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A Survey on Forward-looking Tax Measures and Two Applications

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Abstract

This study provides a survey on corporate taxes around the world. Our analysis has three main objectives. First, we collect tax data and calculate (forward-looking) effective tax measures for a large sample of countries and recent years. We particularly describe how these measures vary over time and across countries. Second, we augment the country-level information with firm- and industry-level data (providing weights for financial structure and asset composition) to contrast statutory measures at the level of countries with measures accounting for firm- and industry-specific weights. Third, we utilize our new data to (i) estimate Laffer-Curves, i.e., the relationship between statutory tax rate and tax revenue, based on non-parametric as well as parametric specifications; (ii) examine how taxes affect investment in fixed assets at the level of firms. As for the latter, our preferred specification, in which we use a firm-specific effective marginal tax rate to capture tax incentives, suggests an elasticity of -0.33.

JEL-Codes: H250, H210, F230, F610.

Keywords: corporate taxes, depreciation allowances, effective marginal (average) tax rates, Laffer-Curve, investment responses.

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1 Introduction

Corporate tax issues have been at the center of public debate in recent years. Very often, this debate has been related to the specific policies of countries to grant preferential tax treatment and tax exemptions for some forms of corporate income (e.g., income from intellectual property). A number of countries feel pressured to respond to the far-reaching corporate tax reform recently implemented by the US government. Most notably, the "Tax Cuts and Jobs Act" involves a massive cut of the federal corporate tax rate from 35% to 21% and allows for immediate expensing of some capital investments for a limited period of time.[1] Apart from this ongoing discussion, the last decades have witnessed many governments pursuing so-called *tax-cut-cum-base-broadening* policies. Most governments have significantly reduced their statutory tax rates ($STRs$) on corporate income, while broadening the tax base through less attractive depreciation allowances and reducing tax exemptions (see Devereux, Griffith, and Klemm (2002), for an early survey).

An important objective of our research is to calculate and analyze forward-looking measures depicting the *effective tax burden* of a hypothetical investment project. Thereby, we distinguish between an *effective average tax rate* ($EATR$), which measures the average tax burden of an investment project, and an *effective marginal tax rate* ($EMTR$), which measures the tax burden of a marginal investment precisely earning the minimum required return on capital. Examining a time series of $EATRs$ and $EMTRs$ for a large set of countries not only yields valuable insights about countries' tax policies over recent years, it also helps us to better understand the associated incentive effects for firm behavior and the resulting consequences for corporate tax revenue.

The analysis of effective tax rates ($ETRs$) has been a key point of interest in previous academic literature. King (1974) and King and Fullerton (1984) have provided a theoretical framework to investigate the effects of taxation on companies' investment decisions. Devereux, Griffith, and Klemm (2002) have calculated $ETRs$ for 16 countries and 20 years (from 1982 to 2001). While they find that $STRs$ have been cut by most countries, this policy has usually been accompanied by a broadening of the tax base. The broader tax base, however, does not fully compensate the reductions in the $STRs$, so that $EATRs$ and $EMTRs$ decrease over time as well. Beside the work of Devereux, Griffith, and Klemm (2002), our study is most closely related to the work of Loretz (2008). The latter paper basically confirms previous findings by providing evidence for 26 OECD countries and more recent years. Our paper also relates to the seminal contributions on $EATRs$ by Devereux and Griffith (1998) and Devereux and Griffith (2003). The studies of Egger, Loretz, Pfaffermayr, and Winner (2009b) as well as Egger and Loretz (2010) draw on these earlier contributions but argue that the focus on country-specific tax law may lead to wrong conclusions as industry- and firm-specific components are neglected.

Another strand of the literature on ETRs shows how the forward-looking measures of the effective tax burden can be refined in order to incorporate specific details of the tax code: Evers, Miller, and Spengel (2015) demonstrate how the formulas for the effective taxes can be adjusted for the case of income from intellectual property, concluding that IP box regimes can vastly reduce the effective average tax burden. Spengel, Heckemeyer, and Streif (2016) study the impact of variations in interest rates and inflation on ETRs. In another paper, Spengel, Heckemeyer, Nusser, Klar, and Streif (2016) analyze how different tax planning strategies affect the effective taxes on cross-border investment. Spengel, Heckemeyer, Bräutigam, Nicolay, Klar, and Stutzenberger (2016) assess the effect of interest deduction limitation rules on ETRs and use country-level effective tax data to evaluate fundamental tax reforms.

Apart from these contributions to academic literature, several groups of researchers have provided comprehensive data collections in the context of forward-looking ETRs. Most prominently, researchers from the Centre for European Economic Research (ZEW) have collected

[1] Additional changes in tax law affect the way how international business income is taxed. Moreover, some new legislation has been implemented to prevent profit-shifting activities of multinational enterprises.

detailed information on effective tax levels for 35 (mainly EU) countries as part of a long-term project for the EU commission (Spengel, Endres, Nicolay, Heckemeyer, Bartholmess, Bräutigam, Braun, Pfeiffer, Evers, Harendt, Streif, Todtenhaupt, and Halter, 2017). Moreover, researchers from the Oxford University Center for Business Taxation have calculated effective tax data for 42 countries and used them for various policy reports, where the focus is on OECD countries (Bilicka and Devereux, 2012).

The first part of our study provides a survey on corporate income taxes. In particular, novel data on corporate income taxes and depreciation rules to calculate forward-looking effective tax rates (*ETRs*) for 142 countries and the most recent years (2004-2016) is presented. Formal *ETRs* are derived from a neoclassical investment model (Section 2), which allows us to distinguish between two effective tax measures: the *EMTR* and the *EATR*. Section 3 outlines the process of data collection, discusses some important data restrictions and necessary assumptions in order to compute the effective tax measures in the most coherent and comprehensive way.

Section 4 provides a descriptive analysis of the data, first focusing on tax measures at the country level (Section 4.1). Thereafter, we demonstrate how the country-level information on taxes can be combined with industry- and firm-level financial data taken from Bureau van Dijk's *Orbis* database (Section 4.2). In this regard, to begin with, we relax two fundamental assumptions made in the country-level analysis. First, we employ firm-specific debt and equity financing shares rather than relying on the assumption of symmetric financing behavior across firms. Second, we relax the assumption of a symmetric capital stock composition and use an industry-specific within-firm asset composition. In both parts of the descriptive analysis, we particularly focus on the distribution of *STRs*, *EMTRs*, and *EATRs* across countries. Moreover, we also show how the average values of these measures have changed over the last 13 years. The data depict a downward trend in taxes over the period 2004 to 2016. At the same time, about half of the countries have broadened their tax bases. To be precise, many of the countries have both decreased the statutory corporate income tax rate (79,2% of all countries considered), as well as depreciation allowances (49,3%). However, average *EMTRs* and *EATRs* go down, suggesting that cutting statutory taxes outweighs the on average somewhat broader tax base. Extreme values in the distribution of all four variables have significantly decreased over time. Since 2011, it seems that the downward trend has come to an end and average tax measures have not changed much since then.

The second part of our study (Section 5) presents two applications for which our new dataset can be utilized: one at the macroeconomic, country level, one at the microeconomic, firm level. The first subsection (5.1) examines whether tax avoidance behavior leads to a Laffer-Curve relationship between statutory tax incentives and data on corporate tax revenue. Our analysis provides conclusive evidence on an inverse-U-shaped relationship between statutory taxes and tax revenue, suggesting revenue-maximizing taxes of 31% *(STR)*, 27% *(EATR)*, and 17% *(EMTR)*. Our analysis makes sure that the Laffer-Curve shape is not imposed on the data by specifying tax revenue as a polynomial function of taxes: additional results show that higher-order polynomials are inferior to a polynomial of degree two; non-parametric specifications of the relationship produce very similar results. In equilibrium, average tax rates are significantly lower than the implied revenue-maximizing tax rates – possibly a result of strategic tax competition between countries.

Second, we combine the firm-specific tax rates analyzed above with further micro-level data and model the fixed assets of a firm as a function of our tax measures (5.2). The empirical results suggest that investment in fixed assets is negatively related to taxes. The estimated tax elasticities prove to lie in a range which is comparable to previous studies. To be specific, the semi-elasticity with respect to the *EMTR* is about -2.24. Including additional variation by alternatively using effective tax measures at the firm-industry-level appears to capture tax incentives even better.

Finally, Section 6 concludes, presenting policy implications and an outlook for further fields of application of the tax measures we have collected.

2 Forward-looking effective tax rates

2.1 Theoretical framework

The notion of a forward-looking measure of the effective tax burden on a hypothetical investment has been conceptualized by King and Fullerton (1984) and extensively used thereafter (OECD, 1991; Devereux and Griffith, 1998; Devereux, Griffith, and Klemm, 2002; Loretz, 2008; Egger, Loretz, Pfaffermayr, and Winner, 2009b; Egger and Loretz, 2010). Following Devereux and Griffith (2003) and Fabling, Gemmell, Kneller, and Sanderson (2014), our forward-looking approach assumes that the firm's hypothetical, future investment project and consequently its financing structure and asset composition are organized in the same manner as previous investments.[2] We derive ETRs from a neoclassical investment model which is briefly outlined in the following.

Let us define the profit of a firm facing an investment decision as

$$\begin{aligned}\Pi = & -(1-\tau A)\cdot I \\ & + \frac{1}{1+\rho}\left[(1-\tau)(1+\pi)\cdot(p+\sigma)+(1-\tau A)(1+\pi)(1-\sigma)\right]\cdot I \end{aligned} \tag{1}$$

where I is the firm's (real) investment and A represents the net present value (NPV) of tax depreciation allowances per unit of investment, which may be interpreted as an upfront subsidy provided by the government.[3] The statutory tax rate on business profits is denoted by τ,[4] ρ is the discount rate,[5] π represents the inflation rate, σ the economic rate of depreciation, and p depicts the pre-tax rate of return. Solving the associated first-order condition with respect to I for p yields

$$\hat{p} = \frac{(1-\tau A)\left[(1+\rho)-(1+\pi)(1-\sigma)\right]}{(1-\tau)(1+\pi)} - \sigma. \tag{2}$$

$\hat{p}$ can be interpreted as the minimum required pre-tax rate of return, for which the investment is marginal (Devereux, Griffith, and Klemm, 2002). This means that $\hat{p}$ is equivalent to the (post-tax) rate of return on an alternative investment, also known as the *user cost of capital* (Auerbach, 1979).[6] For this paper, we abstract from inflation (i.e. $\pi = 0$) and suggest the following user cost of capital

$$\hat{p} = \frac{(1-\tau A)\cdot(\rho+\sigma)}{(1-\tau)} - \sigma \tag{3}$$

It becomes evident that, in the absence of taxation, the user cost of capital is just equal to the nominal interest rate. This suggests a *tax wedge*, i.e., the difference between the required pre-tax rate of return and the interest rate, equal to $\hat{p}-\rho$. The $EMTR$ is then defined as the ratio of this tax wedge and the user cost of capital:

$$EMTR = \frac{\hat{p}-\rho}{\hat{p}} = \frac{(1-A)\cdot\tau(\rho+\sigma)}{(1-\tau A)\cdot\rho+(1-A)\cdot\tau\sigma} \tag{4}$$

[2] We are aware of the fact that this is a fairly strong assumption. To capture incentive effects, however, forward-looking measures are to be preferred to backward-looking measures, which are based on firms' operating profits and tax payments stated in the balance sheet. First, backward-looking rates do not comply with the forward-looking nature of investment decisions (Egger, Loretz, Pfaffermayr, and Winner, 2009b). Second, the amount of taxes paid is strongly affected by tax-planning activities, making backward-looking measures prone to severe endogeneity issues (Fabling, Gemmell, Kneller, and Sanderson, 2014).

[3] For a detailed overview on how A is calculated, consider the Appendix A.1.

[4] We abstract from taxation at the shareholder level, and therefore ignore personal income taxes.

[5] The discount rate is defined as a weighted average of the rates applicable to equity- and debt-financed investment, respectively (see below).

[6] This result, derived from a neoclassical investment model, is equivalent to the results obtained by Devereux, Griffith, and Klemm (2002) and Egger, Loretz, Pfaffermayr, and Winner (2009b) in a cash-flow focused framework.

Note that in a cash flow tax model, which has partially been realized in the US tax reform by allowing for immediate deduction of all investment expenses for some investments, we would have $A = 1$. As a consequence, the user cost $\hat{p}$ would be equivalent to the discount rate ρ and the $EMTR$ would be zero.

While the $EMTR$ is the relevant measure when considering *marginal* investment projects, an $EATR$ is the essential criterion for an investment decision at the extensive margin. It serves as a measure of the effective tax burden of all infra-marginal (*average*) units of capital invested.[7] To be more precise, the $EATR$ is calculated as the difference between the pre-tax NPV (R^*) and the post-tax NPV (R) of the investment for a given pre-tax rate of return p (Devereux and Griffith, 1998):[8]

$$EATR = \frac{R^* - R}{p/(1+\rho)} = \frac{\tau\big(p + \sigma(1+A) - \rho A\big)}{p} \tag{5}$$

In the following, we abstract from economic depreciation and set $\sigma = 0$.[9] We are aware that the assumption of no economic depreciation across all countries is strong. However, we expect that tax depreciation allowance rates (which strongly vary across asset categories) to a large extent capture the economic life of the respective asset type.

Moreover, the variation in depreciation allowances across asset types are reflected in ETRs, which we calculate as weighted averages. The crucial point is that the rates of fiscal depreciation vary not only between asset types, but also across the 142 countries in our sample. In contrast to this, economic depreciation rates are typically assumed to be fixed across countries and time. In this sense, asset-specific economic depreciation rates do not add additional information to the variation in the ETRs. We therefore believe that assuming positive values for σ does not improve the way we calculate ETRs, which we want predominantly to reflect national corporate tax regimes.

2.2 Parameterization

In order to calculate an $EMTR$ and an $EATR$ for a large number of countries, we need to make several assumptions with respect to (i) financing options, (ii) the asset composition within firms, (iii) the discount rate ρ, and (iv) the pre-tax rate of return.[10] While these parameters are assumed to be common across firms in all countries in the first place, we relax some of these assumptions (financing options and asset composition) below when constructing *firm-industry-level* $EMTR$ and $EATR$ measures.

