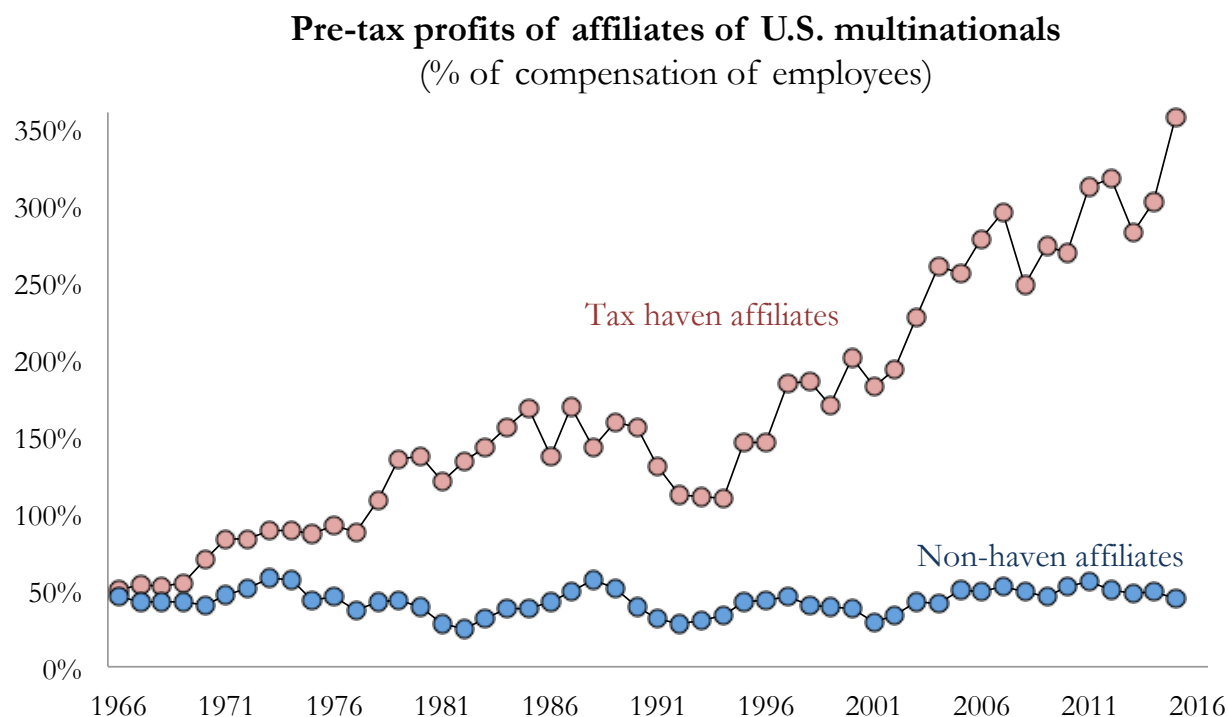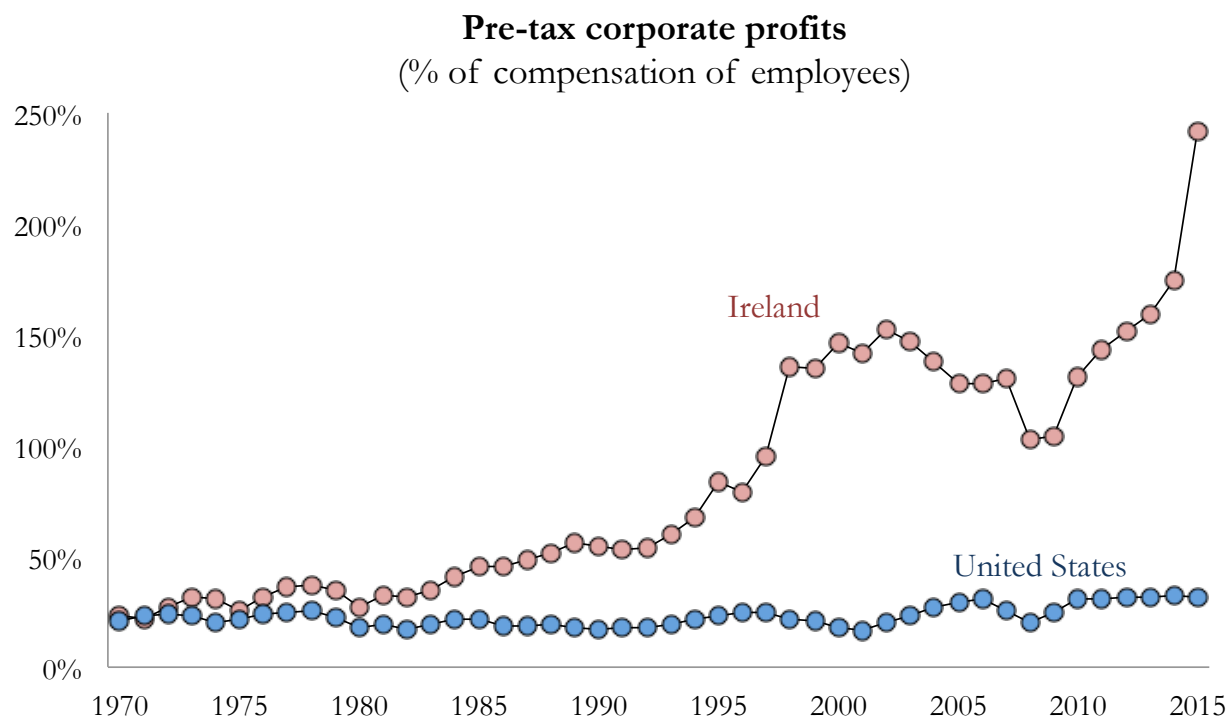
Notes: in the bottom panel, tax havens include: Ireland, Luxembourg, Netherlands, Switzerland, Bermuda and Caribbean tax havens ("Other Western Hemisphere" in the BEA data), and Singapore. Non-havens include all other countries. Sources: For top panel, national accounts of Ireland and the United States and authors' computations; for bottom panel: BEA survey of the activities of U.S. multinationals abroad, Tables II.F.1 and II.F.2, column "profit-type return" and "compensation of employees".

