Essays on Corporate Taxation and Firm-Level Effects of Regulatory Interventions

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Preface

Firms and the state depend on each other in manifold ways. The corporate sector is an important contributor to economic growth and development. Societies benefit from technological progress and innovations rooted in entrepreneurial activity. Revenue from corporate income taxation is an important source of government funding in most countries around the world. Tax revenue is needed to finance health care systems, to provide education and to undertake investments in the public infrastructure, from which in turn firms benefit. Furthermore, firms rely on the legal institutions that the state provides. Stable business growth would not be possible without reliable property rights and sound laws that protect business interests. Corruption as well as underdeveloped financial systems have been shown to significantly hamper firm growth. Moreover, firms count on the state to intervene and level the playing field in the case of imperfect competition and market failures.

Yet, the differing objective functions of profit-maximizing firms and welfare-maximizing governments tend to cause strains in the relationship. According to PwC's 21st Annual Global CEO Survey, top executives see over-regulation as the top threat to business growth. Also the threat of an increasing tax burden is among the 10 most frequent answers (PwC, 2018). This explains, why firms put considerable effort into avoiding taxes via complex corporate structures. They put large amounts of resources into identifying and exploiting legal loopholes and mismatches in corporate tax systems across countries. Recent research from the Tax Justice Network suggests that global annual tax losses from legal tax avoidance and illegal tax evasion add up to 500 billion US dollars (Tax Justice Network, 2017). States react to this by coordinated initiatives at the international level, such as the OECD's plan to tackle base erosion and profit shifting (OECD, 2013).

Understanding the complex interplay between firms and the state lies at the core of this thesis. The main focus is on the empirical analysis of the development of rates and

revenues from corporate taxation over the last decades. In addition, this thesis shows that regulatory interventions can impact firms, even if they are not directed at the corporate sector. Results from the four papers comprising this thesis point out that policies should be designed carefully in order to avoid distortions that might impair the benefits of a thriving corporate sector. In the following, a brief overview on the content of the four chapters of this thesis will be given.

Chapter 1 presents joint work with Clemens Fuest and Felix Hugger and explains the composition of corporate tax revenues. A simple framework is introduced that splits changes in corporate tax revenue into changes in statutory tax rates, firm profits and changes in the definition of the tax base. The analysis is based on a large firm-level panel dataset covering data from 33 OECD countries over the period 1995 to 2016. We show that while the weighted measure of statutory corporate income tax rates fell by 16.5 percentage points over the period covered, total corporate tax revenue across all countries changed by just 0.07 percent. We find that the phenomenon of stable revenues despite falling tax rates can be explained in the following way: 36 per cent of the increase in the tax base is due to higher net financial income of firms, depreciation has declined by 37 per cent and 27 per cent is due to higher EBITDA. We find substantial heterogeneity in the developments when looking at individual countries.

Chapter 2 studies the non-linear relationship between statutory corporate tax rates and tax revenues. This paper, which is joint work with Clemens Fuest and Felix Hugger, uses country and firm-level data for up to 190 countries and covers the period 1965 to 2018. We find evidence for a robust Laffer curve type relationship between rates and revenues from corporate taxation. The revenue-maximizing tax rate is at 32.1 percent and therefore higher than statutory corporate income tax rates in most countries today. There is evidence for substantial heterogeneity across countries with low-income countries showing a significantly lower revenue-maximizing tax rate than high-income countries. Results from the macro data set are complemented by a firm-level analysis of corporate tax payments. The Laffer curve for corporate taxation is confirmed with the micro dataset, also when controlling for the key determinants of the tax base within the corporate sector that have been discussed in Chapter one of this thesis.

Chapter 3 explores firm-level determinants of effective tax rates and analyzes trends in the dispersion of effective corporate income tax rates across firms and over time, with a

special focus on digital firms. The analysis is based on a large firm-level data set, which covers consolidated financial statement data for over 100,000 firms from 138 countries. Results from pooled OLS and fixed effects regressions show that larger and more profitable firms face higher effective tax rates. The relation between the effective tax rate and R&D intensity, the debt ratio and cash holdings is found to be negative. The positive effect of firm size on the effective tax rate is even larger for digital firms, while there is no difference with regard to the influence of R&D intensity, the debt ratio and cash holdings. Contrary to non-digital firms, a higher share of intangible assets in total fixed assets is connected to a lower effective tax rate for digital firms. Both digital and non-digital groups show a wide dispersion of effective tax rates between the 10th and 90th percentile that stays rather constant over time, reflecting that firms are highly heterogeneous in tax relevant characteristics.

Chapter 4 shows that regulatory changes, even if not explicitly directed at firms, can have a measurable impact on the corporate sector. This chapter is based on joint work with Christa Hainz and studies the effects of the removal of a longstanding government guarantee for public banks in Germany. As the policy change only affected public banks, we employ a difference-in-differences analysis in order to identify effects on firms being customers of public banks as opposed to firms being solely affiliated with non-public banks. The paper uses survey data for the period 1998 to 2007 obtained from the ifo Investment Survey as well as balance-sheet information from BvD Amadeus. Our results show that public bank firms perceived a deterioration in their financing situation following the removal of the public guarantee in 2005. We do not find evidence for effects in terms of total investment and employment at the firm level.