[7] Note that, for a marginal investment, the $EATR$ is equal to the $EMTR$. The $EATR$ can hence be interpreted in a way that it summarizes the distribution of tax rates for an investment as long as the latter is profitable, and the $EMTR$ represents the special case of a marginal investment (Devereux and Griffith, 1998).

[8] See the Appendix A.3, for more details on R and R^*.

[9] ETR measures employing different values for economic depreciation are included in Appendix A.4.

[10] We make the assumption of a common 'market interest rate' due to (broadly) two reasons. First, a meaningful measure in this regard is not available, also given the fact that many (multinational) firms finance investments partly via internal capital markets (Desai, Foley, and Hines, 2004), and it is unclear which interest rates apply to such internal capital. Second, it is not our focus to analyze the effect of variations in interest rates across countries.

Table 1: Parameter values

Parameter		Value assigned
ρ	Market interest rate	0.05 (for equity) $0.05 \cdot (1-\tau)$ (for debt)
π	Inflation rate	0
σ	Economic depreciation rate	0
p	Pre-tax rate of return	0.2
debt	Debt-financing share	1/3
equity	Equity-financing share	2/3
Asset structure:		
s_b	Share of investment in buildings	0.38
s_{inv}	Share of investment in inventory	0.26
s_m	Share of investment in machinery	0.2
s_{ifas}	Share of investment in intangibles	0.11
s_c	Share of investment in computer equipment	0.02
s_v	Share of investment in vehicles	0.02
s_o	Share of investment in office equipment	0.01

Notes: More information on variable definitions and sources is provided in Table A.3

Table 1 depicts the parameter values we assume, most of them in line with previous work (OECD, 1991; Devereux and Griffith, 1998; McKenzie, Mansour, and Brûlé, 1998; Devereux, Griffith, and Klemm, 2002; Devereux and Griffith, 2003; Yoo, 2003; Egger, Loretz, Pfaffermayr, and Winner, 2009b; Fabling, Gemmell, Kneller, and Sanderson, 2014). With respect to the financing methods, we merely make the broad distinction between debt and retained earnings, rather than considering retained earnings and new equity as distinct modes of financing. This is, however, fully consistent because we ignore shareholder taxation. Egger, Loretz, Pfaffermayr, and Winner (2009b) argue that, in this case, financing via retained earnings is identical to financing via new equity. Moreover, note that debt financing implies a reduced discount rate, as to the fact that the cost of debt financing is tax-deductible. The composition of assets within a firm is crucial when it comes to computing the NPV of tax depreciation allowances as allowance rates and schedules vary widely, both across asset types and countries. We follow OECD (1991) in large parts, but adjust their suggested asset composition to also include the asset types *Computers*, *Vehicles*, and *Office equipment*.

3 Data collection

For our calculation of effective tax measures, we have compiled data on corporate tax regimes of 193 countries for the time period from 1996 to 2016. This section provides an overview on the data and their sources, obstacles and problems, as well as important assumptions made to warrant a comprehensive and reliable database.

The two key statutory variables for our analysis are the statutory corporate income tax rate and the depreciation allowance rate, including schemes for six asset categories (*Buildings*, *Machinery*, *Office equipment*, *Computers*, *Intangible fixed assets*, and *Vehicles*). The *EY Worldwide Corporate Tax Guides (WCTG)* serve as primary data source. These annual tax guides provide detailed information on the corporate tax regimes of 162 jurisdictions.[11] In spite of considering multiple sources, data coverage strongly varies across countries. The data on statutory corporate income taxes exhibit the best coverage with reliable and complete

[11] When the information from the *WCTG* is insufficient or counterintuitive, additional sources are considered, including the *OECD*, *IBFD* and *World Bank* databases as well as tax guides provided by *PwC* and *KPMG*.

information for 178 countries and all years from 1996 to 2016. Since *WCTG* only provides country-level statutory corporate income tax rates, the reported rates for countries imposing federal- and state-level taxes may be inaccurate. In order to account for regional taxes, we retrieve data for the respective jurisdictions from the *OECD* and *World Bank* databases.[12]

In addition to the statutory tax rates, information on tax depreciation allowances constitutes the second main data compiled from *WCTG*. In this regard, reliable data covering many countries is only available starting from 2004, which is the reason why we calculate our effective tax measures for the years 2004 to 2016. Data coverage varies both across countries and with respect to depreciation regulations for the different asset types. More specifically, information in *WCTG* is most comprehensive for *Buildings*, *Machinery* and *Vehicles*, while the (initial) data coverage for *Computers*, *Office equipment* and *Intangible fixed assets* is somewhat fragmentary.[13]

In order to obtain a balanced panel for a broad and possibly comprehensive analysis of effective tax measures, we make several assumptions which are briefly outlined in the following. Two problems have been frequently encountered: First, no specific rates apply but a *'useful life'* should be assumed for the depreciation of assets. Second, depreciation rates may not be available for all asset types within a country. Concerning the *'useful life'* principle, we follow previous approaches (e.g., Spengel, Endres, Nicolay, Heckemeyer, Bartholmess, Bräutigam, Braun, Pfeiffer, Evers, Harendt, Streif, Todtenhaupt, and Halter (2017)), and assume the useful life of *Machinery* to be 7 years and the useful life of *Intangible fixed assets* to be 10 years.[14] Moreover, for both asset types, a straight line depreciation method is assumed to apply. Concerning the problem of missing rates for some asset types, we resort to the assumption that depreciation patterns are equal to the ones of similar asset categories, for which information is available. For instance, if no rates for *Office equipment* are specified, we assume the depreciation rates of *Office equipment* to equal the ones of *Machinery*. Similarly, *Computers* is assumed to be part of *Office equipment* whenever rates are not specified. When no rates for *Vehicles* are provided, we also assume *Vehicles* to depreciate like *Machinery*.

Nonetheless, we have to disregard 15 countries, for which information is insufficient. In many cases, this is related to political reasons: some countries have dissolved during the considered time period, e.g., the Netherlands Antilles or Yugoslavia, other countries face violent interior or exterior conflicts, such as Syria or Afghanistan.

4 Taxes around the world

The purpose of this section is to survey the three types of forward-looking tax measures we have collected, first at the country level (Section 4.1), then at the firm-industry level (Section 4.2).[15] The first tax measure we will present is the statutory tax rate (STR) on corporate profits. We have collected data on $STRs$ for 178 countries and over the time period from 1996 to 2016. The second measure includes information on countries' depreciation rules to account for tax base effects. In particular, we calculate the NPV of depreciation allowances and measure an effective marginal tax rate ($EMTR$). The $EMTR$ captures the tax burden on a *marginal* investment project that just breaks even. We further present measures on an effective average tax rate ($EATR$), which captures the *average* tax burden of a hypothetical investment project. The average tax burden considers that the total project may earn above-normal returns and is therefore the relevant incentive variable for discrete decisions of firms, such as location choices. $EMTRs$ as well as $EATRs$ are presented for a sample of 142

[12] Most notably, these countries include Germany, Switzerland, Japan, USA, and Canada.

[13] Concerning the allowances for buildings, we always choose the available rate for industrial buildings. Furthermore, we have treated *Furniture* to be representative for *Office equipment* if not specified differently.

[14] As data coverage for *Intangible fixed assets* is particularly poor, we assume a straight line depreciation scheme for a period of 10 years whenever no information is specified for this asset type, yet data on all other types is available.

[15] A precise definition of what we mean with *firm-industry level* is given below.

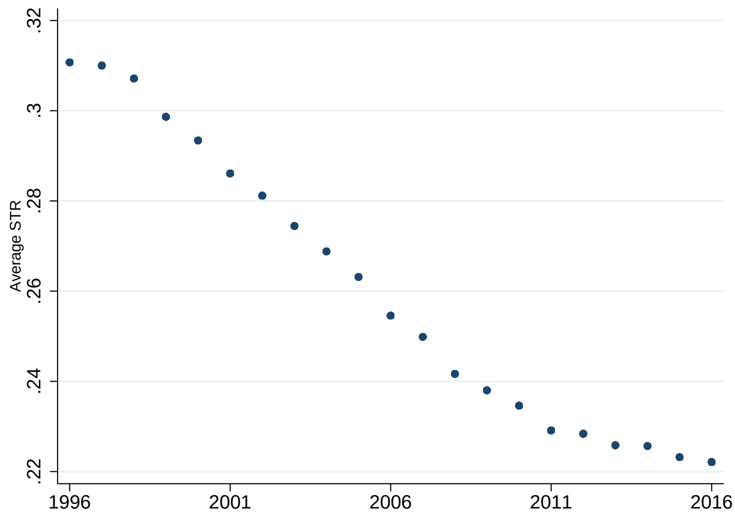
countries and over the time period 2004 to 2016. Both $EMTRs$ and $EATRs$ are calculated following the theoretical approach discussed in Section 2.

4.1 Country-level tax measures

4.1.1 Statutory tax rates

Devereux, Griffith, and Klemm (2002) demonstrate that there is a clear downward trend when depicting the yearly average of the statutory tax rate (STR) throughout the 1980s and 1990s. For our sample of 178 countries and 21 years, Figure 1 confirms this long-run pattern for the STR.

Figure 1: Statutory tax rates



While it appears that this process has slowed down and the average STR converges to a lower level of roughly 22%, between the years 1996 and 2016, 141 countries have cut their $STRs$, only 22 have increased it, and 15 countries have kept it constant. The reduction in the average STR between 1998 and 2011 is particularly evident (7.8 percentage points), compared to the 0.7 percentage points from 2011 to 2016.[16] In any case, after the massive US corporate tax cut in 2018, we expect the general downward trend in the STR to continue.

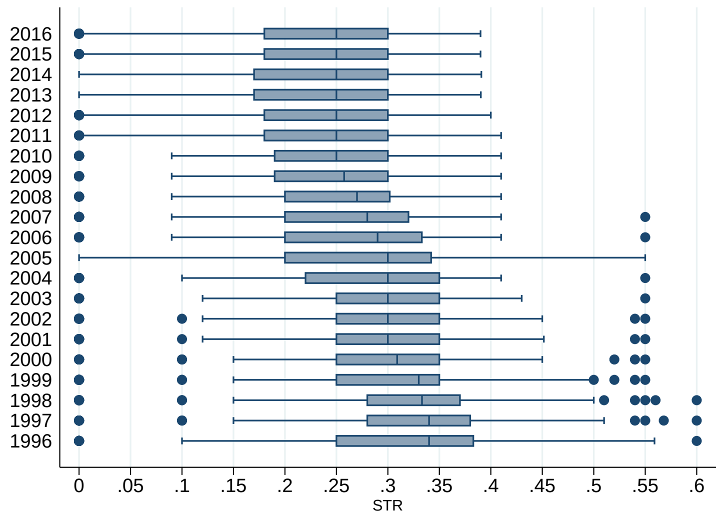
Figure 2 suggests that the distribution of the $STRs$ has shifted to the left. Very high values of the STR have disappeared over time. An interesting observation is that, from 2009 on, the median value is virtually unchanged. Very few countries have imposed $STRs$ of more than 40%. Many larger economies have implemented $STRs$ above the global time-average value of 26.09%, for example, France, Germany, Japan, and Canada in the late 1990s.[17] In 2011, only Japan and Puerto Rico sustained rates above 40%; in 2016, only the United States, Puerto Rico, and the U.S. Virgin Islands imposed rates around 40%.

In Figure 3, we provide an alternative way of illustrating the distribution of the $STRs$ over time, depicting a non-parametric conditional density. In line with the observation that the distribution has shifted, the most frequent STR values have decreased from around 35% in 1996 to about 25% in 2016. Moreover, it becomes evident that, in recent years, there is a larger probability density at the left side of the distribution. Most importantly, this implies that an increasing number of countries exhibit relatively low $STRs$. The figure also shows

[16] Note that we have collected data on $STRs$ from 1996 to 2016. Although the focus of this survey is on effective tax measures, which have been collected for the time period 2004 to 2016 – for reasons of data availability –, we present the $STRs$ for the extended period of time to additionally show a more long-run development which can be compared to previous studies (Devereux, Griffith, and Klemm, 2002; Loretz, 2008).

[17] Note that the German STR accounts for the (average) local (municipality) business tax.

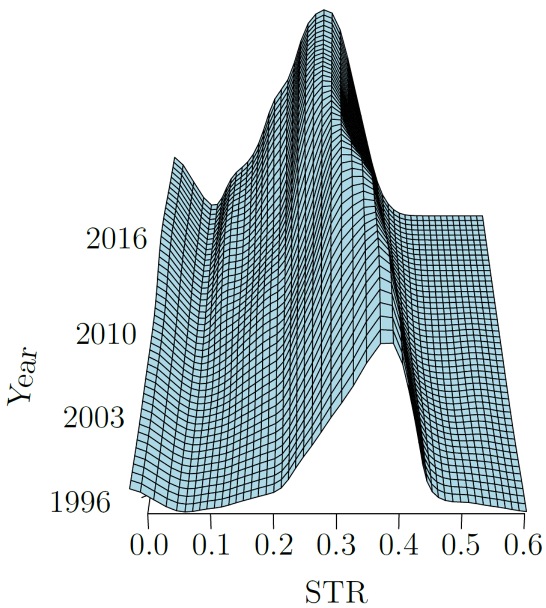
Figure 2: Statutory tax rates



Notes: The box portrays the interquartile range (IQR) of the STR distribution. The vertical line in the box represents the median. The whisker's range includes the most extreme values within the 1.5 × IQR. The dots indicate extreme values outside of the 1.5 × IQR.

that a non-negligible share of countries do not tax corporate income at all, i.e., the STR is equal to 0.