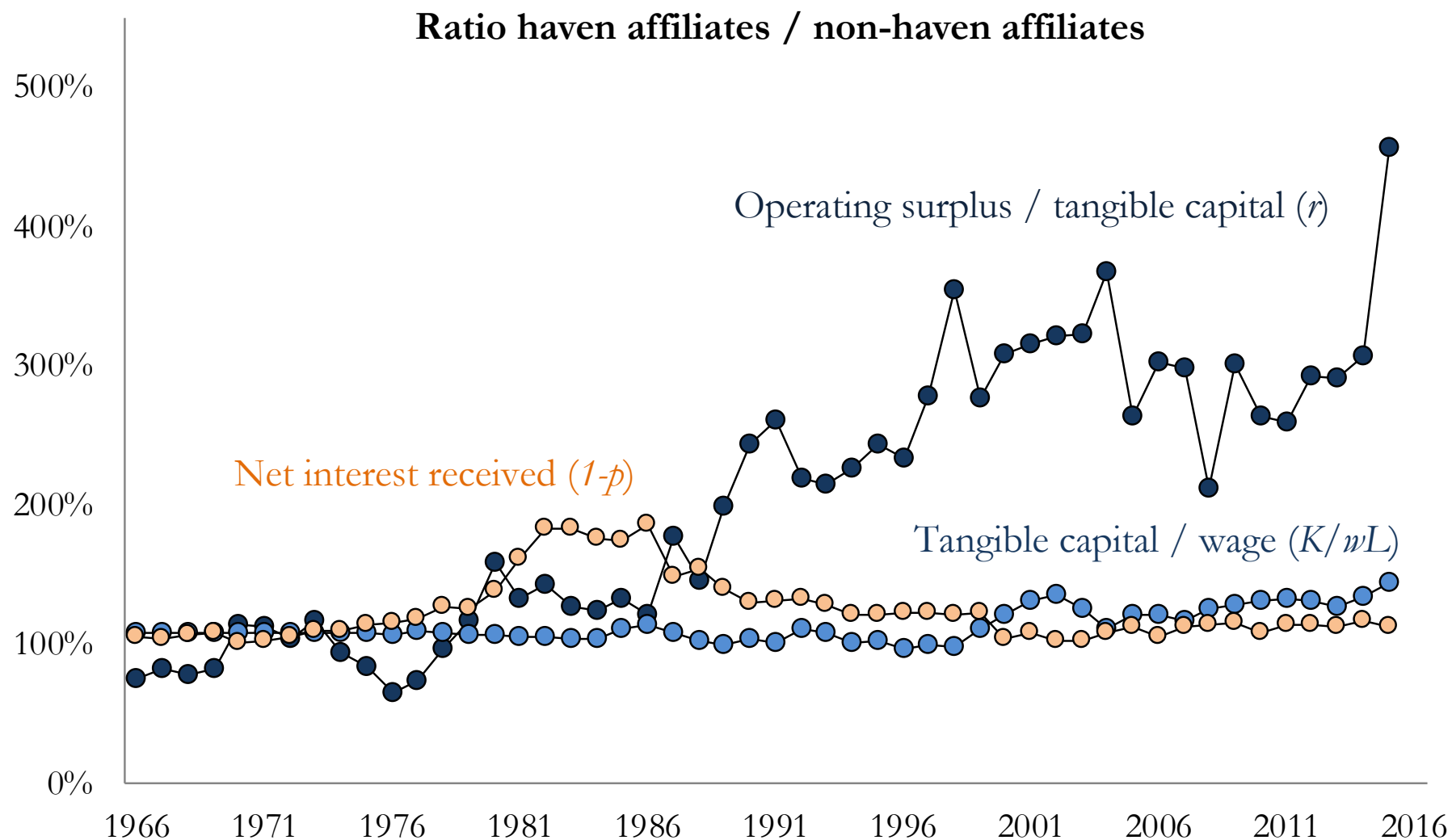# Figure 5: Profitability in Foreign vs. Local Firms

Pre-tax corporate profits
(% of compensation of employees)

- Foreign firms
- Local firms

Notes: data are for 2015. Source: Appendix Table A.7.