The Appendices to the respective papers can be found at the end of each chapter. A consolidated bibliography is presented at the end of this thesis.

Chapter 1

Explaining corporate tax revenues

1.1 Introduction

Corporate income taxation continues to be an important source of revenue for governments. Data from the OECD shows, that corporate income tax (CIT) revenues contributed between 4.4 percent (Slovenia) and 21 percent (Chile) to total tax revenue in OECD countries in the year 2015 (OECD, 2017).[1] Looking at trends over time, corporate tax revenues are surprisingly stable despite pronounced cuts in statutory tax rates over the last decades. These developments of CIT rates and revenues may seem contradictory at first glance. Why have CIT revenues not declined given the pronounced decrease in statutory corporate income tax rates?

Several factors may have contributed to the observed stability of corporate tax revenues: firstly, many recent corporate tax reforms were characterized by a combination of rate cuts and base-broadening measures. Tax-cut cum base-broadening measures gained popularity for a number of reasons: broadening the tax base may decrease distortions caused by the corporate income tax and may result in better compliance due to reduced incentives for tax avoidance and evasion. Furthermore, if base broadening reduces the complexity of the tax system, administration and enforcement costs fall (OECD, 2010a). Secondly, the share

This chapter is joint work with Clemens Fuest and Felix Hugger.

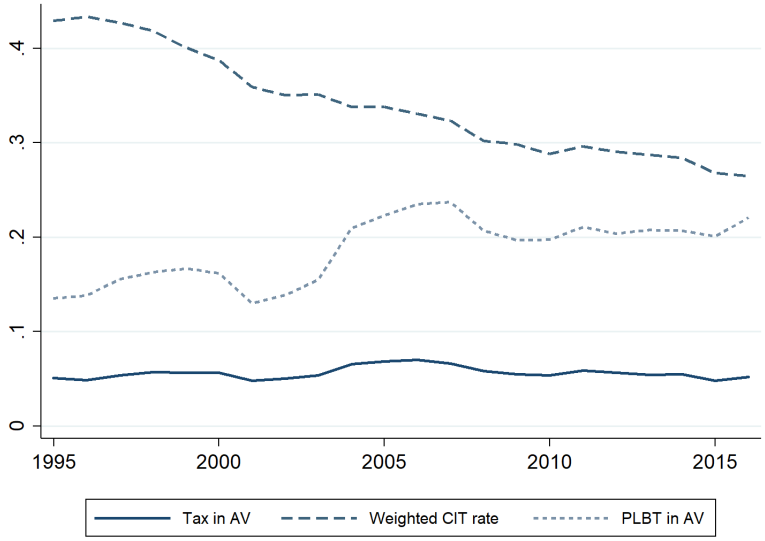
[1] In the OECD, the average share of corporate taxes in total tax revenue was 8.13 percent in 1995 and 8.86 percent in 2015. Numbers are obtained from the OECD Revenue Statistics, available at `https://stats.oecd.org/index.aspx?DataSetCode=REV` (last access August 16, 2018)

of income declared as corporate income increased in many countries over the last decades. The share of the corporate sector in total value added increased from 60.4 percent in 1995 to 65.7 percent in 2005. One factor explaining the growing corporate sector share is the changing industry composition within countries in the OECD. Sectors where incorporated firms dominate have grown faster than other sectors. Thirdly, there is an increase in corporate profitability. This is illustrated by Figure 1.1, which shows that the share of corporate profits before taxes in value added of incorporated firms has increased significantly, from 14 per cent in 1995 to 22 per cent in 2016.[2]

It is the purpose of this paper to investigate the factors that have led to the growth of the corporate tax base, which has prevented corporate tax revenues from falling despite declining tax rates. Our analysis is based on a comprehensive firm-level dataset covering 33 OECD countries over the period 1995 to 2016. Using firm level data allows us to disentangle the role of different components of corporate profits, in particular the role of depreciation, interest costs and financial income of firms, and changes in profitability driven by the development of earnings before interest, taxes, depreciation, and amortization. Our key findings are as follows: 37 percent of the increase in the tax base is caused by lower depreciation, 27 percent is due to higher profitability, and 36 percent of the increase is due to higher net financial income of firms. Within financial income, interest expenditure has declined substantially. At the same time, however, financial income has declined, too, reducing the net effect to just over one third of the change in profits. It is important to note that these results are derived from an unbalanced panel. Although the tax revenue generated by the unbalanced panel is close to aggregate tax revenue, we find substantial heterogeneity in the developments when looking at individual countries.

[2]Note that this is the change in profitability for an unbalanced sample of firms, as will be explained in greater detail below. The growing share of profits in value added is also documented in other studies (e.g. Piotrowska and Vanborren, 2008).