Figure 3: Statutory tax rates (non-parametric conditional density)



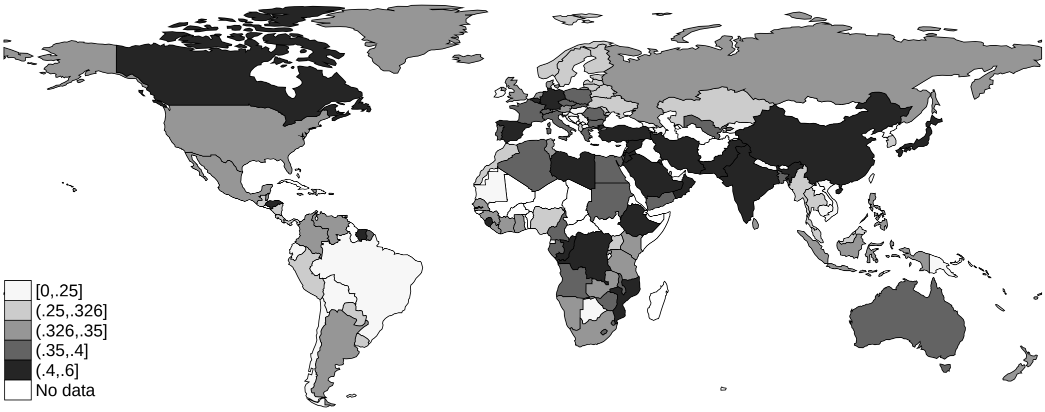
Notes: For the above illustration, we choose a bandwidth of the kernel according to Silverman's rule of thumb, the underlying density being Gaussian (Silverman, 1986).

In addition to the development and distribution of the tax over time, it is worthwhile to shed light on the STR variation across countries. Our data shows that there is substantial variation across countries, indicating that the tax-setting behavior of countries vastly differs.[18]

[18]In Figure 18 in Appendix A.5, for each country, we pool the annual $STRs$ over the period from 1996 to 2016 and subtract the global average STR (26.09%) from each country's time average.

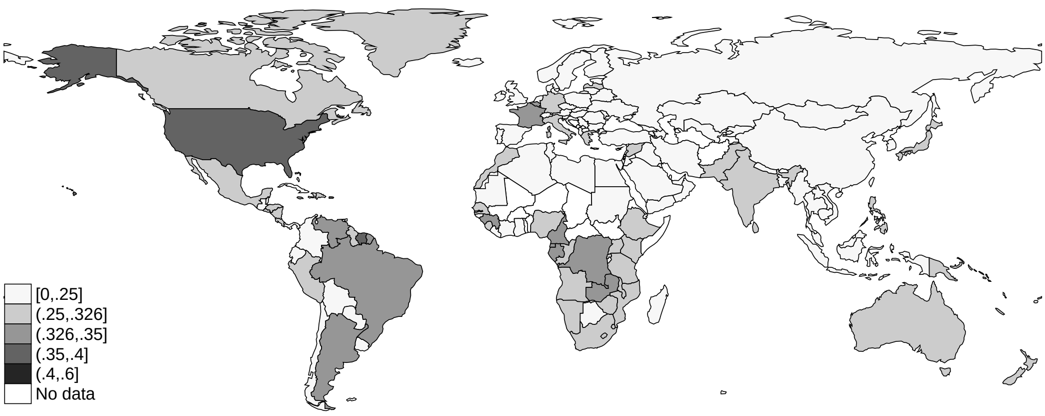
An interesting insight is revealed when we compare the tax rate distribution across countries at the beginning of the sample period (1996) with the one at the end of the sample period (2016). In this regard, Figure 4 and Figure 5 indicate that the vast majority of countries have reduced their *STR*, whilst the US and several South American countries have maintained a comparatively high *STR*.

Figure 4: Statutory taxes across countries (1996)



Notes: The darker in color a country's area, the higher is the *STR*.

Figure 5: Statutory taxes across countries (2016)



Notes: The darker in color the country's area, the higher is the *STR*

4.1.2 NPV of depreciation allowances

Since depreciation rules are the second major factor influencing *ETRs*, we will first provide information on the *NPVs* of depreciation allowances for 142 countries over the time period 2004 to 2016. A higher *NPV* of depreciation allowances implies a reduction in taxable income (tax base) and therefore leads to a lower effective tax burden. The values presented in Figure 6 are calculated following the method established in Egger and Loretz (2010).[19] Devereux, Griffith, and Klemm (2002) have identified a pattern of *base-broadening* throughout the 1980s and 1990s. According to Figure 6, it seems that the more recent cuts in *STRs* in the 2000s

[19]See the Appendix A.1 for more information.

have also been accompanied by less generous depreciation rules. However, particularly since 2009, there appears to be some convergence to a value of about 0.482.

Figure 6: NPV of tax depreciation allowances

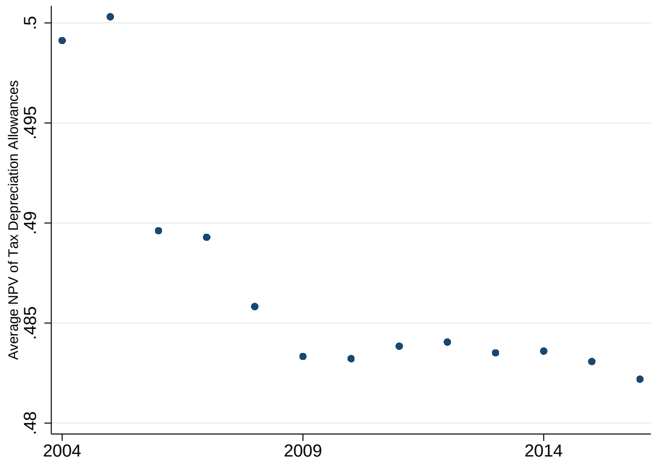
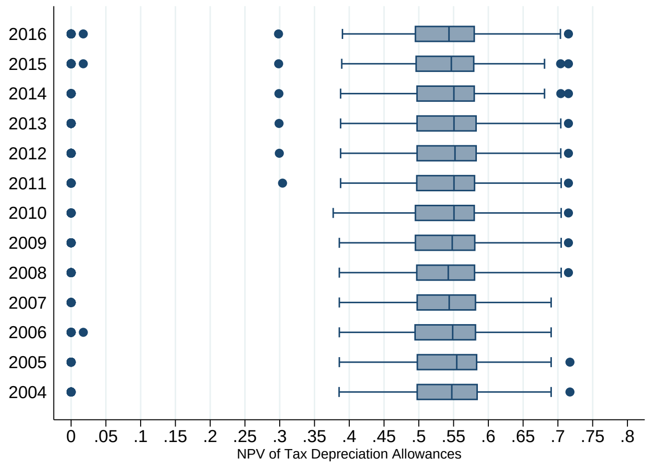


Figure 7: NPV of tax depreciation allowances



Notes: The box portrays the interquartile range (IQR) of the NPV distribution. The vertical line in the box represents the median. The whisker's range includes the most extreme values within the 1.5 × IQR. The dots indicate extreme values outside of the 1.5 × IQR.

The largest changes in the NPV happened between 2005 and 2006 (0.011) as well as between 2007 and 2008 (0.0035). The average NPV has dropped by roughly 0.017 from 2004 to 2016. Over the 13 years covered in our data, the NPV of depreciation allowances has decreased in 70 countries, increased in 41 and has not changed in 31.

Concerning the distribution of the $NPVs$, illustrated in Figure 7, we see that the median NPV has not shifted to the left but remained relatively stable. Moreover, our data suggest that also the whisker's range, i.e., the distance between the 1.5 × interquartile range, and also the most extreme values outside of this range do not change significantly.

To conclude, while earlier contributions have observed tax-cut-cum-base-broadening, in particular for the 1980s and 1990s, our findings indicate that no clear base-broadening trend can be identified for the last 13 years.

4.1.3 Effective marginal tax rates

This section presents our data on $EMTRs$. The $EMTR$, as outlined in Section 2, is a measure to quantify the corporate tax burden for a marginal investment, which just earns the cost of capital. All calculations concerning the $EMTR$ follow the theoretical model introduced above.

We have demonstrated that between the years 1996 (2004) and 2016, tax policy is, on the one hand, characterized by substantial corporate tax cuts; on the other hand, no distinct base-broadening pattern can be observed. While Devereux, Griffith, and Klemm (2002) do not identify any clear trend when analyzing $EMTRs$ – although they find a tendency for falling rates in the late 1990s –, Figure 8 suggests that the average $EMTR$ has substantially declined between 2004 and 2011, but has then remained rather stable in the years until 2016.

Figure 8: Effective marginal tax rates

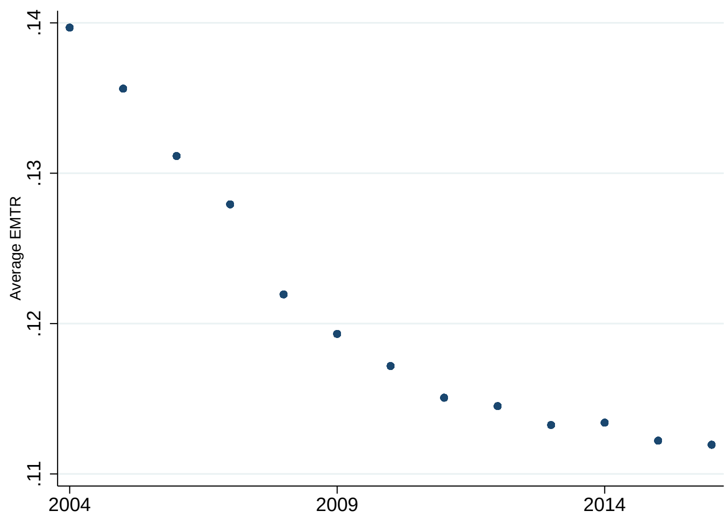
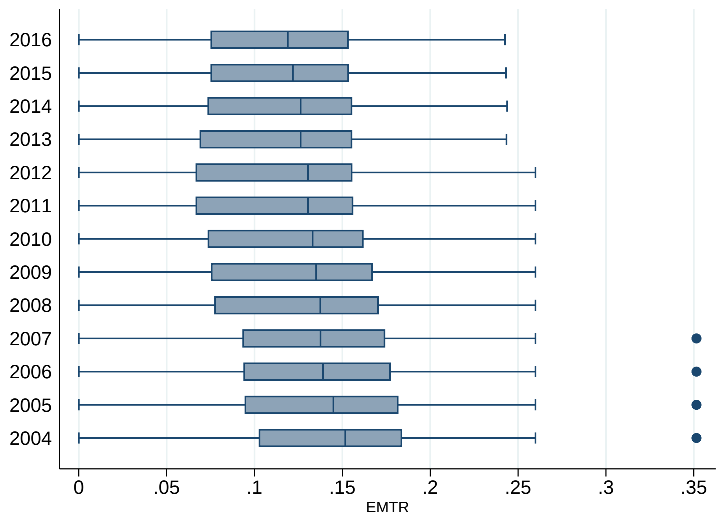


Figure 9: Effective marginal tax rates



Notes: The box portrays the interquartile range (IQR) of the EMTR distribution. The vertical line in the box represents the median. The whisker's range includes the most extreme values within the 1.5 × IQR. The dots indicate extreme values outside of the 1.5 × IQR.

Over the whole time period, i.e., from 2004 to 2016, the average $EMTR$ has dropped from roughly 13.97% to 11.19%. In 98 countries, the $EMTR$ has decreased, it has increased in 13 countries and has not changed in 31 countries between 2004 and 2016. While there is a positive increase from 2013 to 2014, it is a relatively small one (0.00015 percentage points). Figure 9 demonstrates that the downward trend in Figure 8 is not only driven by the disappearance of extreme values, but also by a shift of the whole distribution.

To sum up, given the findings of the previous sections, we can conclude that cutting taxes outweighs the effect of a somewhat broader tax base, so that the average $EMTR$ has been declining for most of the time. Figure 8 suggests that the average value has converged to a level of approximately 11.2%.

4.1.4 Effective average tax rates

This section focuses on the measure of the average tax burden, the effective average tax rate ($EATR$) for the years 2004 until 2016. As explained in Section 2, the $EATR$ is a more appropriate measure for discrete or extensive-margin investment decisions. We calculate it according to equation (5) above.

Devereux, Griffith, and Klemm (2002) have demonstrated that the average $EATR$ has mostly decreased in the 1980s and 1990s. Figure 10 suggests that this trend has continued for the years from 2004 to 2016. In particular, the $EATR$ has decreased by 3.94 percentage points from 22.3% in 2004 to 18.36% in 2016. It seems that it has stabilized at a value of below 18.5% since 2011. Over the whole time span, the $EATR$ has decreased in 98 countries, increased in 13 and has not changed in 31 countries. Similar to the $EMTR$, the decrease in the average value happened at a relatively fast pace between 2004 and 2011. Thereafter, however, the $EATR$ remains at a rather constant level.

Figure 10: Effective average tax rates

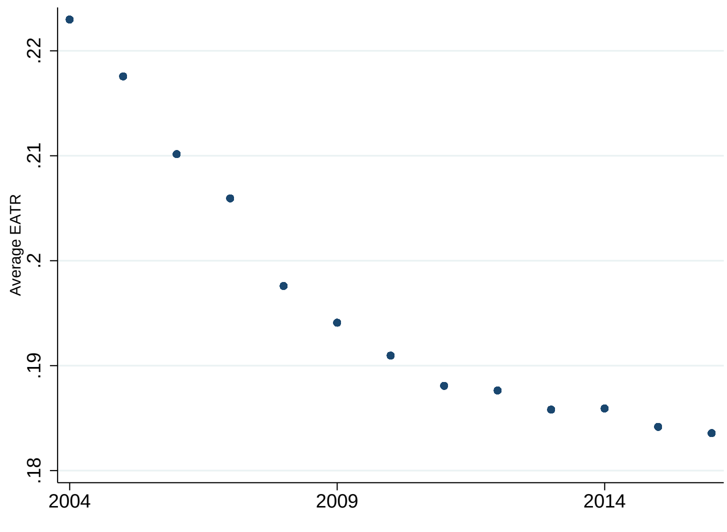
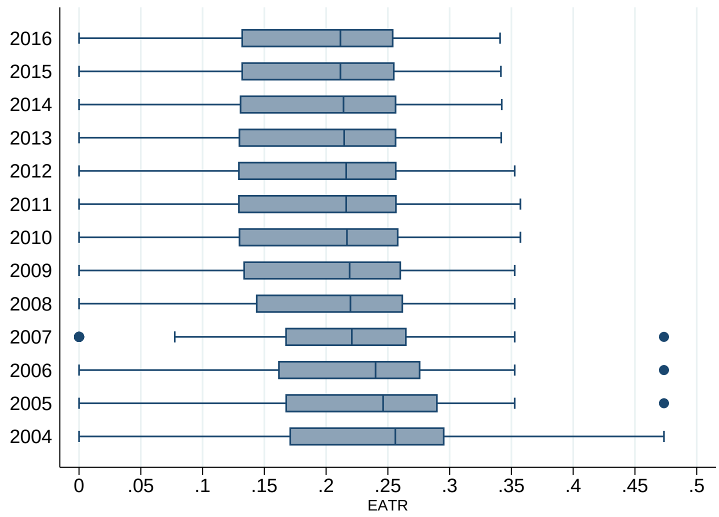


Figure 11 depicts the same pattern as the figures for the STR and the $EMTR$. Extreme values (e.g., Kuwait) have disappeared over time; the median value has slightly shifted to the left; the variance has declined.