Figure 6: Capital Intensities in Tax Havens

Tangible assets
(% of compensation of employees)

Pre-tax corporate profits
(% of compensation of employees)
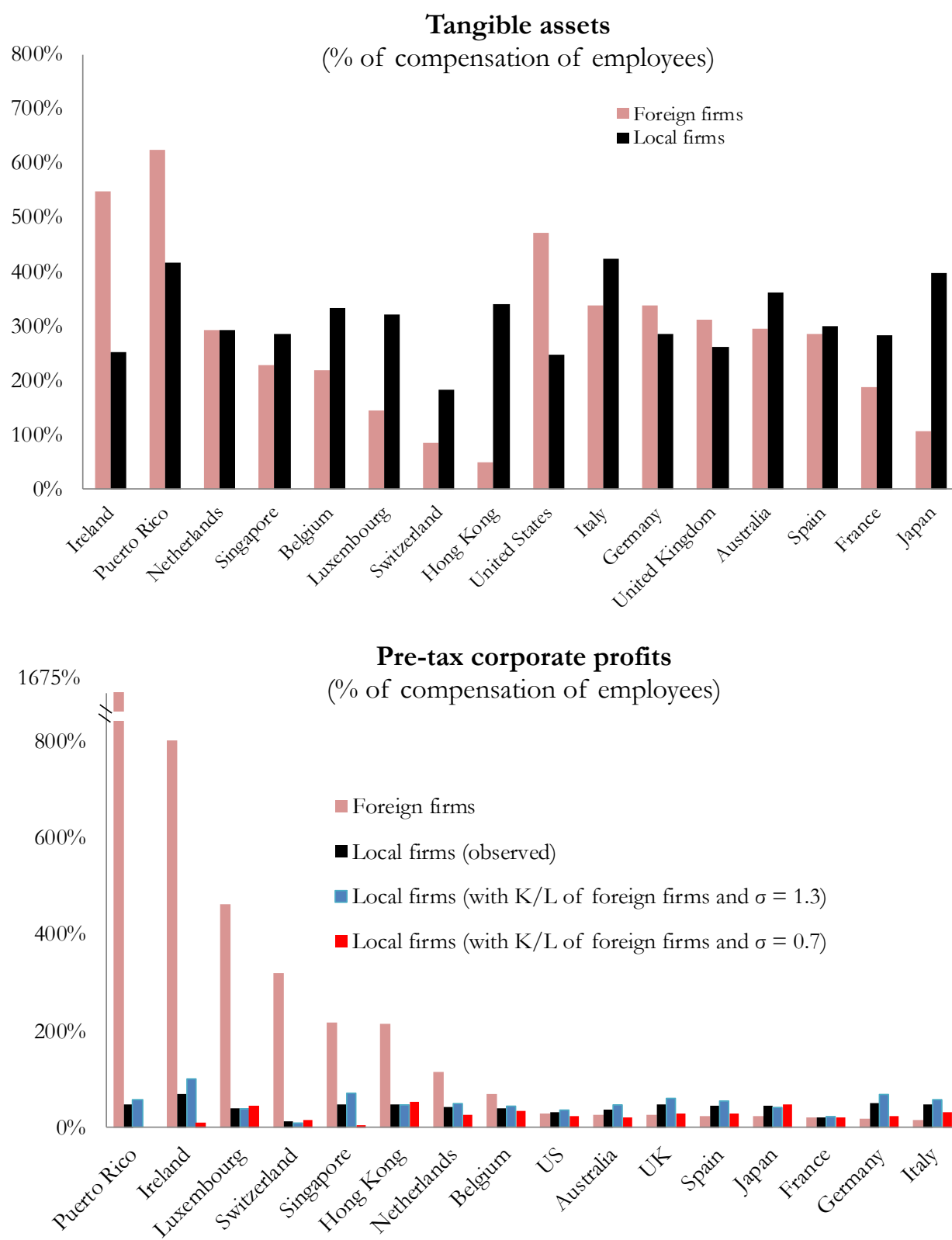
Source: Appendix Table E.1 .

Figure 7: The Profitability of the Affiliates of US Multinationals

Ratio haven affiliates / non-haven affiliates

Operating surplus / tangible capital (r)

Net interest received (1-p)

Tangible capital / wage (K/wL)