Figure 1.1: CIT rates and revenue from the corporate sector



In the literature, various papers analyze the development of corporate tax revenues and the relationship between corporate tax rates and bases. Clausing (2007) looks at variation of CIT revenues among OECD countries over the period 1979 to 2002 and focuses on the size and profitability of the corporate sector. She finds that the tax-to-GDP ratio is larger for countries with more profitable firms and larger corporate sectors measured as the sector's share in total GDP. Here, the positive effect of the corporate profit rate is stronger than the effect of the rising corporate sector share. Sœrensen (2006) looks at the development of corporate income tax revenues in OECD countries over the period 1982 to 2004 and analyzes the relative influence of increasing incorporation, shifting between personal and corporate income, and base broadening. In line with de Mooij and Nicodeme (2007), he concludes that stable revenues are largely driven by increasing incorporation and income shifting. Piotrowska and Vanborren (2008) focus on the European Union and find corporate tax revenues to be stable at around 3% of GDP on average over the period 1995 to 2004. However, they also find heterogeneity across countries with some countries experiencing decreases in CIT revenue while finding rising revenues for the majority of countries. They see the effect of incorporation to be more pronounced than changes in tax burdens and profitability. There are several papers that try to shed light on developments with regard to CIT base definitions. Blouin et al. (2014) focus on caps in interest deductibility. They compile a detailed dataset on characteristics of thin capitalization regimes and compare

those for 54 countries over the years 1982 to 2004. They find the number of countries with a thin capitalization regime to be increasing over time. In 2004, 50 percent of the countries in their sample have an explicit set of thin capitalization rules. Kawano and Slemrod (2016) construct a dataset covering a wide range of aspects of tax base definitions such as R&D tax credits, loss carry-forward/carry-back rules, controlled foreign company (CFC) legislation, and depreciation allowances. They cover OECD countries between 1980 and 2004 and find that the majority of tax reforms combined changes in statutory rates with changes in the definition of the tax base. They find heterogeneity in the direction of the base change: decreases in the CIT rate were combined with base broadening measures in 37 percent of the cases and with base narrowing measures in 26 percent of the cases. While the papers presented differ in the time period and regions analyzed, they all build their analysis on aggregate data at the country level. There is a small number of papers using sectoral or firm level data to investigate revenue trends. Devereux et al. (2004) analyze the development of corporate tax revenue on the UK and emphasize the role of financial sector profits. Auerbach (2008) focuses on the US and argues that the increase in the average CIT rates observed in the early 2000s is largely due to loss offset limitations. In a recent contribution, Nicodeme et al. (2018) use sector level data from the EU for the period 1995 to 2015, and find that the stability of CIT revenues is due to base broadening measures.
Our paper presents an alternative approach by providing an analysis based on micro data obtained from the Bureau van Dijk's (BvD) Orbis database. Using firm-level balance-sheet data allows for a more thorough analysis of the components of the tax base. Besides disentangling influencing factors of tax payments at the firm level, we quantify their relative importance in explaining stable revenues at the aggregate level. However, there are some drawbacks to our approach. Some factors which may drive corporate tax revenues cannot be observed. One example is corporate sector size, as we are bound to observe changes only *within* the corporate sector. In addition, some countries have very limited data coverage in BvD Orbis, which confines the representativeness of our data. We will address these data concerns in more detail in the discussion section.

The rest of the paper is structured as follows: Section 1.2 introduces the conceptual framework of our analysis. Section 1.3 describes the data set, while Section 1.4 presents the results. We first look at developments across all countries in our sample and then pay attention to country heterogeneity by looking at selected countries individually. Section 1.5 puts our obtained results into perspective and discusses further relevant factors that explain developments with regard to CIT revenues. Section 1.6 concludes.

1.2 Conceptual framework

In the literature on the relationship between tax rates and revenues, the standard approach (introduced by Sœrensen (2006)) decomposes changes in CIT revenues relative to GDP (R/GDP) into changes in the size or structure of the business sector (B/GDP and C/B) and changes with regard to the effective tax burden of the corporate sector (R/C):

$$\frac{R}{GDP} = \frac{R}{C} \cdot \frac{C}{B} \cdot \frac{B}{GDP} \tag{1.1}$$

with R being corporate tax revenue, C representing total corporate income, and B total business income.[3]

Our conceptual framework, in contrast, may be regared as a "bottom-up approach": we use firm-level data, which we aggregate by year over all countries and firms in our sample. This allows us to disentangle the different components of the corporate income tax base and to quantify their respective contributions to aggregate CIT revenue.

With regard to CIT revenues, we differentiate between hypothetical tax revenue ($Hyp.\ Revenue$) and actual tax revenue ($TAXA$). Information on actual tax payments is directly obtained from financial statements of firms.[4] Aggregate actual tax revenue in year t is equal to the sum of individual tax payments ($TAXA$) over all firms in the dataset. Hypothetical tax revenue at the firm level is equal to the statutory tax rate of the country the firm is located in multiplied with the tax base. The tax base of a firm is equal to its pre-tax income $PLBT$. With τ indicating the statutory tax rate, aggregate hypothetical tax revenue in year t is then equal to:

$$\sum_{j,i} Hyp.Revenue_{j,i,t} = \sum_{j,i} (\tau_{j,i,t} \cdot PLBT_{j,i,t}) \tag{1.2}$$

Equation 1.2 indicates that aggregate hypothetical revenue in year t is equal to the sum of revenues over all firms j and countries i. This paper focuses on changes in the composition of the tax base. Using financial statement data, the tax base can be decomposed into

[3] Soerensen refers to B as "total profit earned in the economy as a whole" (Sœrensen, 2006, p.8). B therefore also includes profits that are not accrued to the corporate sector.