Figure 11: Effective average tax rates



Notes: The box portrays the interquartile range (IQR) of the EMTR distribution. The vertical line in the box represents the median. The whisker's range includes the most extreme values within the 1.5 × IQR. The dots indicate extreme values outside of the 1.5 × IQR.

4.2 Firm-industry-level tax measures

The conceptual framework presented in Section 2 has shown that the forward-looking effective tax measures are non-linear functions of numerous determinants, most notably (i) statutory tax rates, (ii) depreciation allowances specific to the type of investment, (iii) asset composition, and (iv) modes of financing (Egger and Loretz, 2010). While statutory corporate tax rates are country specific (abstracting from the distinction between state, federal and local taxes), the asset composition of an investment as well as the share of debt financing are naturally specific to the individual firm. In this section, we show how the country-level statutory tax rates can be combined with firm- and industry-specific data in order to yield firm-industry-level tax measures. The latter may be particularly useful when analyzing behavioral incentives at the micro level, such as firms' investment decisions (see Section 5.2).

In the preceding analysis of *country-specific* effective tax measures, we have assumed a given set of asset types (*Buildings*, *Machinery*, *Office equipment*, *Computers*, *Intangible fixed assets*, and *Vehicles*) and financing opportunities (Debt and Equity) to calculate $EMTR$ and $EATR$ as weighted averages over these investment and financing opportunities (Egger, Loretz, Pfaffermayr, and Winner, 2009b). In line with most of the existing literature referred to above, the weights we employ are defined as identical across all countries. However, to the extent that asset composition and the shares of debt-financed investment vary considerably across firms, effective tax measures at the country level may be inaccurate. Disregarding the heterogeneous nature of firms with respect to their investment and financing opportunities implies that tax measures based on uniform weights may not capture the correct incentive effects for future decisions. In a sense, we would neglect that firms are in different situations, reflecting choices made in the past (Egger and Loretz, 2010). We therefore combine the collected (country-level) data on statutory taxes and depreciation allowances with micro-level data for a large sample of firms, provided in Bureau van Dijk's *Orbis* database.[20]

In the country-level analysis (Section 4), assumptions on debt-financing shares and asset composition necessarily have to be made. With respect to the first point, exploiting balance-sheet data allows us to get firm-specific information in this regard. More specifically, we

[20] *Orbis* is a commercial database, providing comprehensive balance-sheet data for firms from across the globe. In particular, we make use of 17,024,351 firm observations for the time period 2004 to 2014.

calculate a firm's long-term debt (non-current liabilities) ratio, i.e., long-term debt relative to total assets.[21] When it comes to the composition of a firm's capital stock, the *Orbis* database does not report firm-specific asset-type distributions. Similar to Egger, Loretz, Pfaffermayr, and Winner (2009b), however, we exploit variation at the industry-level to account for heterogeneous asset composition. We do so by using industry-specific asset-type shares provided by Fabling, Gemmell, Kneller, and Sanderson (2014), matching their industry codes with the ones available in *Orbis*.[22]

Based on the asset composition specific to industry i and the firm-j-specific debt-equity ratio, we then calculate effective tax measures at the firm-industry level ($EMTR_{jict}$ and $EATR_{jict}$, respectively). To this end, we consider the 17,024,351 firm observations in our *Orbis* sample and compute average $ETRs$ for every industry i in country c and year t.

Table 2: Firm-industry-level effective taxes, pooled over time (2004-2014)

Industry	Firm observations	EMTR	EATR
Accommodation and Food Services	228,124	0.1401	0.2577
Agriculture, Forestry, Fishing	514,975	0.1293	0.2303
Information Media and Telecommunication	71,455	0.1277	0.2433
Construction	2,334,641	0.1388	0.2828
Cultural and Recreational Services	180,568	0.1410	0.2615
Electricity, Gas, Water, Waste Services	351,376	0.1287	0.2487
Education and Training	105,443	0.1392	0.2518
Financial and Insurance Services	1,636,346	0.1336	0.2661
Health Care and Social Assistance	386,035	0.1434	0.2792
Manufacturing	4,581,178	0.1325	0.2504
Mining	145,685	0.1373	0.2467
Other Services	99,588	0.1435	0.2619
Rental, Hiring and Real Estate Services	1,706,884	0.1409	0.2631
Retail Trade	1,411,142	0.1398	0.2614
Transport, Postal, Warehousing	796,796	0.1313	0.2563
Wholesale Trade	2,474,115	0.1342	0.2555

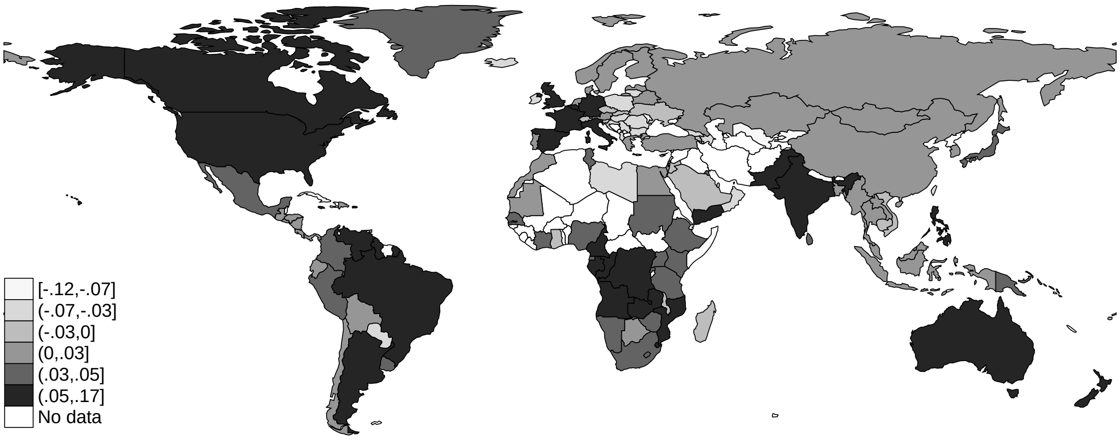
Notes: We use two-digit *ANZSIC96* industry codes to determine industry-specific asset compositions. Firm-specific debt and equity shares are taken from *Orbis*. For all industries, we pool firm observations over the years 2004-2014 and calculate average firm-industry-level ETRs.

Table 2 presents industry-specific average $ETRs$, pooling all observations from 2004 to 2014. We see that there is substantial variation across industries. For the $EMTR$, we observe values between 12.77% and 14.35%, values of the $EATR$ lie in the range of 23,03% and 28,28%. While the (pooled) industry-specific $EMTRs$ are only slightly larger than the average $EMTRs$ at the country level (12,32%), it becomes evident that the industry-specific $EATRs$ are much higher than their country-level counterpart, calculated in Section 4.1.4 (19,96%). A straightforward explanation for this is that the firm-specific long-term debt ratio, which is our measure for the share of debt financing, is on average substantially lower than before, where we assume a share of 1/3. This, in turn, leads to a higher weighted market interest rate and a ceteris paribus higher $EATR$. A further source of variation lies in the industry-specific capital stock composition. As depreciation allowances for asset types vary considerably, this may either increase or decrease the $EATR$.

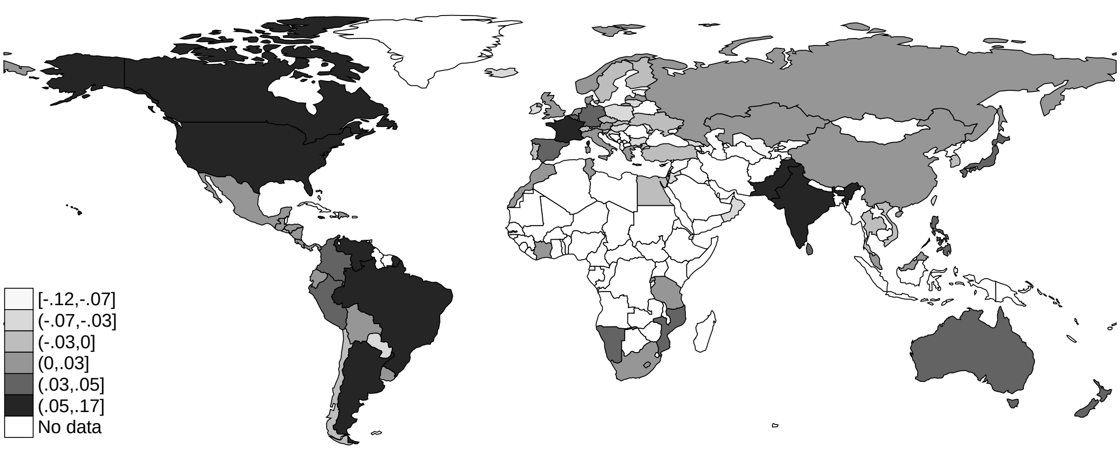
[21] In contrast to Egger and Loretz (2010), who employ the sum of non-current and current liabilities, we think that long-term debt is the relevant measure to be considered in terms of a firm's investment opportunity. Only non-current liabilities can be harnessed to finance investment projects. The long-term debt-to-total assets ratio, of course, underestimates a firm's (total) debt ratio, yet seems to be more accurate in the given context.

[22] Fabling, Gemmell, Kneller, and Sanderson (2014) use data from Statistics New Zealand's Longitudinal Business Database, which combines administrative and survey data on New Zealand firms and provide the asset-type shares based on two-digit *ANZSIC96* codes. The latter are very closely related to the commonly used *ISIC* codes.

Figure 12: $EMTRs$ across countries – Country vs. firm-industry-level



a) Country level

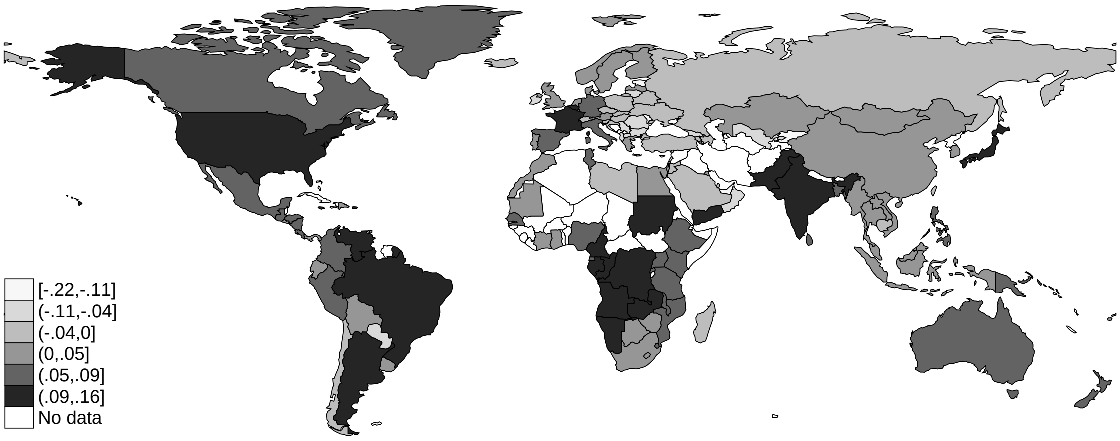


b) Firm-industry level

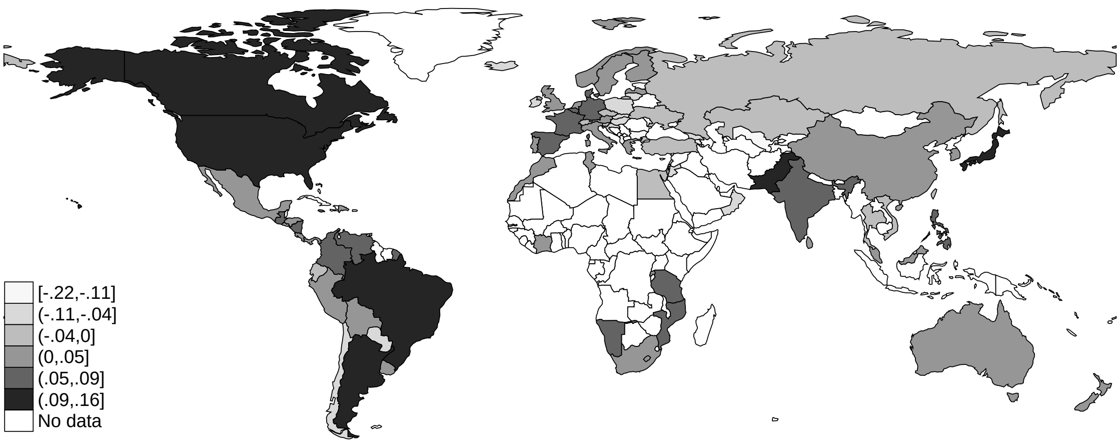
Notes: The darker in color a country's area, the higher the respective country's $EMTR$.

In Figures 12 and 13, we compare the country-level effective tax measures with the firm-industry-level ETRs. For both figures, we pool the ETRs for each country and depict the time average, demeaned by the global mean over the whole sample period. Considering the $EMTR$, we see that countries like Canada, France, and India tend to exhibit taxes exceeding the average more distinctly than in the country-level analysis. In contrast, the UK, Italy, Portugal, Sweden, and Finland seem to decrease $EMTRs$ compared to the average $EMTR$. Turning to the $EATR$, only for very few countries (Canada and Brasil), taxes in relation to the average become higher when we exploit variation at the firm-industry level. Numerous countries both in Europe (France, Poland, Slovakia, and Hungary), South America (Venezuela, Peru, Chile) and Australia exhibit lower firm-industry $EATRs$ than country-level $EATRs$ (compared to the respective world average).