Figure 8: Comparing estimates of profit shifted into each haven: excess profitability vs. excessive cross-border transactions (billions of US$)
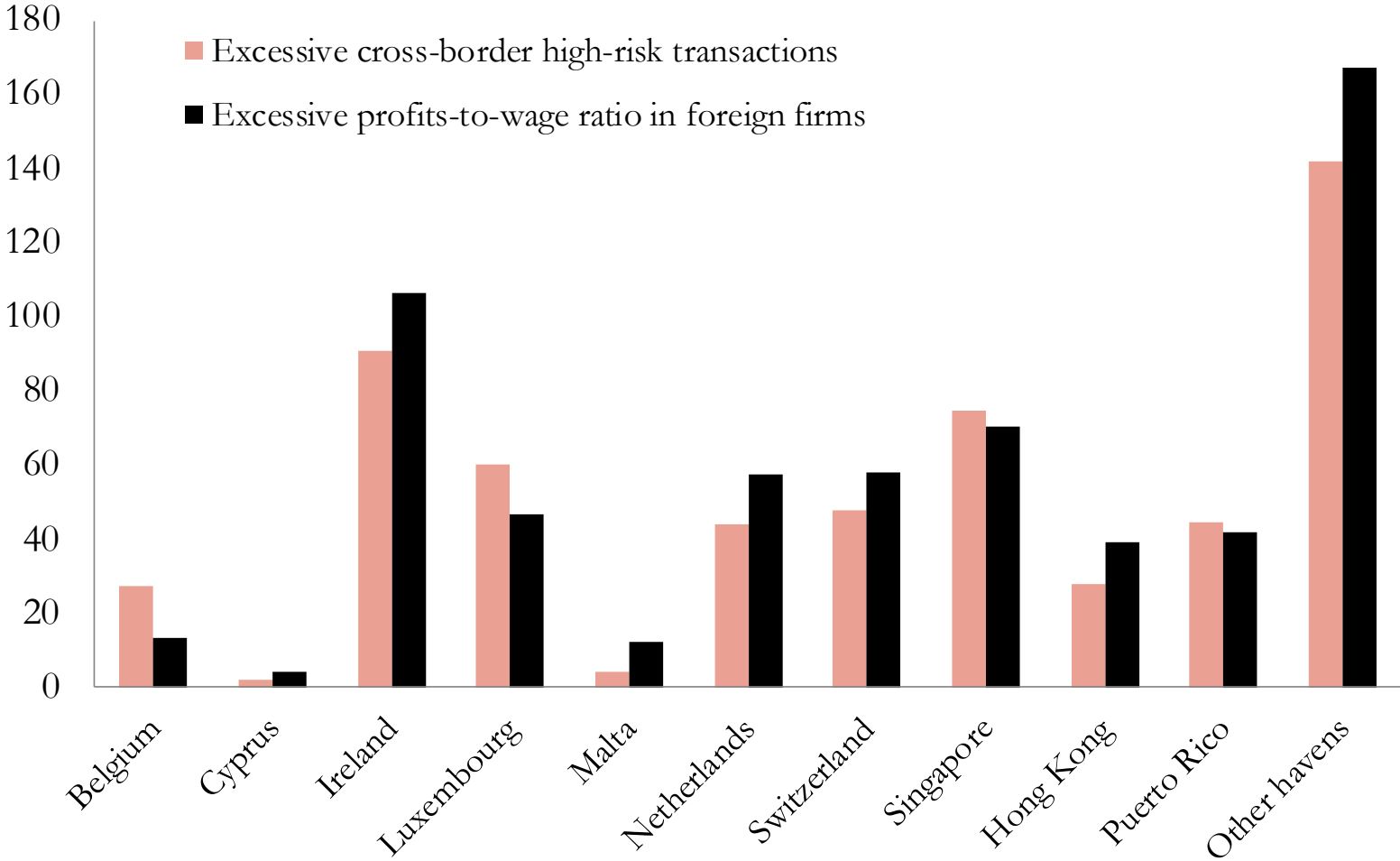
Source: Appendix Tables A7 and C2.

Figure 9: Allocating the Shifted Profits

Allocating the profits shifted to tax havens

Legend:
- Where the shifted profits come from
- To whom the shifted profits accrue

Tax revenue lost due to profit shifting
(% of corporate tax revenue collected)
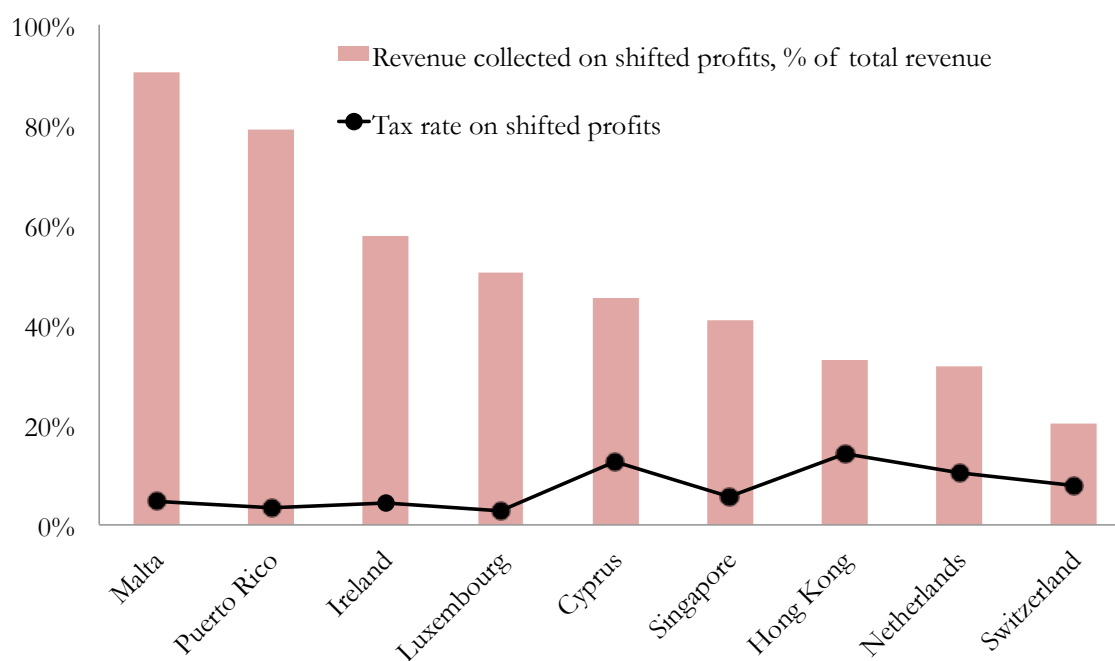