[4] Variables that are directly observed in the data are labeled with capital letters, such as $TAXA$, $PLBT$, etc. Other variables such as $Hyp.\ Revenue$ are computed.

three parts: earnings before interest, taxes, depreciation and amortization ($EBITDA$), financial profit/loss ($FIPL$) and financial depreciation ($DEPR$). Making use of this decomposition, we can rewrite equation 1.2 in the following way:

$$\sum_{j,i} Hyp.Revenue_{j,i,t} = \sum_{j,i} [\tau_{j,i,t} \cdot (EBITDA_{j,i,t} + FIPL_{j,i,t} - DEPR_{j,i,t})] \tag{1.3}$$

$EBITDA$ indicates how much profit the firm generates with its present assets and ordinary business activities. This measure allows for a comparison of profitability across firms despite any differences in their leverage, location, or collection of assets, as it does not take into account interest payments, taxation, and depreciation. $FIPL$ is the financial net result, defined as the difference between financial revenue and financial expenses. It includes interest payments of firms as part of financial expenses. In some specifications, we will split $FIPL$ into interest payments ($INTE$) and the rest of the financial net result ($Other\_FIPL$) in order to analyze developments with regard to interest payments of firms. $Other\_FIPL$ can be interpreted as the net financial result excluding interest payments. $DEPR$ represents depreciation and amortization. Financial depreciation stated in financial statements is likely to differ from depreciation rules applied for tax purposes. Therefore, we do not claim that observed developments reflect changes in tax depreciation rules in the context of base-broadening reforms.[5]

The analysis in most parts of the paper is based on data from an unbalanced sample of firms. This sample of firms changes over time in terms of the total number of observations available as well as in terms of industry, size, and country composition. To account for these issues, we present results obtained from the analysis of the unbalanced sample as shares in added value. We chose added value for two main reasons: Firstly, it is widely available across firms. Secondly, aggregate value added is a close proxy for GDP as Figure A1 in the Appendix shows and therefore offers an intuitive interpretation of the results. The statutory CIT rates used are computed as a added-value weighted mean to reflect that larger firms contribute a larger share of tax revenue.[6]. Overall, computed hypothetical

[5] A detailed summary of variable definitions is contained in Table A1 in the Appendix.

[6] To be more specific, we compute the weighted CIT rate for year t in the following way: $\left[\frac{\sum_{j,i} \tau_{j,i,t} VA_{j,i,t}}{\sum_{j,i} VA_{j,i,t}}\right]$ with VA indicating value added of firm j in country i.

tax revenue and actual tax revenue obtained from our data ($TAXA$) are very similar in magnitude and show the same trend over time.

To deal with potential concerns regarding the unbalancedness of our panel, we also report results for a shorter, balanced panel of firms for the years 2004 to 2016. For the balanced panel, we report the developments of tax base components and revenues as shares in added value as well as in absolute terms. However, the balanced panel is not without imperfections as well. For example, it does not reflect structural changes in the firm and industry composition that might be relevant for the development of revenues.

The stability of corporate tax revenues despite pronounced cuts in statutory CIT rates can only be explained with an compensating increase in the tax base. Making use of the presented decomposition of tax base components at the firm level, we expect to see the following developments in our sample over time:

1. Due to a different treatment of depreciation for accounting and tax purposes, declining depreciation allowances as a part of base-broadening reforms will not be reflected in our data. Therefore, we expect $DEPR$ to stay rather stable over time. A slight negative trend might be visible due to weak downward trends in investment in physical assets in many advanced economies.[7]

2. Interest rates significantly declined in all OECD countries over the past 10 years. This will affect reported financial income of firms ($FIPL$). However, the sign of the effect remains unclear and depends on the leverage structure of firms. Declining interest rates lead to lower interest expenses but also to reduced financial income. Moreover, companies may have changed their financing structure. If companies are net debtors on average, one would expect $FIPL$ to fall over time.

3. We expect to see a positive trend in $EBITDA$ at the aggregate level as previous research suggests a rise in the profitability of firms in OECD countries (OECD, 2006).

1.3 Data

The firm-level data used in the analysis is obtained from BvD Orbis. The data covers the period 1995 to 2016 and contains balance-sheet information on firms from 33 OECD

[7] See for example Crass, Licht and Peters (2014), who provide evidence for German firms by finding an increasing focus on investments in intangible assets.

countries. We complement our firm-level data with relevant macro data for the countries in our sample. Deflators for the analysis of absolute values in our balanced panels are taken from the World Bank's World Development Indicators database. Information on the development of gross value added, GDP, and the size of the corporate sector comes from the OECD Annual National Account Statistics. Data on statutory tax rates is obtained from several issues of KPMG's Corporate Tax Surveys and EY's Annual Worldwide Corporate Tax Guides. All CIT rates are the top statutory rates taking into account all levels of government.[8] Details on data sources and definitions are provided in the Appendix. Table A2 in the Appendix summarizes the steps to the final samples. After dropping data from consolidated group-level accounts and excluding implausible values and outliers, our final sample includes 12,100,556 observations from 2,608,778 firms.[9] This gives an average of 4.6 observations per firm.