Figure 13: *EATRs* across countries – Country vs. firm-industry-level



a) Country level



b) Firm-industry level

Notes: The darker in color a country's area, the higher the respective country's *EATR*.

5 Two applications

5.1 Laffer-Curve estimates

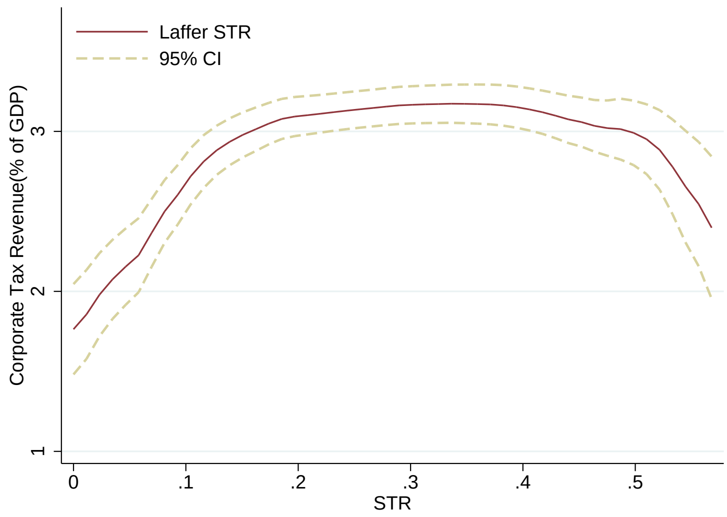
The objective of this section is to estimate whether corporate income tax revenue (expressed relative to GDP) and statutory tax incentives are related in a way known as the Laffer-Curve.[23] The latter is supposed to show an inverted-U-shape as depicted in Figure 14, where we present the smoothed values of a kernel-weighted local polynomial regression of tax revenue on the statutory tax rate for the period between 1996 and 2014.[24]

The concept of the Laffer-Curve reflects the insight that tax revenue is determined by

[23] Arthur Laffer, economist and member of Reagan's Economic Policy Advisory Board (1981 to 1989), became famous for making the argument that the relationship between tax revenue and statutory tax incentives is such that a tax rate between 0% and 100% maximizes tax revenue. Piketty and Saez (2013) argue that economists have known the idea of the inverted-U-shaped revenue curve long before, early contributions going back more than 170 years (e.g., Dupuit (1844)). Loretz (2008) alike discusses the historical background of the concept, stating that its origin dates back as far as the 14th century.

[24] Note that more recent tax revenue data have not been made available.

Figure 14: Non-parametric Laffer-Curve (STR)



statutory rate and tax base, where the latter is not a fixed quantity but rather an endogenous outcome of tax avoidance activities. Economists would broadly agree on the existence of the concept and the associated notion of the presence of a statutory tax rate that maximizes tax revenue. At which exact point (or tax rate), however, the slope of the revenue function becomes negative depends on the extent of behavioral responses of firms and individuals to a tax and the specific design of the tax under consideration.

Comprehensive empirical investigations in this regard are surprisingly scarce.[25] Clausing (2007) provides empirical support for a parabolic Laffer-Curve relationship between statutory tax rates and revenues for OECD countries and the years 1979 to 2002.[26] In contrast to this, Kawano and Slemrod (2012), who likewise focus on OECD countries, find that the relationship between tax rates and revenue is rather tenuous.

In the following, we will illustrate how corporate income tax revenue as percent of GDP ($TAX\ REVENUE$) is related to our measures of tax burden (STR, $EMTR$ and $EATR$). The data for the corporate income tax revenue are taken from the IMF's World Revenue Longitudinal Data (WoRLD). The analysis is based on 1,073 observations from 2004 to 2014 and 112 countries. To the best of our knowledge, no previous study has examined such a large sample of countries in this context. Our estimation approach accounts for time-constant country-specific characteristics and aggregate year effects. To control for time-varying determinants of tax revenue, we also include the variable $GROWTH_{ct}$.[27] In particular, we estimate the following linear regression model:

$$TAX\ REVENUE_{ct} = \alpha + \beta_1 TAX_{ct} + \beta_2 TAX_{ct}^2 + \beta_3 GROWTH_{ct} + Y_t + C_c + \epsilon_{ct}.$$

The variable TAX_{ct} is one of our measures of tax burden (STR, $EMTR$, or $EATR$). Y_t and C_c are year and country effects. The Laffer-Curve concept would suggest that TAX_{ct} and TAX_{ct}^2 predict an inverted U-shape relationship with $TAX\ REVENUE_{ct}$.

[25]Most of the previous contributions to the literature have either (i) focused on trends in corporate income tax revenue, without providing a thorough analysis of the sources of the observed variations (Bènassy-Quéré, Fontagné, Lahrèche-Révil, et al., 2000; Gropp and Kostial, 2000; Devereux, Griffith, and Klemm, 2002, 2004; Loretz, 2008), or (ii) calculated country-specific Laffer-Curves (Trabandt and Uhlig, 2011; Strulik and Trimborn, 2012).

[26]Very broadly, our paper and Clausing (2007) differ in terms of the following aspects: the observed time periods (1979-2002 vs. 2004-2016), the sample (29 OECD countries vs. 112 countries from all over the world), and the empirical approach.

[27]$GROWTH_{ct}$ is taken from the World Bank's World Development Indicators (WDI) database and is defined as GDP growth per capita.

Table 3: Laffer-Curve estimates (OLS regressions)

	STR	*EMTR*	*EATR*
TAX_{ct}	9.801***	13.589**	11.309***
	(3.722)	(5.828)	(4.318)
TAX^2_{ct}	-15.695**	-39.764**	-21.239**
	(6.785)	(17.715)	(9.127)
$GROWTH_{ct}$	0.056***	0.056***	0.056***
	(0.011)	(0.011)	(0.011)
Constant	1.295**	1.663***	1.318**
	(0.535)	(0.484)	(0.535)
Year effects	Yes	Yes	Yes
Country effects	Yes	Yes	Yes
Observations	1,073	1,073	1,073
$Adj.\ R-squared$	0.8587	0.8584	0.8587
$Within\ R-squared$	0.100	0.098	0.099

Standard errors in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

The estimation results presented in Table 3 suggest that $GROWTH$ is always positively related to tax revenue, as expected. TAX and TAX^2 (or the respective measures thereof, to be precise) are always estimated with a positive (TAX) and negative (TAX^2) sign.[28]

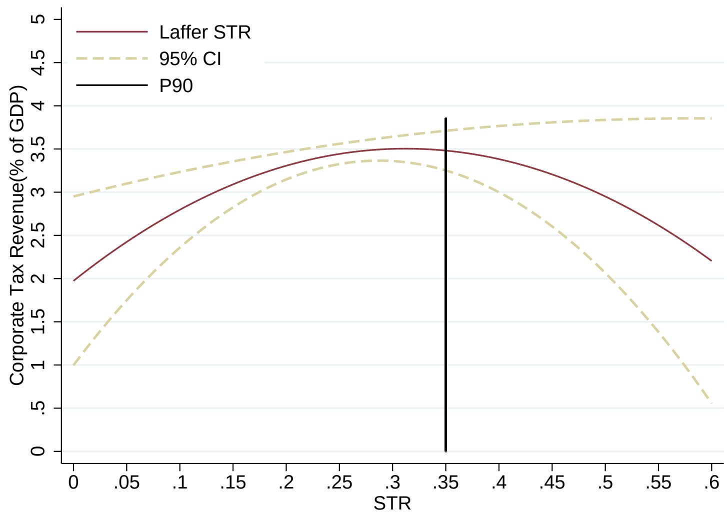
Table 4: Laffer-Curve estimation: Comparison of polynomials

Tax measure	Polynomial order	BIC	AIC
STR	2	2946.18	2876.49
	3	2952.88	2878.21
	4	2959.41	2879.76
EMTR	2	2948.20	2878.51
	3	2953.38	2878.71
	4	2960.22	2880.57
EATR	2	2946.37	2876.67
	3	2953.00	2878.33
	4	2959.59	2879.94

Note that we have also produced results where we include higher-order polynomials, which turned out to be insignificant. Formal testing, where we compare higher-order polynomials to the squared term specification, show that the latter captures the shape of the revenue curve better than the former specifications. The tests, based on the Bayesian information criterion (BIC) as well as the Akaike information criterion (AIC), clearly suggest that a polynomial function of order two best fits the data (see Table 4).

[28] Note that the constant in these estimates is not zero. At first glance, this may seem contradictory to theory, which would suggest zero tax revenue at a zero tax rate. However, in a fixed effects regression, this coefficient is not interpretable in a reasonable way (Wooldridge, 2010). When it comes to Figures 15 to 17, where we illustrate the predicted tax revenue curves, we see in fact a non-zero intercept. However, this is justifiable as these figures visualize the predictions from our linear regression model and hence, the model may predict a non-zero tax revenue even with a zero tax rate.

Figure 15: Parametric Laffer-Curve (STR)



Figures 15 to 17 visualize the predicted revenue curves for the three tax measures. The first insight of these estimates is that the shape of the revenue curve looks quite similar, with a specific maximum point depending on the respective tax. Table 5 illustrates the estimated revenue-maximizing values of the respective measures, the tax revenue associated with these revenue-maximizing rates and the mean tax rates actually observed in our data.

Figure 16: Parametric Laffer-Curve ($EMTR$)

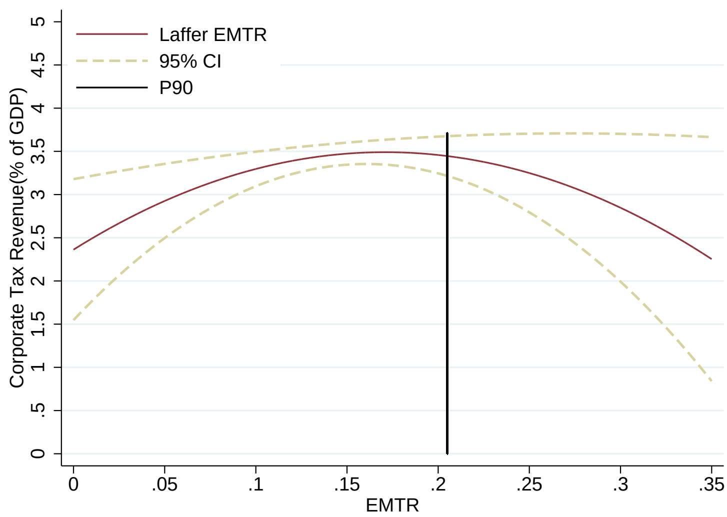
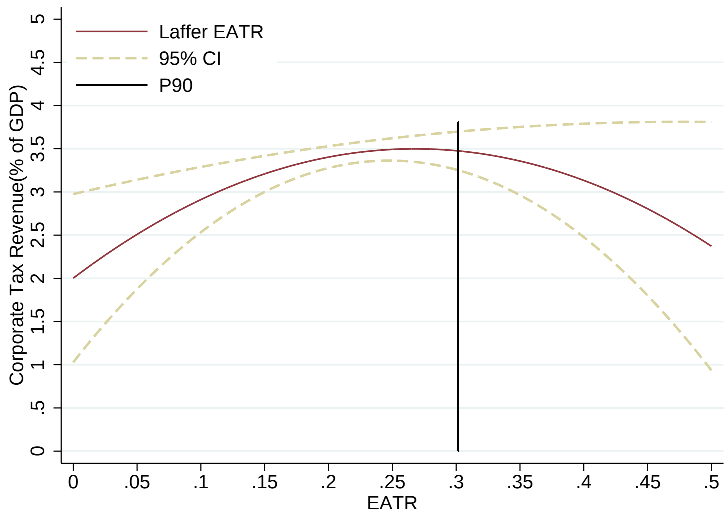


Figure 17: Parametric Laffer-Curve ($EATR$)



The revenue-maximizing STR is estimated to be roughly 31%, the $EMTR$ that maximizes tax revenue is about 17%, and the $EATR$ is around 27%. Comparing these rates with the actual averages reveals that all measured mean values lie clearly below the predicted revenue maximum: the means of STR, $EMTR$, and $EATR$ are 25%, 14%, and 22%, respectively (see Table 5). This suggests that taxes are, on average, below the revenue-maximizing rates, which is consistent with arguments on tax competition resulting in lower taxes in equilibrium (see, for example, Oates (1972); Zodrow and Mieszkowski (1986); Bucovetsky (1991); Wilson (1999)). As a large literature on profit shifting argues that countries compete not only for productive capital but also for taxable profits, it is not surprising that the difference between revenue-maximizing tax and average tax is largest for the STR.[29]

Table 5: Laffer-Curve estimation: Maximum and observed tax rates

Tax measure	Tax rate at maximum	Maximum tax revenue	Average tax rate
STR	31%	3.5038	25%
EMTR	17%	3.4946	14%
EATR	27%	3.4991	22%

Notes: The maximum tax values are those of the specific maximum points from the Laffer-Curves in Figures 15 to 17. The average tax values are those actually observed in the sample used for the Laffer-Curve estimates.

In order to underpin the robustness of the estimated Laffer-Curve relationship, we include 95% confidence bands depicted by the dotted lines in the figures. Taking into account that, as indicated by the vertical lines for the 90th percentiles in Figures 15 to 17, the vast majority of countries have implemented tax rates in a range where the confidence bands are rather narrow, the predicted revenue curves prove to be precisely estimated. We see that in both tails of the respective tax measures' distributions, the confidence bands are broadening. Particularly for high values of the tax measures, this can be explained by a lower support of observations. Hence, the larger the deviation from the predicted optimal rates, the more difficult it is to precisely estimate the Laffer-Curves. All in all, though, the estimates seem to predict

[29]The STR, which does not consider depreciation rules, is the relevant indicator when the goal is to measure incentives in the context of profit shifting.

a very plausible and robust pattern of the relationship between tax rates and tax revenue. Let us mention that Section A.6 provides some statistics on the difference in tax-setting behavior, distinguishing between small and large countries. This difference is not relevant for the way we estimate the Laffer-Curve. The reason is that we remove all cross-sectional variation between countries: the regressions condition on country-specific effects so that all time-constant country characteristics are controlled for. Moreover, the dependent variable in our regressions is the tax-to-GDP ratio. This implies that the estimated shape of the Laffer-Curve reflects the inefficiencies and distortions produced by the tax system. This is exactly what we are interested in.