Global average: 10%
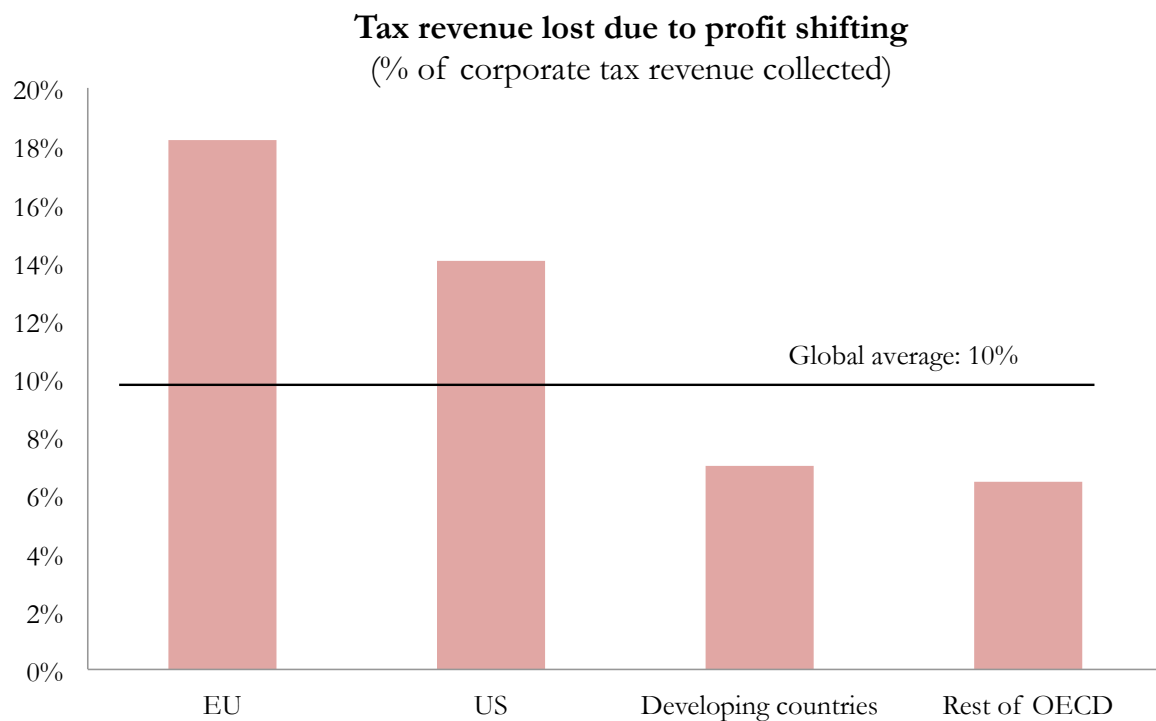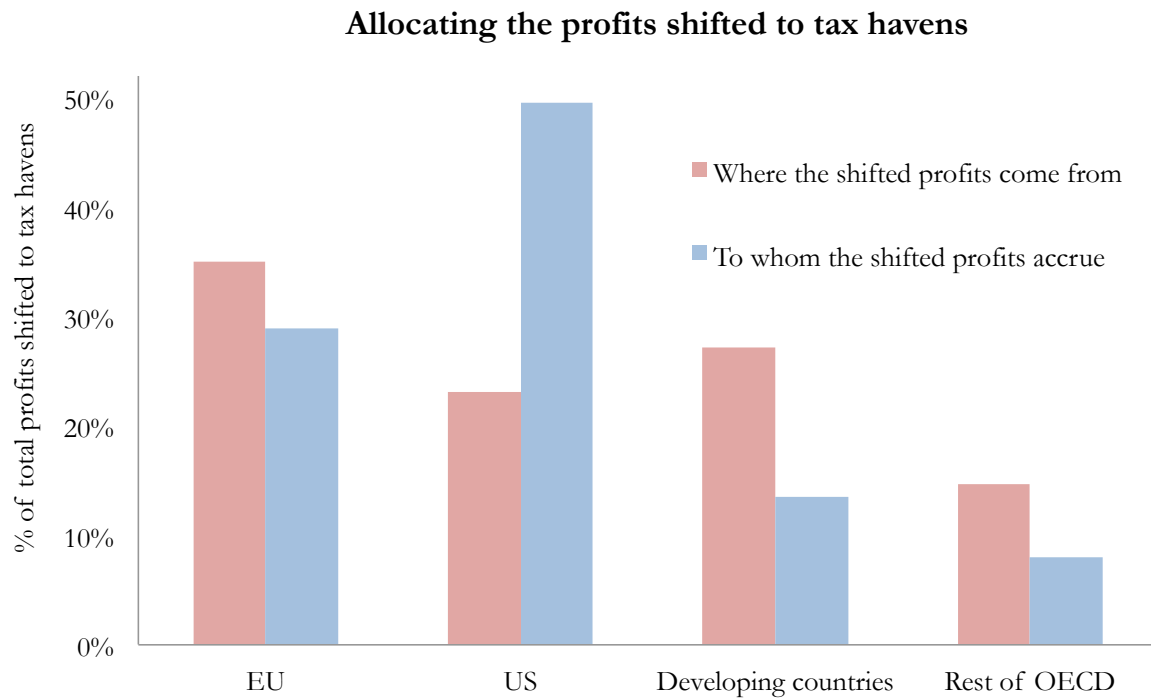
Note: Estimates are for 2015. Source: Appendix Tables C.4b, C.4c, and C.4d.