In our analysis using the unbalanced full panel, we express all relevant variables as shares in value added. Value added at the firm level reflects the value of goods or services produced after accounting for intermediate inputs. At the aggregate macro level, gross value added serves as a basis for computing the gross domestic product by adding the public sector share (taxes minus subsidies). Figure A1 in the Appendix shows that the ratio of gross value added to GDP is constant over time at around 0.9.

Since the number of firms being included in the BvD Orbis database strongly increases over the years, we also construct a balanced panel data set to account for potential biases stemming from a changing composition of firms in the data over time. The balanced panel also allows for an analysis of absolute values of revenues, taxation, and firm profits after accounting for inflation. Our balanced sample covers 13 years from 2004 to 2016 and includes 67,241 firms from 19 countries. Tables A3 and A4 in the Appendix give an overview on the number of firms and observations by country in the respective samples. As a robustness check, we construct a dataset with imputed values. Here, we also include firms for which there is a one-year reporting gap in the covered period from 2004 to 2016. This imputed panel contains observations from 108,631 firms.

[8] CIT rates of a country with different regional or local taxes reflect averages. Deductibilities of regional or local taxes from federal taxes are taken into account.

[9] To be more specific, we excluded the observations in the 1st and 99th percentile of the distribution of our key variables.

An important question for our analysis is how well the companies in our sample cover the economy as a whole. Table 1.1 shows the coverage of the unbalanced sample in terms of added value. Coverage varies considerably between countries. For the full sample period, the sample used covers more than a third of added value in Spain (37.89 percent), Italy (34.68 percent), and the Czech Republic (33.72 percent), but less than one percent of added value for Turkey (0.22), Ireland (0.39), Greece (0.52), and the United States (0.97). Since coverage of US firms is low, Table 1.1 reports values with and without the US share. The average coverage of all countries without the US is 23.1 percent of total added value between 1995 and 2016. In general, coverage increases strongly over time, from about 6 percent of added value for the period 1995 to 1999 to 26.8 percent (2005-2010) and 36.1 percent for the years between 2010 and 2016. If the added value of the US and the US firms in the sample is taken into account, the coverage is 13.4 percent of added value on average. To put this into perspective, Kalemli-Ozcan et al. (2015) provide an in-depth analysis on how well Orbis covers gross output of the corporate sector in individual countries. In line with the numbers presented in Table 1.1, they also find significant heterogeneity in coverage across countries and improvements in coverage over time.[10]

Table 1.1: Coverage in terms of total added value

Period	**Coverage (without US)**	**Coverage (including US)**
1995 – 1999	6.01	4.97
2000 – 2004	10.97	5.82
2005 – 2009	26.83	15.51
2010 – 2016	36.08	20.51
1995 – 2016	23.10	13.36

Notes: Coverage in terms of added value (in percent) for the unbalanced panel, calculated as sum of added value in the sample divided by the sum of added value of all countries in the dataset in a given year.

Table 1.2 reports summary statistics on our main variables. Section A of Table 1.2

[10]The numbers obtained by Kalemli-Ozcan et al. (2015) regarding data coverage are higher than what we report. This is likely due to three facts: firstly, we exclude a significant number of firms from our sample, due to implausible values in some variables. Secondly Kalemli-Ozcan et al. (2015) look at coverage in terms of gross output (turnover) instead of added value. Thirdly, they only include European countries, which are covered relatively well. Our reported average coverage would increase if we did not include any non-European OECD countries in the sample.

reports summary statistics in terms of absolute values at the firm-level. The average firm in our sample has slightly over 60 employees and total assets in the range of about 16 million Euros. The mean value of $FIPL$ is negative, which means that on average, firms' financial expenses are larger than their financial revenues. $INTE$ reflects interest expenses, which are part of the firms' financial expenses. With $Other\_FIPL$ being computed from $FIPL = Other\_FIPL - INTE$, it reflects the net financial result of firms aside from interest payments. It is positive but smaller in magnitude than $INTE$, such that we get the negative net result indicated by $FIPL$. $DEPR$ is positively defined and shows a mean value of 460,000 Euros. $EBITDA$ of our mean firm is slightly above 1.2 million Euros. Taking into account the median values indicated in the table, we see that the sample comprises many very small firms. However, by weighing all relevant variables in terms of added value at the firm level, it is accounted for that these firms do not significantly contribute to overall tax revenue. Our full sample also contains loss-making firms and firms with negative tax payments in order to provide a full picture on the distribution of profits within the corporate sector. In Section 4.3 we will also report results for a sample that excludes firms with negative profits and show that results are not distorted by including them in our main specification. $TAXA$ reflects tax payments of the firm as indicated in the financial statements of the firm. We are aware that book-tax differences exist and therefore information from accounting data presents an imperfect measure of actual tax payments.[11] Also our measure of the tax base, $PLBT$ has flaws in this regard. As previously indicated, $DEPR$ just captures financial depreciation that follows different rules than depreciation schemes allowed for tax purposes. While financial statements are compiled following international financial reporting standards (IFRS) or generally accepted accounting principles (GAAP), actual tax payments are determined by the respective national tax laws. However, corporate tax return data is confidential and thus not available for analysis. Given that we are mainly interested in depicting developments over time at the aggregate level, we are confident that our data picks up a significant share of relevant trends.