Note that, finally, we could use our approach to assess the potential revenue consequences of the recent US corporate tax cut. Our estimates suggest that the US moves from the right-hand side of the Laffer-Curve to the left-hand side. Applying the relative change in the corporate-tax-to-GDP ratio implied by a 14 percentage points tax cut for the US to actual US tax revenue numbers (corporate tax revenue over the last 10 years), we find that the yearly loss in revenue is equal to about 39 million US-dollars. The advantage of our approach is that the Laffer-Curve estimates directly account for potential growth effects through the tax cut, which allows us to come up with a plausible estimate without having to speculate about potential behavioral effects of lower taxes. However, according to our prediction, these growth effects are not sufficient to compensate for the loss through the direct tax-cut effect. We should be aware of the fact that any quantification of a big tax reform implemented by a big country has major general equilibrium implications. This naturally makes quantifications of such events very difficult.

5.2 Taxes and investment

This section utilizes our tax data to better understand the micro-level investment behavior of firms. For this purpose, we combine the tax data with firm-level information on firm j's tangible fixed assets reported in the *Orbis* database. Tables 6 and 7 provide OLS results where we define the logarithm of the fixed assets of firm j as the dependent variable. The two tables crucially differ with respect to the definition of the employed tax measures: In Table 6, we use taxes measured at the country level, while in Table 7, we analyze the impact of the firm-industry-specific taxes calculated above (Section 4.2).

All regressions include firm and year effects, descriptive statistics of all variables are presented in Table A.2 in the Appendix.[30] As to Table 6, we are mainly interested in the following tax variables measured at the level of country c at time t: $EMTR_{ct}$, $EATR_{ct}$, STR_{ct}, and NPV_{ct} (see above). We further include two firm-j-specific variables: the one-period lagged log of sales ($log\ SALES_{jt-1}$), and the one-period lagged log of the number of employees, ($log\ EMPL_{jt-1}$).[31] At the level of countries c, we control for the host country's GDP ($log\ GDP_{ct}$), GDP per capita ($log\ GDPPC_{ct}$), and GDP growth ($GDP\ growth_{ct}$) (all GDP measures are taken from the World Bank's World Development indicator database). The variable CPI_{ct} is an index measuring corruption perception. It takes values from 0 to 10, where 10 is the hypothetical case of a country that is completely free from corruption (the variable is provided by Transparency International). FIF_{ct} is an index measuring financial freedom. It takes values from 0 to 100, where higher values indicate more financial freedom (FIF is provided in the Heritage indicator database). The variable domestic credit provided by the banking sector (in % of GDP), DCB_{ct}, is included to capture the depth of country c's financial market (the variable is taken from the World Bank's World Development indicator database). $NDTT_{ct}$ and $NBIT_{ct}$ count the number of double taxation treaties (DTTs)

[30]Note that our sample basically captures information from all unconsolidated balance-sheets reported in *Orbis* for the years 2004 until 2014. We exclude firms operating in the financial and insurance business as well as all firms associated with public administration, as these are often subject to different tax rules and regulation. We finally require that a firm is observed for at least 4 years in our data.

[31]We have chosen control variables in line with the paper by Egger, Merlo, and Wamser (2014), as far as the respective information was available in *Orbis*.

and the number of bilateral investment treaties (BITs) concluded by country c ($NDTT_{ct}$ and $NBIT_{ct}$ are based on own calculations, where the respective information is taken from UNCTAD). Finally, we condition on $log\ TCAP_{ct-1}$ to capture the general attractiveness of a location. It is measured as the sum over the total assets of all firms included in our data in a given country c and year $t-1$.

Table 6: Taxes and fixed asset investment - country level

	(1)	(2)	(3)
$EMTR_{ct}$	-2.2426***		
	(0.5167)		
$EATR_{ct}$		-1.6069***	
		(0.4035)	
STR_{ct}			-1.2908***
			(0.3645)
NPV_{ct}			1.6051*
			(0.9055)
$log\ SALES_{jt-1}$	0.0676***	0.0675***	0.0675***
	(0.0055)	(0.0055)	(0.0055)
$log\ EMPL_{jt-1}$	0.2968***	0.2967***	0.2972***
	(0.0150)	(0.0150)	(0.0150)
$log\ GDP_{ct}$	-0.2262	-0.2747	-0.1647
	(0.3868)	(0.3899)	(0.3705)
$log\ GDPPC_{ct}$	0.6396*	0.6997*	0.5397
	(0.3800)	(0.3827)	(0.3676)
$log\ GDP\ growth_{ct}$	0.0071**	0.0073**	0.0074**
	(0.0031)	(0.0031)	(0.0031)
CPI_{ct}	0.0144	0.0136	0.0133
	(0.0235)	(0.0230)	(0.0228)
FIF_{ct}	0.0007	0.0008	0.0006
	(0.0010)	(0.0010)	(0.0010)
DCB_{ct}	0.0003	0.0004	0.0003
	(0.0006)	(0.0006)	(0.0006)
$NDTT_{ct}$	-0.0052**	-0.0044*	-0.0051**
	(0.0024)	(0.0024)	(0.0023)
$NBIT_{ct}$	0.0007	0.0004	0.0006
	(0.0013)	(0.0014)	(0.0014)
$log\ TCAP_{ct-1}$	0.0478*	0.0451	0.0453*
	(0.0269)	(0.0280)	(0.0259)
Observations	569,002	569,002	569,002
$adjR-sq$	0.9440	0.9440	0.9440
EMTR (elast.)	-0.3321***		
EATR (elast.)		-0.3927***	
STR (elast.)			-0.3677***
NPV (elast.)			0.9030*

Notes: Dependent variable in all specifications: Logarithm of fixed asset investment.
Robust and clustered (country-year level) standard errors in parentheses.
***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

The results provided in Table 6 are based on 569,002 observations and 99,198 firms.[32] The panel is unbalanced with most observations in the year 2012 (71,727). The results indicate that taxes are negatively related to investment in fixed assets. Below each column, for each tax measure, we provide the corresponding tax elasticity. The estimated coefficient on the $EMTR$ is highly significant at the 1% level. Note that reported standard errors are robust and clustered at the country-year level. The coefficient on the $EATR$ is estimated to be slightly smaller. Given the specification of the estimation equation (focusing on the intensive margin of asset investment), and particularly given that we focus on time variation by conditioning on firm-specific effects, we would expect that the $EMTR$ captures tax incentives in a more appropriate way.

Column (3) shows that the tax parameters can also be estimated when we separate tax rate and tax base effects. Expressing the tax semi-elasticities as elasticities demonstrates that our results are in a reasonable range and comparable to previous studies (see De Mooij and Ederveen (2003), Mooij and Ederveen (2008) and Feld and Heckemeyer (2011) for an overview, Zwick and Mahon (2017)). The recent study by Zwick and Mahon (2017) suggests that US firms (particularly small ones) are very responsive to changes in bonus depreciation.

Their average semi-elasticity of 3.7 with respect to bonus depreciation compares to the NPV-semi-elasticity of 1.6 shown in the last column of Table 6. They also provide a tax-term elasticity of -1.6, which is about 4.4 times larger than the estimated elasticity on STR.[33]

The estimated effects of the control variables are in line with previous findings. The negative effect of $NDTT_{ct}$ can be interpreted as the consequence of more regulation and information exchange – for example, to reduce profit-shifting activities of multinational firms – between countries when concluding DTTs. The positive effect of $NBIT_{ct}$ suggests that bilateral investment treaties facilitate foreign direct investment in a country (the effect is not statistically significant, however). Before we discuss the results of Table 7, we should note that the time variation of the country-specific measures used above is substantial, as, given the estimation sample, the $EMTR_{ct}$ changes its value more than 80 times (focusing on within-country variation and neglecting all cross-country differences).

Note that we may be concerned about how precisely the tax variables capture incentive effects as firms differ in asset composition and financial choices. We may therefore make use of the weighted tax variables as calculated in Section 4.2. The main advantage of using the weighted variables is that they introduce additional variation through weights at the industry- and firm-level. The estimation results of this latter analysis are presented in Table 7. Both $EMTR$ and $EATR$ measured at the firm-industry-country-time level are significant at the 1% level, and the reported elasticities also suggest a quantitatively very similar influence of taxes on investment as above (where we focus on country-time variation). To be precise, a 1% increase in $EMTR_{jict}$ triggers a 0.33% decrease in fixed asset investment. If we ignore the variation across countries and only distinguish by industries ($EMTR_{jit}$ and $EATR_{jit}$), the $EMTR$ is still significant at the 5% level. The $EATR$, however, does not seem to have a significant impact on fixed asset investment, which is consistent with the notion explained above, namely that the $EMTR$ is the appropriate measure when we are focusing on the intensive margin investment. But of course, variation in the $EATR$ may still be related to changes in investment as many big projects are less marginal but rather lumpy. Note, finally, that if we include both measures (the $EMTR$ as well as the $EATR$), we always find a negative and significant impact for the $EMTR$, and a positive though insignificant impact of the $EATR$. Both variables are, however, strongly correlated with each other which inflates the estimated standard errors to some extent.

Surprisingly, the variable $NDTT_{ct}$ turns out to be insignificant in the last two columns of Table 7. This means that a higher level of regulation and information exchange seems to be

[32] A firm in our data is an entity (affiliate) of a multinational enterprise. All j-specific variables are taken from (unconsolidated) balance-sheet information provided for these entities.

[33] While both our estimates are smaller than in Zwick and Mahon (2017), we should also note that the average change in NPV_{ct} is only -.002 (over all observations in our sample).

less relevant in the last two specifications. One way to explain this result is that including (possibly endogenous) variation at the firm and industry level implies that we allow for firms engaging in tax-planning behavior.

Table 7: Taxes and fixed asset investment - firm-industry level

	(1)	(2)	(3)	(4)
$EMTR_{jict}$	-2.5880***			
	(0.6083)			
$EATR_{jict}$		-1.4160***		
		(0.3961)		
$EMTR_{jit}$			-2.1153**	
			(1.0099)	
$EATR_{jit}$				-0.5513
				(0.6207)
$log\ SALES_{jt-1}$	0.0676***	0.0676***	0.0681***	0.0681***
	(0.0055)	(0.0055)	(0.0055)	(0.0055)
$log\ EMPL_{jt-1}$	0.2968***	0.2968***	0.2965***	0.2962***
	(0.0150)	(0.0150)	(0.0152)	(0.0152)
$log\ GDP_{ct}$	-0.2229	-0.2684	-0.4092	-0.4097
	(0.3865)	(0.3939)	(0.3854)	(0.3867)
$log\ GDPPC_{ct}$	0.6466*	0.6923*	0.8601**	0.8626**
	(0.3797)	(0.3879)	(0.3896)	(0.3909)
$GDP\ growth_{ct}$	0.0072**	0.0074**	0.0078**	0.0078**
	(0.0031)	(0.0032)	(0.0033)	(0.0033)
CPI_{ct}	0.0148	0.0121	-0.0065	-0.0066
	(0.0233)	(0.0229)	(0.0242)	(0.0243)
FIF_{ct}	0.0007	0.0008	0.0007	0.0007
	(0.0010)	(0.0010)	(0.0011)	(0.0011)
DCB_{ct}	0.0003	0.0004	0.0007	0.0007
	(0.0006)	(0.0006)	(0.0006)	(0.0006)
$NDTT_{ct}$	-0.0048**	-0.0045*	-0.0035	-0.0035
	(0.0024)	(0.0024)	(0.0025)	(0.0025)
$NBIT_{ct}$	0.0007	0.0005	0.0010	0.0010
	(0.0013)	(0.0014)	(0.0016)	(0.0016)
$log\ TCAP_{ct-1}$	0.0462*	0.0469*	0.0605**	0.0604**
	(0.0274)	(0.0280)	(0.0267)	(0.0266)
Observations	569,002	569,002	569,002	569,002
$adj.R-sq$	0.9440	0.9440	0.9440	0.9440
$EMTR_{jict}$ $(elast.)$	-0.3295***			
$EATR_{jict}$ $(elast.)$		-0.3570***		
$EMTR_{jit}$ $(elast.)$			-0.2786**	
$EATR_{jit}$ $(elast.)$				-0.1392

Notes: Dependent variable in all specifications: Logarithm of fixed asset investment.
Robust and clustered (country-year level) Standard errors in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

We finally address two concerns about the estimations in Tables 6 and 7. First, it may be that adjustment costs are relevant when analyzing the log of the fixed assets. We therefore first-difference the estimation equation and run dynamic regression models by including the lagged dependent variable as explanatory variable. Since the latter approach violates strict exogeneity, we apply the difference GMM estimator as suggested by Arellano and Bond (1991). Second, we instrument $EMTR_{jict}$ as the weights used to capture financing and asset composition may cause endogeneity issues (as mentioned above).

Table 8: Dynamics and endogeneity

	(1)	(2)	(3)	(4)	(5)
$log\ FA_{jt-1}$	0.6333***	0.6367***	0.5980***	0.7012***	0.6081***
	(0.0219)	(0.0219)	(0.0232)	(0.0224)	(.0216)
STR_{ct}	-0.4714***				
	(0.080)				
NPV_{ct}	0.4173***				
	(0.1811)				
$EMTR_{jict}$		-1.0954***	-1.194***	-7.8075***	-5.5948***
		(0.1421)	(0.1416)	(0.4561)	(.3809)
Test for AR(1)	0.000	0.000	0.000	0.000	0.000
Test for AR(2)	0.381	0.383	0.362	0.221	0.243

Notes: 384,606 observations, dynamic panel-data estimation, two-step difference GMM (see Arellano and Bond (1991)). Robust standard errors in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. AR(1) and AR(2) report z-values on the Arellano and Bond tests for autocorrelation. Specification (1): differenced lag ($\Delta log\ FA_{jt-1}$) instrumented by the two-period lagged level ($log\ FA_{jt-2}$); Specification (2): differenced lag ($\Delta log\ FA_{jt-1}$) instrumented by the two-period lagged level ($log\ FA_{jt-2}$); Specification (3): differenced lag ($\Delta log\ FA_{jt-1}$) instrumented by all available lagged level variables ($log\ FA_{j.}$); Specification (4): differenced lag and $EMTR_{jict}$ instrumented by the one-period lagged levels; Specification (5): differenced lag and $EMTR_{jict}$ instrumented by all available lagged level variables.