Figure 10: Corporate Tax Revenue in Tax Havens

Corporate income tax revenue
(% of national income)

Average among non-havens: 3.5%

Malta, Luxembourg, Cyprus, Hong Kong, Japan, Australia, Ireland, Canada, Belgium, Switzerland, Korea, Singapore, Mexico, United Kingdom, Netherlands, France, Puerto Rico, Spain, Germany, United States, Italy, Poland
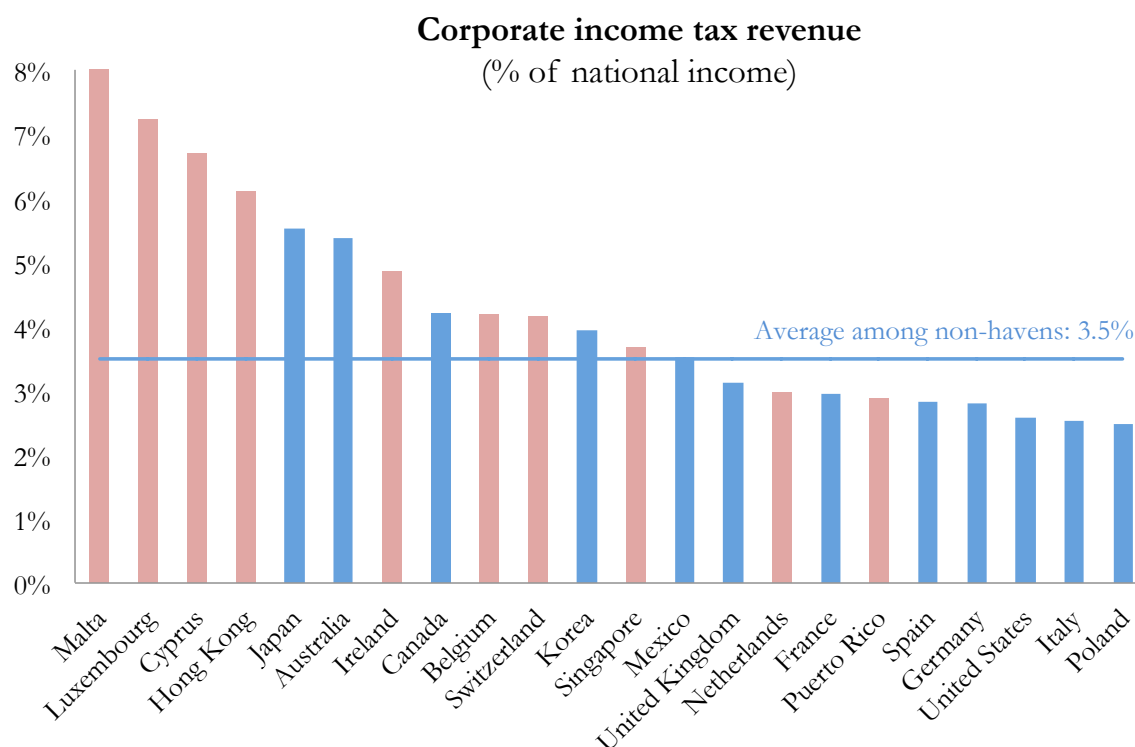
Corporate tax revenue collected & tax rate on shifted profits

Revenue collected on shifted profits, % of total revenue

Tax rate on shifted profits

Malta, Puerto Rico, Ireland, Luxembourg, Cyprus, Singapore, Hong Kong, Netherlands, Switzerland

Notes: data are for 2015. Source: Appendix Tables A.3., A.6., A.7, and A.11.

Figure 11: The Redistribution of Corporate Income Tax Revenue

Corporate income tax revenue
(% net national income)