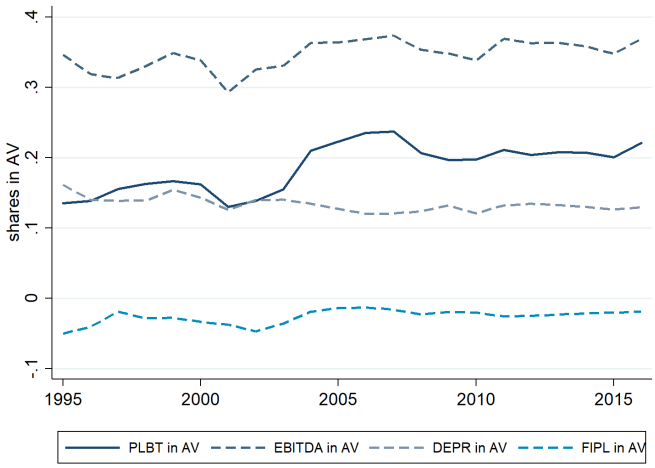
[11] Graham et al. (2012) as well as Hanlon and Heitzman (2010) provide excellent overviews on the accounting literature on book-tax differences. They stress that taxation indicated in financial statements does not reflect temporary differences, such as accelerated depreciation schemes that would reduce current tax expenses but increase deferred tax expenses by the same amount and therefore provides an imperfect proxy for actual tax payments.

Table 1.2: Summary Statistics on balance-sheet variables

	Mean	Std. Dev.	Median	Min.	Max.	Obs.
A: absolute values (firm-level)						
TOAS	15,936.12	617,571.30	1,611.00	0.72	659,000,000	9,738,931
EMPL	62.27	1,273.00	10	0	1,014,335	9,433,812
AV	3,555.35	134,349.93	438.02	1.36	365,000,000	12,100,556
PLBT	725.11	23,020.78	42.00	-3,414,998.30	14,215,468.25	12,100,556
EBITDA	1,266.95	36,103.92	96.63	-1,384,824.00	17,688,823.00	12,100,556
FIPL	-80.84	6,847.84	-5.00	-5,072,000.00	3,960,655.25	12,100,556
INTE	229.76	13,921.18	9.27	-74,855.00	32,768,944.00	12,100,556
Other_FIPL	148.92	12,970.45	0.76	-2,789,905.50	32,768,694.00	12,100,556
DEPR	460.95	13,703.02	26.00	0.00	9,002,999.92	12,100,556
TAXA	201.32	6,612.54	10.31	-495,366.82	3,080,000.00	12,100,556
B: Shares in added value (yearly aggregates)						
TOAS	3.80	0.66	4.15	2.45	4.47	9,738,931
PLBT	0.21	0.02	0.21	0.09	0.24	12,100,556
EBITDA	0.36	0.01	0.36	0.29	0.37	12,100,556
FIPL	-0.02	0.01	-0.02	-0.08	-0.01	12,100,556
INTE	0.06	0.01	0.06	0.05	0.11	12,100,556
Other_FIPL	0.04	0.01	0.04	0.03	0.07	12,100,556
DEPR	0.13	0.01	0.13	0.12	0.16	12,100,556
TAXA	0.06	0.01	0.05	0.04	0.07	12,100,556

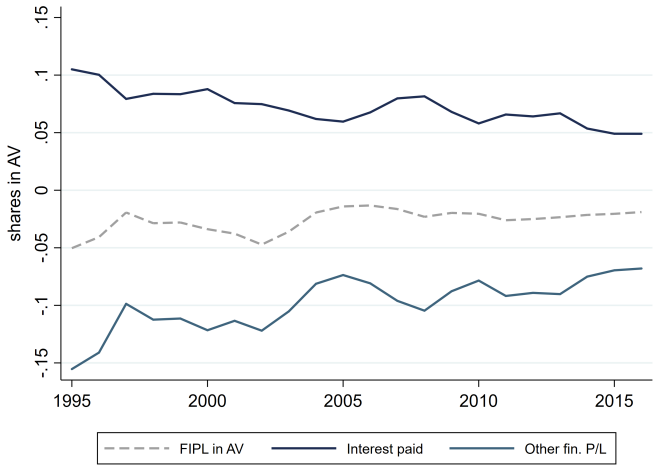
Notes: Part A presents summary statistics for the unbalanced panel at the firm level. *EMPL* indicates the number of employees in a firm (in persons), all other values in the upper part of the table (A) are in thousand Euros. Variables in the lower part (B) are aggregate shares in added value. In Part B, aggregation was done over all firms in a given year.

Figure 1.2: Components of the corporate tax base



Notes: Values are computed using the unbalanced sample and represent shares in added value.