The results of the dynamic model are presented in Table 8. Note that we include all additional control variables as before. The specifications differ in the number of instruments used. Columns (1), (2), and (4) are parsimonious specifications employing only the two-period lagged level (of the dependent variable) to instrument $log\ FA_{jt-1}$; columns (3) and (5) use all available instruments (lagged levels), where we also treat $EMTR_{jict}$ as endogenous in columns (4) and (5). The approach seems to produce reliable estimates for the following reasons: (i) the estimate on the lagged fixed asset variable lies in a plausible range; (ii) we always reject (cannot reject) the hypothesis of autocorrelation of order 1 (2) at the 1% significance level; (iii) the estimated tax coefficients are negative; the coefficient on $EMTR_{jict}$ is estimated to be -1.0954, which corresponds to a long-run effect of about -3.0, which we can roughly compare to the coefficient of -2.6 in Table 7.

The results where we instrument $EMTR_{jict}$ suggest substantially higher semi-elasticities. These estimates need to be interpreted in light of the quantitatively very moderate average change in $EMTR_{jict}$ of -0.0024.

6 Conclusions

This study demonstrates that there is significant variation in taxes on corporate profits across countries and over time. To the best of our knowledge, no study has calculated tax measures for such a large sample of countries as we do (including measures of tax base, as well as effective marginal and average tax measures). We describe the recent trends in tax policy and highlight salient features of the cross-country distributions of different tax measures. We then combine statutory rules with firm- and industry-level information on financing behavior as well as asset composition. This allows us to calculate effective tax measures that account for a typical firm with respect to financing and asset composition, given the specific industry and country a firm is operating in. The latter may be interesting for various reasons. For example, firms in high-tax countries use more debt financing, on average, to avoid part of the profit tax through deductible interest cost. A generic effective tax measure, neglecting weights at a more micro level, may overestimate the effective tax burden faced by a typical firm.

We demonstrate that our data can be utilized for a number of interesting research questions. First, we show that the predicted relationship between tax revenue and statutory tax rates is inverse-U-shaped. This shape is known as the Laffer-Curve. The maximum values, i.e., the revenue-maximizing tax rates, are estimated to be above the mean (and median) tax rates observed in our data, a finding we ascribe to strategic tax setting and international tax competition. While it is beyond the scope of this paper to provide more evidence that international tax competition is the driving force behind low tax rates, it is consistent with the clear downward trend in taxes we observe in the descriptive statistics. Furthermore, we make sure that the Laffer-Curve shape is not imposed on the data by specifying tax revenue as a polynomial function of taxes: additional results show that higher-order polynomials in taxes are not significantly related to tax revenue; non-parametric specifications of the relationship produce very similar results. Finally, we believe that business cycle effects and other spurious correlations are well captured by running regressions which control for country- as well as year-specific shocks.

Second, we combine our tax data with firm-level information on investment in fixed assets. We find very plausible tax and tax base elasticities. For example, the firm- and industry-weighted $EMTR$ elasticity is estimated to be -0.33. Separating the statutory tax rate elasticity from the tax base (measured as NPV) elasticity suggests an estimate of -0.37 for the former, and an estimate of 0.90 for the latter. Future research may use our tax data to analyze numerous firm decisions not analyzed in this paper, particularly in an international context.

References

Arellano, M., and S. Bond (1991): "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, 58(2), 277–297.

Auerbach, A. (1979): "Wealth Maximization and the Cost of Capital," *The Quarterly Journal of Economics*, 93(3), 433–446.

Bènassy-Quéré, A., L. Fontagné, A. Lahrèche-Révil, et al. (2000): "Foreign direct investment and the prospects for tax co-ordination in Europe," *CEPII Working Paper*.

Bilicka, K., and M. Devereux (2012): *CBT Corporate tax ranking 2012*.

Bucovetsky, S. (1991): "Asymmetric tax competition," *Journal of Urban Economics*, 30(2), 167 – 181.

Clausing, K. A. (2007): "Corporate tax revenues in OECD countries," *International tax and public finance*, 14(2), 115–133.

De Mooij, R. A., and S. Ederveen (2003): "Taxation and foreign direct investment: a synthesis of empirical research," *International tax and public finance*, 10(6), 673–693.

Desai, M. A., C. F. Foley, and J. Hines (2004): "A Multinational Perspective on Capital Structure Choice and Internal Capital Markets," *Journal of Finance*, 59(6), 2451–2487.

Devereux, M. P., and R. Griffith (1998): "The taxation of discrete investment choices," IFS Working Papers W98/16, Institute for Fiscal Studies.

——— (2003): "Evaluating tax policy for location decisions," *International Tax and Public Finance*, 10(2), 107–126.

Devereux, M. P., R. Griffith, and A. Klemm (2002): "Corporate income tax reforms and international tax competition," *Economic policy*, 17(35), 449–495.

Devereux, M. P., R. Griffith, and A. Klemm (2004): "Why has the UK corporation tax raised so much revenue?," *Fiscal Studies*, 25(4), 367–388.

Dupuit, J. (1844): "On the measurement of the utility of public works," *International Economic Papers*, 2(1952), 83–110.

Egger, P. H., and S. Loretz (2010): "Homogeneous Profit Tax Effects for Heterogeneous Firms?," *The World Economy*, 33(8), 1023–1041.

Egger, P. H., S. Loretz, M. Pfaffermayr, and H. Winner (2009a): "Bilateral effective tax rates and foreign direct investment," *International Tax and Public Finance*, 16(6), 822–849.

Egger, P. H., S. Loretz, M. Pfaffermayr, and H. Winner (2009b): "Firm-specific forward-looking effective tax rates," *International Tax and Public Finance*, 16(6), 850–870.

Egger, P. H., V. Merlo, and G. Wamser (2014): "Unobserved Tax Avoidance and the Tax Elasticity of FDI," *Journal of Economic Behavior & Organization*, 108(C), 1–18.

Evers, L., H. Miller, and C. Spengel (2015): "Intellectual property box regimes: effective tax rates and tax policy considerations," *International Tax and Public Finance*, 22(3), 502–530.

Fabling, R., N. Gemmell, R. Kneller, and L. Sanderson (2014): "Estimating firm-level effective marginal tax rates and the user cost of capital in New Zealand," Motu Working Paper 13-14, Motu Economic and Public Policy Research.

Feld, L. P., and J. H. Heckemeyer (2011): "FDI and Taxation: a Meta-Study," *Journal of economic surveys*, 25(2), 233–272.

Gropp, M. R., and M. K. Kostial (2000): *The disappearing tax base: is foreign direct investment (FDI) eroding corporate income taxes?*, no. 0-173. International Monetary Fund.

Kawano, L., and J. Slemrod (2012): "The effect of tax rates and tax bases on corporate tax revenues: Estimates with new measures of the corporate tax base," Discussion paper, National Bureau of Economic Research.

King, M. (1974): "Taxation and the cost of capital," *The Review of Economic Studies*, 41(1), 21–35.

King, M., and D. Fullerton (1984): "Introduction to the Taxation of Income from Capital: A Comparative Study of the United States, the United Kingdom, Sweden, and Germany," in *The Taxation of Income from Capital: A Comparative Study of the United States, the United Kingdom, Sweden, and Germany*, pp. 1–6. University of Chicago Press.

Loretz, S. (2008): "Corporate taxation in the OECD in a wider context," *Oxford Review of Economic Policy*, 24(4), 639–660.

McKenzie, K. J., M. Mansour, and A. Brûlé (1998): *The calculation of marginal effective tax rates*. Technical Committee on Business Taxation.

Mooij, R. A. d., and S. Ederveen (2008): "Corporate tax elasticities: a reader's guide to empirical findings," *Oxford review of economic policy*, 24(4), 680–697.

Oates, W. E. (1972): *Fiscal Federalism*. Harcourt Brace Jovanovich, Inc.

OECD (1991): *Taxing profits in a global economy : domestic and international issues*. Organisation for Economic Cooperation and Development ; OECD Publication and Information Centre, Paris.

Piketty, T., and E. Saez (2013): "Chapter 7 - Optimal Labor Income Taxation," in *Handbook of Public Economics, Vol. 5*, ed. by M. F. Alan J. Auerbach, Raj Chetty, and E. Saez, vol. 5 of *Handbook of Public Economics*, pp. 391 – 474. Elsevier.

Silverman, B. W. (1986): *Density Estimation for Statistics and Data Analysis*. Chapman & Hall, London.

Spengel, C., D. Endres, K. Nicolay, J. Heckemeyer, A. Bartholmess, R. Bräutigam, J. Braun, O. Pfeiffer, M. Evers, C. Harendt, F. Streif, M. Todtenhaupt, and M. Halter (2017): *Effective Tax Levels using the Devereux/Griffith Methodology - Final report 2016, Project for the EU Commission TAXUD/2013/CC/120*. ZEW - Zentrum für Europäische Wirtschaftsforschung / Center for European Economic Research.

Spengel, C., J. H. Heckemeyer, R. Bräutigam, K. Nicolay, O. Klar, and K. Stutzenberger (2016): *The effects of tax reforms to address the debt-equity bias on the cost of capital and on effective tax rates*, no. 65. Taxation Papers.

Spengel, C., J. H. Heckemeyer, H. Nusser, O. Klar, and F. Streif (2016): *The impact of tax planning on forward-looking effective tax rates*, no. 64. Taxation Papers.

Spengel, C., J. H. Heckemeyer, and F. Streif (2016): *The effect of inflation and interest rates on forward-looking effective tax rates*, no. 63. Taxation Papers.

Strulik, H., and T. Trimborn (2012): "Laffer strikes again: Dynamic scoring of capital taxes," *European Economic Review*, 56(6), 1180–1199.

Trabandt, M., and H. Uhlig (2011): "The Laffer curve revisited," *Journal of Monetary Economics*, 58(4), 305–327.

Wilson, J. D. (1999): "Theories of Tax Competition," *National Tax Journal*, 52(2), 269–304.

Wooldridge, J. M. (2010): *Econometric Analysis of Cross Section and Panel Data*. MIT Press.

Yoo, K.-Y. (2003): "Corporate taxation of foreign direct investment income 1991-2001," OECD Economics Department Working Papers 365, Organisation for Economic Co-operation and Development.

Zodrow, G. R., and P. Mieszkowski (1986): "Pigou, Tiebout, property taxation, and the underprovision of local public goods," *Journal of urban economics*, 19(3), 356–370.

Zwick, E., and J. Mahon (2017): "Tax Policy and Heterogeneous Investment Behavior," *American Economic Review*, 107(1), 217–48.

A Appendix

A.1 Depreciation allowances

The following formulas depict how the $NPVs$ of tax depreciation allowances are calculated for a given depreciation allowance regime and asset type i. The formulas are adapted from OECD (1991).

Declining Balance method:

$$A_D^i = \frac{\phi_D^i \cdot (1+\rho)}{\rho + \phi_D^i} \tag{A.1}$$

Straight Line method:

$$A_S^i = \frac{\phi_S^i \cdot (1+\rho)}{\rho} \cdot \Big(1 - \frac{1}{(1+\rho)^N}\Big) \tag{A.2}$$

Straight Line method with initial allowance:

$$A_{S,IN}^i = \Big[\frac{\phi_{S,IN}^i \cdot (1+\rho)}{\rho \cdot (1 - \frac{1}{(1+\rho)^N})}\Big] + A_S^i \cdot \Big(\frac{1}{(1+\rho)^N}\Big) \tag{A.3}$$

Declining Balance method with initial allowance:

$$A_{D,IN}^i = (\phi_{D,IN}^i \cdot (1+\rho)) \cdot (\phi_{D,IN}^i) + \Big(\frac{\phi_D^i \cdot (1+\rho)}{\phi_D^i + \rho}\Big) \cdot (1 - \phi_{D,IN}^i) \tag{A.4}$$

In the following, ϕ_D^i (ϕ_S^i) is the depreciation rate under the declining balance (straight line) method, ρ is the market interest rate, N is the depreciation period, $\phi_{D,IN}^i$ ($\phi_{S,IN}^i$) is the initial allowance rate under the declining balance (straight line) method.

A.2 Equality of cashflow-based NPV model and neoclassical investment model

As mentioned in Section 2, we derive the specifications of our effective tax measures from a neoclassical investment model. Previous approaches (e.g., Devereux, Griffith, and Klemm (2002); Egger, Loretz, Pfaffermayr, and Winner (2009a)) primarily rely on a cashflow-oriented representation of NPVs to define the $EMTR$ formula. Nonetheless, both approaches lead to the same results:[34]

$$R = -(1-\tau A) + \frac{(1+\pi)(1-\tau)(p+\sigma) + (1+\pi)(1-\sigma)(1-\tau A)}{1+\rho} \stackrel{!}{=} 0 \tag{A.5}$$

$$p = \frac{(1-\tau A)((1+\rho) - (1+\pi)(1-\sigma))}{(1+\pi)(1-\tau)} - \sigma \tag{A.6}$$

If we ignore π, we get:

$$R = -(1-\tau A) + \frac{(1-\tau)(p+\sigma) + (1-\sigma)(1-\tau A)}{1+\rho} \stackrel{!}{=} 0 \tag{A.7}$$

$$p = \frac{(1-\tau A)(\rho+\sigma)}{(1-\tau)} - \sigma \tag{A.8}$$

Comparing with Equation (3) above, it becomes clear that both methods lead to an equivalent term for the required pre-tax rate of return.

[34] The only difference compared to Devereux, Griffith, and Klemm (2002) and Egger, Loretz, Pfaffermayr, and Winner (2009a) lies in the way we define the NPV of depreciation allowances. In this regard, we follow Egger and Loretz (2010) and separate the NPV of depreciation allowances (A) from the STR (τ).