Corporate income tax revenue vs. tax rate in Ireland
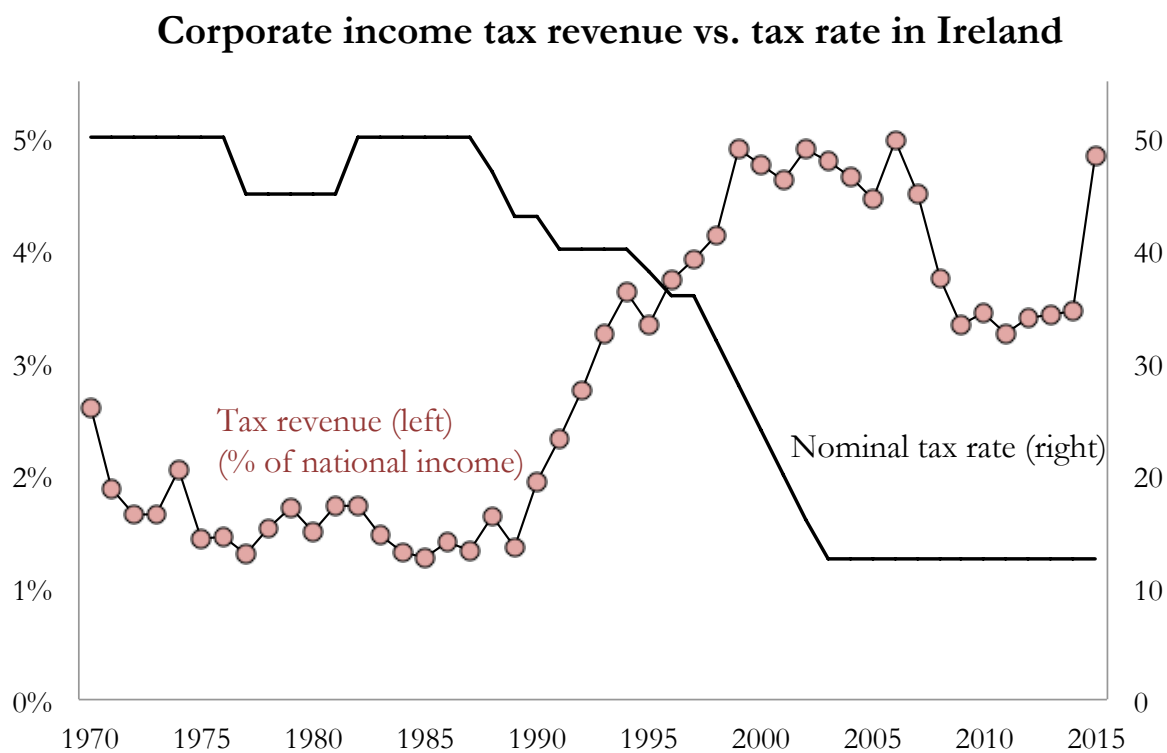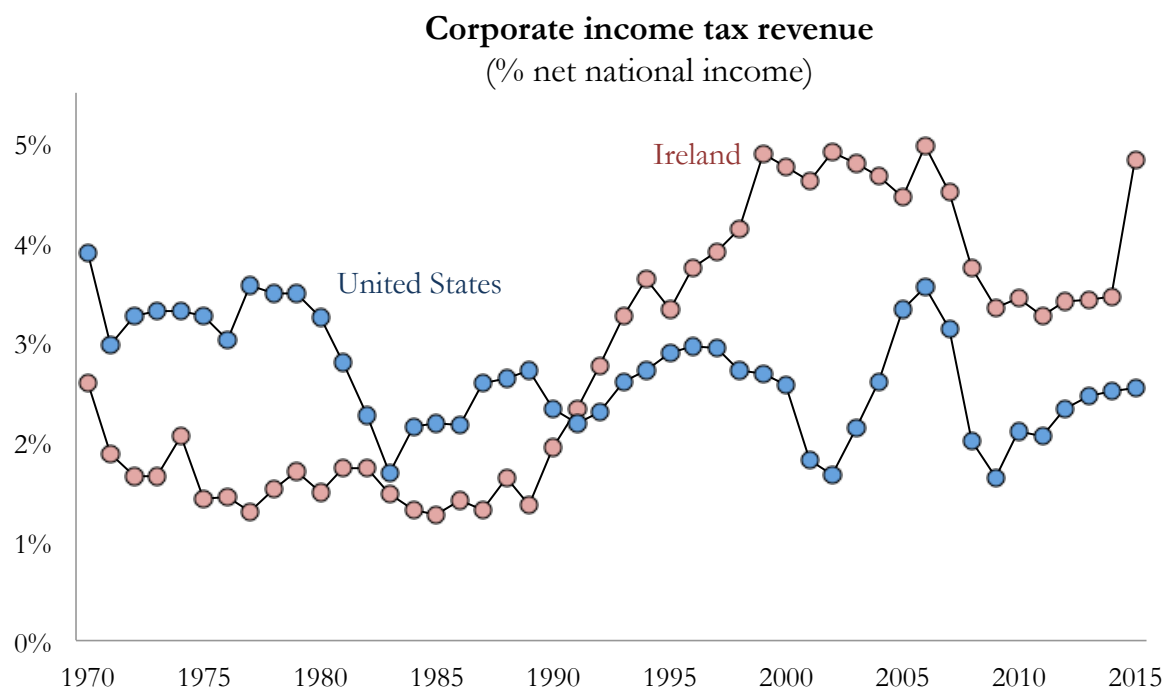
Source: national accounts of Ireland and the United States; see text.

Table 1: Global Output, Corporate Output, and Corporate Taxes Paid (2015)

	Billions of current US$	% of net corporate profits
Global gross output (GDP)	75,038	
Depreciation	11,940	
Net output	63,098	
Net corporate output	34,083	296%
Net corporate profits	11,515	100%
Net profits of foreign-controlled corp.	1,703	15%
Of which: shifted to tax havens	616	5%
Net profits of local corporations	9,812	85%
Corporate income taxes paid	2,154	19%

Notes: Profits of foreign corporations include all the profits made by companies more than 50% owned by a foreign country; profits of local corporations equal all corporate profits minus the profits of foreign corporations. Source: Appendix Tables C.5 and A.3.

Table 2: Shifted Profits: Country-by-Country Estimates (2015)