Figure 1.3: FIPL: Net financial result of firms



Notes: Values are computed using the unbalanced sample and represent shares in added value

Part B of Table 1.2 shows the main variables as shares of value added. They are computed by summing the respective variable over all firms in a year and dividing it by the total sum of added value in that year. The mean value for $PLBT$ of 0.21 is explained by the sum of $EBITDA$ (0.36) and $FIPL$ (-0.02), minus the value of $DEPR$, which is 0.13. Figure 1.2 shows a graphical representation of the components of pre-tax profits ($PLBT$) between 1995 and 2016. The solid line represents $PLBT$ as a share of added value. The dashed lines show the developments in $EBITDA$, $DEPR$, and $FIPL$. Figure 1.3 disentangles the financial result of firms ($FIPL$) further into interest expenses and the net financial result without interest paid. We can see a negative trend in interest payments. This is likely due to two reasons: firstly, many countries included caps on interest deductibility as part of base broadening reforms as previous research showed (see for example Blouin et al., 2014), which might make debt financing less attractive. Falling interest payments could therefore reflect changes in the financing structure of firms. Figure A8 in the Appendix shows the development of the share of long-term debt in total assets. We see a positive trend that is interrupted by the financial crisis in 2008. After 2012, the positive trend picks up again. Therefore, less debt financing is unlikely to drive the observed negative trend in interest payments. Secondly, especially in the time after 2008, there was a pronounced negative trend in interest rates in most OECD countries. We expect the low interest rate environment to be the main driver of the observed negative trend.

Figure 1.2 also shows the development of depreciation over time. We see a decline in depreciation for the first 10 years of our sampling period, which is consistent with previous findings in the literature (see for example Devereux et al., 2002). Since 2006, the share of depreciation in added value has been rather stable at around 0.13 percent of value added. $EBITDA$, in contrast, shows a strongly positive trend over the period from 2001 to 2007. It declined during the crisis years 2008 to 2010 from 0.38 to around 0.34 percent of value added. Between 2011 and 2015, $EBITDA$ remained rather stable and seems to have picked up its positive trend in the last year of our sample period. Regarding the financial results of firms, $INTE$ and the rest of the financial net result add up to a value converging towards zero with a value of around 0.01 percent of value added in 2016.

1.4 Results

1.4.1 Full sample

Figure 1.4 shows percentage point changes in CIT rates, tax revenue, and our measure of the tax base, $PLBT$, across all countries in our sample. We split the sample into 4 sub-periods, 1995 to 2000, 2000 to 2005, 2005 to 2010, and 2010 to 2016, to better capture the heterogeneity in developments within the different periods. Table 1.4 shows the corresponding numbers and adds developments of the components of the tax base. The $CITrate$ column in Table 1.4 decomposes the percentage point change of 16.46 in Figure 1.4 into changes in the respective sub-periods. While CIT rates decreased throughout all sub-periods, the overall decline in CIT rates mainly stems from the earlier years in our sample. In the years 2010 to 2016 the decrease in statutory rates was less pronounced, with a value of 2.35 percentage points. Revenues from corporate taxation increased in the first half of the sample period by a total of 1.74 percentage points in added value, but declined by 1.46 percentage points between 2005 and 2010. This decline was due to a combination of lower rates and a smaller tax base due to the financial crisis. In all other periods, the tax base measure $PLBT$ increased and thus offset or even overcompensated the effects of the declining tax rates. The strongest increase of the share of $PLBT$ in added value occurred between 2000 and 2005 (6.1 percentage points). Between 2010 and 2016 revenues remained more or less constant (– 0.20 percentage points).

The development of the tax base can be investigated in more detail. To recall, $PLBT$ can be decomposed in the following way: $PLBT = EBITDA + FIPL - DEPR$. The strong increase in $PLBT$ in the first ten years of the sample (1995 to 2000 and 2000 to 2005) is driven mainly by a rising share of financial profits in added value (+ 3.7 percentage points in total between 1995 and 2005) and decreased depreciation (– 3.4 percentage points). $EBITDA$ only increased by 1.8 percentage points in added value between 1995 and 2005. Looking at $INTE$ reveals that the positive financial result of firms during that time seems to been driven by a pronounced decline in interest expenses. The contraction of the tax base after 2005 was primarily due to a decline in $EBITDA$ of 2.6 percentage points. In addition, weaker financial results compensated for lower deprecation. The increase in net financial income of firms over the full sample period by 3.1 percentage points was mainly due to the falling interest expenses (minus 5.6 percentage points of value added). For the entire period of 1995 to 2016 our key results regarding the factors driving the develop-

ment of the corporate tax base are as follows: Aggregate firm pre-tax profits, our measure of the tax base, increased by 8.6 percentage points. This led to a marginal increase in corporate tax revenue of 0.07 percentage points in added value across all countries. 36 percent of this increase in the tax base can be attributed to higher net financial income of firms, depreciation has declined by 37 percent, and 27 percent is due to higher $EBITDA$.