A.3 EATR Calculation

The calculation of the $EATR$ follows Devereux, Griffith, and Klemm (2002). The following expression depicts the pre-tax NPV of the hypothetical investment:

$$R^* = -I + \frac{1}{1+\rho}[(p+\sigma)(1+\pi) + (1-\sigma)(1+\pi)] \cdot I \tag{A.9}$$

Setting investment I=1 and disregarding inflation, we can simplify this to

$$R^* = -1 + \frac{1}{1+\rho}[(p+1)] = \frac{p-\rho}{1+\rho}. \tag{A.10}$$

The NPV of a hypothetical investment subject to taxation is

$$\begin{aligned} R &= -(1-\tau A) + \frac{(1-\tau)\cdot(p+\sigma) + (1-\tau A)(1-\sigma)}{1+\rho} \\ &= \frac{\tau A(\rho-\sigma) - \rho - \tau\sigma + p(1-\tau)}{1+\rho}. \end{aligned} \tag{A.11}$$

Combining these two present values, we get

$$\begin{aligned} R^* - R &= \frac{p-\rho}{1+\rho} - \frac{\tau A(\rho-\sigma) - \rho - \tau\sigma + p(1-\tau)}{1+\rho} \\ &= \frac{\tau\big(p + \sigma(1+A) - \rho A\big)}{1+\rho}, \end{aligned} \tag{A.12}$$

and finally

$$EATR = \frac{R^* - R}{p/(1+\rho)} = \frac{\tau\big(p + \sigma(1+A) - \rho A\big)}{p} \tag{A.13}$$

A.4 The role of economic depreciation

As an alternative to the results assuming zero economic depreciation (i.e., $\sigma = 0$), we have modified our calculations of the effective tax measures and rerun our estimations based on the adapted tax measures, using various values for σ. Incorporating economic depreciation in the model increases the required pre-tax rate of return (thus, the user cost of capital) and consequently leads to larger ETRs. The following comparative statics exercise shows this:

$$\frac{\partial \hat{p}}{\partial \sigma} = \frac{1-\tau A}{1-\tau} - 1 > 0 \tag{A.14}$$

$$\frac{\partial EMTR}{\partial \sigma} = \frac{(1-\tau)\cdot\rho}{((1-\tau A)\cdot\rho + (1-A)\cdot\tau\sigma)^2} \cdot (1-A)\cdot\tau > 0 \tag{A.15}$$

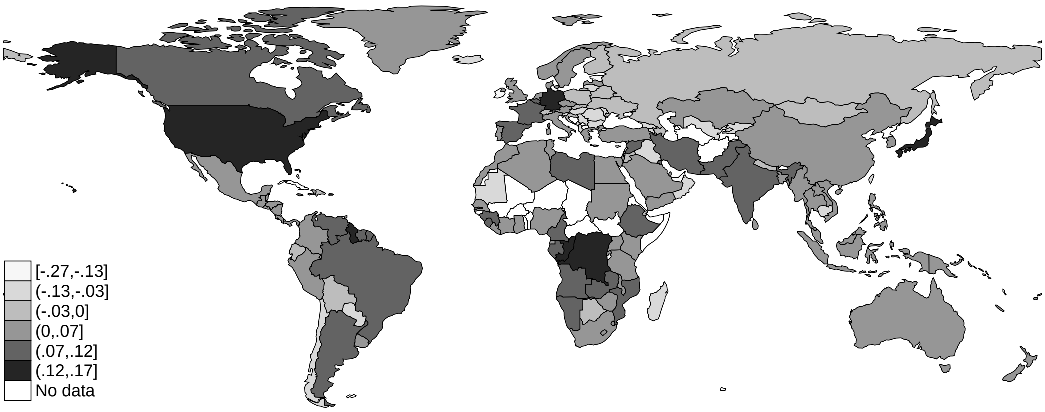
$$\frac{\partial EATR}{\partial \sigma} = \frac{\tau(1+A)}{p} > 0 \tag{A.16}$$

We have calculated the ETRs with a non-zero economic depreciation rate and compare various values for the latter: 0.01, 0.025, and 0.0608, where the latter value is in line with the assumptions in OECD (1991) and Egger, Loretz, Pfaffermayr, and Winner (2009b). Table A.1 suggests that, in line with the theoretical predictions, the ETRs (i) are higher than with economic depreciation assumed to be zero and (ii) are increasing in the economic depreciation rate.

Table A.1: The role of economic depreciation

	$EMTR(\sigma = 0)$	$EMTR(\sigma = 0.01)$	$EMTR(\sigma = 0.025)$	$EMTR(\sigma = 0.0608)$
$MEAN$	0.135	0.1571	0.1878	0.2517
STD	0.0554	0.0632	0.0736	0.0933
Min	0	0	0	0
Max	0.3515	0.3941	0.4485	0.5458
	$EATR(\sigma = 0)$	$EATR(\sigma = 0.01)$	$EATR(\sigma = 0.025)$	$EATR(\sigma = 0.0608)$
$MEAN$	0.2182	0.2239	0.2324	0.2528
STD	0.0778	0.0799	0.083	0.0905
Min	0	0	0	0
Max	0.4735	0.4857	0.504	0.5477

Figure 18: (Demeaned) Statutory taxes across countries, 1996-2016 (pooled)



Notes: The darker in color a country's area, the higher the respective country's *STRs*.

A.5 Statutory taxes: cross-country variation

For each country, we pool the annual *STRs* over the period from 1996 to 2016 and subtract the global (time-) average *STR* (26.09%) from each country's time average. These demeaned tax rates are illustrated in Figure 18; the darker in color a country's area, the higher the respective country's *STRs*.

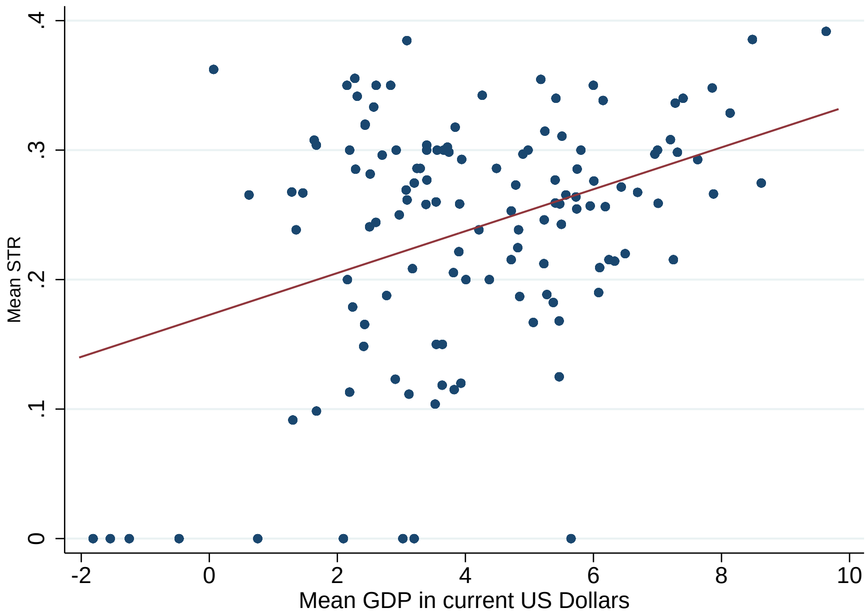
One can see that there is substantial variation across countries, indicating that the tax-setting behavior of countries vastly differs. Highly developed countries like the US, Germany and Japan, but also a considerable number of very poor countries in Sub-Saharan Africa exhibit *STRs* that are well above the global average. In contrast to this, the majority of Eastern European countries, including Russia, have comparatively low statutory tax rates.

A.6 Laffer-Curve estimates and country size

In the Laffer-Curve estimates above, we assume identical (average) tax base elasticity coefficients for all countries. However, in general, one could argue that country size affects optimal tax-setting behavior. The seminal work here goes back to Bucovetsky (1991), who shows that small and large countries face a capital outflow after an increase in their tax rate. Yet, the larger country faces a less elastic tax base and therefore chooses a higher tax rate.

While Figure 19, depicting the correlation between log(GDP) and the statutory tax rate,

Figure 19: (Log) GDP and statutory tax rates



confirms this pattern, we should be aware of the point that this comparison is based on cross-sectional differences in country size.

The point about the cross-sectional comparison between countries becomes crucial when interpreting the Laffer-estimates. There, we regress tax revenue (relative to GDP) of a country on country-specific (fixed) effects (which should take out all cross-sectional variation, including the different tax-setting behaviour of countries of different size), GDP growth and time dummies (which should account for business cycle effects), and tax as well as tax squared (we also test for higher order polynomials). The dependent variable is normalized by country size and all cross-sectional variation is removed. As a consequence, the estimated shape of the Laffer-Curve must be related to inefficiencies and distortions produced by the tax system. This is exactly what we want but it makes an interpretation of the Laffer-Curve in light of the tax competition literature difficult.

To conclude, if (at all) a distinction between small and large countries is made, then this should be in the spirit of the seminal theoretical paper of Bucovetsky (1991), i.e., in a cross-sectional analysis. In addition, in any empirical analysis, the definition of a 'small' country is highly arbitrary, and a wide range of fundamentally different results could be produced, depending on how we define a 'small' country.[35]

[35]In our estimation approach, the difference in the tax-setting behavior between small and large countries cannot be analyzed in a meaningful way. This is because identification is based on changes in tax rates over time and all cross-sectional differences in country size are removed. This generally implies that in the fixed effects approach, a marginal increase in GDP (which is used to normalize the dependent variable, anyway) cannot be interpreted as the effect of becoming larger. For example, a marginal increase in the GDP of Latvia would not make Latvia a large country. We do not see a way to capture these discrete jumps in the definition of being small.

A.7 Descriptive statistics (Section 5.2)

Table A.2: Descriptive statistics

	Mean	*Std.Dev.*	*Minimum*	*Maximum*
$log\ FA_{jt}$	7.379	2.540	-1.978	18.512
STR_{ct}	0.285	0.070	0.000	0.410
NPV_{ct}	0.563	0.076	0.000	0.705
$EMTR_{ct}$	0.148	0.041	0.000	0.231
$EATR_{ct}$	0.244	0.059	0.000	0.339
$EMTR_{ict}$	0.132	0.011	0.117	0.160
$EATR_{ict}$	0.252	0.017	0.214	0.298
$EMTR_{jict}$	0.127	0.036	0.000	0.207
$EATR_{jict}$	0.252	0.063	0.000	0.374
$log\ SALES_{jt-1}$	9.839	2.048	0.000	19.064
$log\ EMPL_{jt-1}$	4.161	1.599	0.000	12.545
$log\ GDP_{ct}$	27.538	1.227	23.056	30.475
$log\ GDPPC_{ct}$	10.364	0.365	8.331	11.479
$GDP\ growth_{ct}$	1.024	3.314	-14.800	15.316
CPI_{ct}	6.256	1.743	2.100	9.600
FIF_{ct}	65.169	12.253	30.000	90.000
DCB_{ct}	146.989	72.856	15.306	376.955
$NDTT_{ct}$	86.756	22.937	0.000	128.000
$NBIT_{ct}$	77.091	29.141	1.000	136.000
$log\ TCAP_{ct-1}$	20.763	1.525	11.251	22.673

Notes: 569,002 *Observations*. For variable definitions and sources, see 5.2

A.8 Variable definitions and sources

Table A.3: Variable definitions and sources

Variable	Definition and Source
STR_{ct}	Statutory corporate income tax rate of country c in period t; Source: *EY, OECD, WB*
NPV_{ct}	NPV of depreciation allowances of country c in period t; Source: *EY, PwC*
$EMTR_{ct}$	Effective marginal tax rate of country c in period t; Source: *EY, OECD, IBFD, WB*
$EATR_{ct}$	Effective average tax rate of country c in period t; Source: *EY, OECD, IBFD, WB*
$EMTR_{ict}$	Effective marginal tax rate of country c and industry i in period t; Source: *EY, OECD, IBFD, WB*
$EATR_{ict}$	Effective average tax rate of country c and industry i in period t; Source: *EY, OECD, IBFD, WB*
$EMTR_{jict}$	Firm(j)-industry(i)-country(c)-level effective marginal tax rate in period t; Source: *EY, OECD, IBFD, WB*
$EATR_{jict}$	Firm(j)-industry(i)-country(c)-level effective average tax rate in period t; Source: *EY, OECD, IBFD, WB*
$TAX\ REVENUE_{ct}$	Corporate income tax revenue as % of GDP of country c in period t; Source: *IMF; World Revenue Longitudinal Data (WoRLD)*
TAX_{ct}	Tax rate (STR, EMTR or EATR) of country c in period t; Source: *EY, OECD, IBFD, WB, PwC*
$GROWTH_{ct}$	GDP growth (in %) per capita of country c in period t; Source: *World Bank, World Development Indicator (WDI) database*
Y_t	Year fixed effects in period t
C_c	Country fixed effects of country c
FA_{jt}	Fixed asset investment of firm j in period t; Source: *Orbis*
$SALES_{j,t-1}$	Total sales of firm j in period $t-1$; Source: *Orbis*
$EMPL_{j,t-1}$	Number of employees of firm j in period $t-1$; Source: *Orbis*
GDP_{ct}	GDP of country c in period t; Source: *World Bank, World Development Indicator (WDI) database*
GDP_{ct}	GDP of country c in period t; Source: *World Bank, World Development Indicator (WDI) database*
$GDPPC_{ct}$	GDP per capita of country c in period t; Source: *World Bank, World Development Indicator (WDI) database*
$GDP\ growth_{ct}$	GDP growth of country c in period t; Source: *World Bank, World Development Indicator (WDI) database*
CPI_{ct}	Corruption perception index of country c in period t; Source: *Transparency International*
FIF_{ct}	Financial freedom index of country c in period t; Source: *Heritage Foundation*
DCB_{ct}	Domestic credit provided by the banking sector in % of GDP of country c in period t; Source: *World Bank, World Development Indicator (WDI) database*
$NDTT_c$	Number of double tax treaties concluded by country c; Source: *United Nations Conference on Trade and Development (UNCTAD) database*
$NBIT_c$	Number of bilateral investment treaties concluded by country c; Source: *United Nations Conference on Trade and Development (UNCTAD) database*
$TCAP_{c,t-1}$	Sum of total assets of all firms in country c in period $t-1$; Source: *World Bank, World Development Indicator (WDI) database*