	Reported pre-tax profits	*Of which: Local firms*	*Of which: Foreign firms*	Shifted profits	Effective corporate tax rate	Corp. tax revenue loss/gain (% collected)
OECD countries						
Australia	**179**	*151*	*28*	**12**	30%	7%
Austria	**48**	*37*	*11*	**4**	18%	11%
Canada	**143**	*96*	*47*	**17**	35%	9%
Chile	**68**	*58*	*10*	**5**	15%	11%
Czech Republic	**34**	*16*	*17*	**2**	20%	5%
Denmark	**52**	*47*	*5*	**3**	15%	8%
Estonia	**4**	*3*	*1*	**0**	12%	10%
Finland	**25**	*21*	*4*	**3**	20%	11%
France	**188**	*156*	*32*	**32**	27%	21%
Germany	**553**	*510*	*43*	**55**	11%	28%
Greece	**23**	*21*	*1*	**1**	19%	7%
Hungary	**21**	*11*	*10*	**2**	11%	21%
Iceland	**2**	*2*	*0*	**0**	19%	22%
Israel	**54**	*48*	*6*	**1**	17%	2%
Italy	**212**	*199*	*13*	**23**	18%	19%
Japan	**634**	*602*	*32*	**28**	26%	6%
Korea	**248**	*246*	*3*	**4**	18%	2%
Latvia	**4**	*3*	*1*	**0**	10%	7%
Mexico	**325**	*302*	*23*	**12**	12%	10%
New Zealand	**44**	*37*	*6*	**1**	18%	5%
Norway	**76**	*69*	*7*	**5**	22%	8%
Poland	**88**	*68*	*19*	**4**	10%`	8%
Portugal	**27**	*22*	*5*	**3**	23%	9%
Slovakia	**12**	*6*	*5*	**1**	25%	5%
Slovenia	**3**	*2*	*1*	**0**	18%	6%
Spain	**159**	*138*	*21*	**14**	18%	14%
Sweden	**63**	*39*	*24*	**9**	23%	13%
Turkey	**213**	*209*	*4*	**5**	6%	8%
United Kingdom	**425**	*353*	*72*	**61**	17%	18%
United States	**1,889**	*1,737*	*153*	**142**	21%	14%
Main developing countries						
Brazil	**274**	*245*	*30*	**13**	20%	8%
China	**2,069**	*1,906*	*162*	**55**	20%	3%
Colombia	**59**	*52*	*7*	**1**	29%	2%
Costa Rica	**13**	*12*	*1*	**1**	12%	19%
India	**376**	*368*	*8*	**9**	10%	8%
Russia	**290**	*253*	*37*	**11**	14%	5%
South Africa	**76**	*68*	*9*	**4**	25%	6%
Tax havens						
Belgium	**80**	48	32	**-13**	19%	16%
Ireland	**174**	58	116	**-106**	4%	58%
Luxembourg	**91**	40	51	**-47**	3%	50%
Malta	**14**	1	13	**-12**	5%	90%
Netherlands	**195**	106	89	**-57**	10%	32%
Caribbean	**102**	4	98	**-97**	2%`	100%
Bermuda	**25**	1	25	**-24**	0%	
Singapore	**120**	30	90	**-70**	8%	41%
Puerto Rico	**53**	10	43	**-42**	3%	79%
Hong Kong	**95**	45	50	**-39**	18%	33%
Switzerland	**95**	35	60	**-58**	21%	20%
Other				**-51**		

Notes: amounts are in current billion US$. All data are for 2015. Source: Appendix Tables A.6., A.7, C.4d, and C.4.

Table 3: Macro Statistics Corrected for Profit Shifting (2015)

	Corrected capital share	*Difference with published data*	Corrected trade balance	*Difference with published data*
OECD countries				
Australia	26%	*+1.1%*	-1.4%	*+0.8%*
Austria	29%	*+1.3%*	4.1%	*+0.8%*
Canada	24%	*+1.4%*	-1.4%	*+0.9%*
Chile	51%	*+1.5%*	1.8%	*+1.8%*
Czech Republic	39%	*+1.0%*	6.5%	*+0.7%*
Denmark	31%	*+1.2%*	8.2%	*+0.8%*
Estonia	35%	*+1.1%*	5.0%	*+0.9%*
Finland	28%	*+1.6%*	0.9%	*+1.0%*
France	19%	*+2.1%*	0.4%	*+1.1%*
Germany	31%	*+1.8%*	9.2%	*+1.2%*
Greece	43%	*+1.1%*	0.3%	*+0.5%*
Hungary	39%	*+2.3%*	10.4%	*+1.5%*
Iceland	33%	*+3.4%*	9.5%	*+2.0%*
Israel	37%	*+0.2%*	3.2%	*+0.2%*
Italy	30%	*+1.9%*	3.9%	*+1.0%*
Japan	28%	*+0.8%*	0.0%	*+0.5%*
Korea	37%	*+0.4%*	8.0%	*+0.2%*
Latvia	31%	*+0.9%*	-0.5%	*+0.6%*
Mexico	71%	*+0.6%*	-1.2%	*+0.9%*
New Zealand	44%	*+0.7%*	1.4%	*+0.7%*
Norway	41%	*+1.2%*	6.5%	*+1.0%*
Poland	45%	*+0.9%*	3.7%	*+0.6%*
Portugal	33%	*+1.8%*	2.8%	*+1.1%*
Slovakia	35%	*+1.1%*	3.4%	*+0.6%*
Slovenia	18%	*+0.9%*	9.1%	*+0.4%*
Spain	29%	*+1.6%*	3.4%	*+1.0%*
Sweden	31%	*+2.2%*	6.3%	*+1.4%*
Turkey	55%	*+0.4%*	-2.3%	*+0.5%*
United Kingdom	31%	*+2.5%*	0.2%	*+1.8%*
United States	27%	*+1.1%*	-2.1%	*+0.7%*
Main developing countries				
Brazil	26%	*+1.0%*	-0.3%	*+0.5%*
China	44%	*+0.5%*	3.7%	*+0.4%*
Colombia	54%	*+0.5%*	-5.9%	*+0.4%*
Costa Rica	45%	*+1.9%*	1.6%	*+1.7%*
India	56%	*+0.5%*	-2.6%	*+0.4%*
Russia	40%	*+0.8%*	8.9%	*+0.7%*
South Africa	39%	*+1.4%*	0.0%	*+1.0%*

Source: Appendix Tables C.5 and C.5b.