Table 1.3: Changes in tax revenues (in percent)

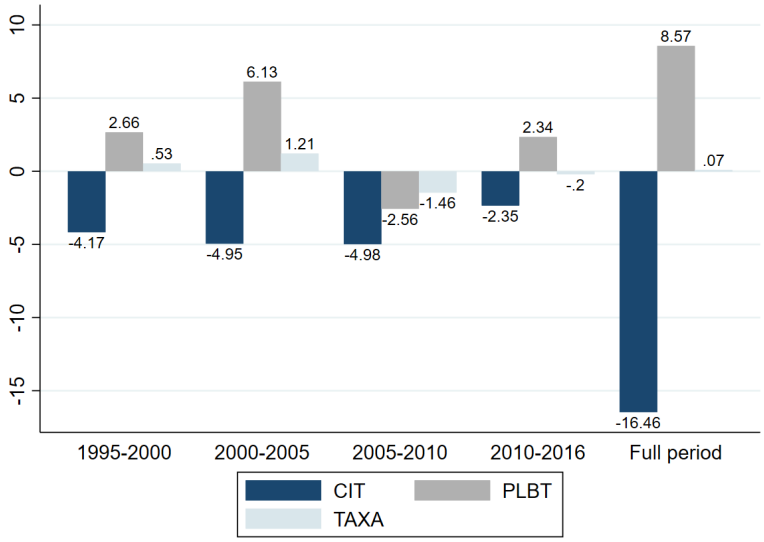
Period	**CIT rate**	**PLBT**	**Hyp. Rev.**	**Act. Rev.**
1995 – 2000	– 9.7	+ 19.7	+ 8.1	+ 10.4
2000 – 2005	– 12.8	+ 37.9	+ 20.3	+ 21.5
2005 – 2010	– 14.7	– 11.5	– 24.5	– 21.4
2010 – 2016	– 8.2	+ 11.8	+ 2.7	– 3.8
Full period	– 38.3	+ 63.4	+ 0.8	+ 1.3

Notes: All values are computed using the unbalanced panel and present changes in percent.

Table 1.3 summarizes changes in the mean statutory $CITrate$ and $PLBT$ in percent. It furthermore includes two columns, which show the hypothetical revenue ($Hyp.Rev.$) and a measure of actual tax revenue ($TAXA$).[12] Hypothetical revenues are computed by multiplying our tax base measure $PLBT$ with an added value weighted mean of statutory tax rates. Differences between actual and hypothetical revenues occur due to the fact that our statutory CIT variable does not perfectly capture the applicable CIT rate for a firm due to local or regional differences in taxation within a country and the aforementioned book-tax differences regarding the tax base. According to Table 1.3, the percentage change in hypothetical revenue of 0.8 percent is explained by the rate change of – 38.3 percent and the base change of + 63.4 percent ($0.8 = (-38.3\% + 63.4\% + ((-38.3\%) * 63.4\%))$). The actual revenue change of + 1.3 percent is close to the development expected based on this calculation.

[12] Actual revenue ($TAXA$) is the sum of taxation as stated in financial statements of firms and obtained from BvD Orbis. As previously discussed, we are aware of book-tax differences and that taxation figures from financial statements provide an imperfect proxy of actual tax payments.

Figure 1.4: Trends in CIT rates, the corporate tax base and tax revenue



Notes: The values indicate changes in percentage points in our weighted measure of statutory CIT rates (CIT), actual tax revenues (TAXA) and the corporate tax base (PLBT).

Table 1.4: Percentage point changes across all countries

Period	CIT	TAXA	PLBT	EBITDA	DEPR	FIPL	INTE
1995 – 2000	– 4.17	+ 0.53	+ 2.7	– 0.8	– 1.8	+ 1.7	– 1.7
2000 – 2005	– 4.95	+ 1.21	+ 6.1	+ 2.6	– 1.6	+ 2.0	– 2.8
2005 – 2010	– 4.98	– 1.46	– 2.6	- 2.6	– 0.7	– 0.6	– 0.2
2010 – 2016	– 2.35	– 0.20	+ 2.3	+ 3.1	+ 0.9	+ 0.1	– 0.9
Full period	– 16.46	+ 0.07	+ 8.6	+ 2.3	– 3.2	+ 3.1	– 5.6

Notes: The values in this table represent changes in percentage points and are computed using the unbalanced panel. Numbers in this table correspond to the graphical representation in Figure 1.4. $\Delta PLBT = \Delta EBITDA + \Delta FIPL - \Delta DEPR$. Corresponding changes in percent can be found in the Appendix in Table A7.

In sum, the expectations, formulated in Section 1.2, were partially confirmed. (1) Depreciation declined over the full sample period and in three out of the for sub-period. This is consistent with most reforms being of the tax cut cum base broadening type, which often includes the introduction of more restrictive depreciation schemes. (2) The variable for

financial profit/loss by firms, $FIPL$, is increasing in most periods. This is mainly due to decreasing interest expenses. Since its values are negative, this is congruent with $FIPL$ converging towards zero. (3) $EBITDA$ increased for the full sample period, indicating increasing corporate profitability, but this results only holds for two of the sub-periods.

1.4.2 Heterogeneity across countries

We look at the development of the components of $PLBT$ for six countries in our sample in more detail: Germany, Spain, Italy, Great Britain, France, and Sweden. We chose those six countries due to their good firm coverage in Orbis [13] and because they offer variation in their CIT rate due to tax reforms over our period of interest. Looking at individual countries allows for a more thorough analysis of conducted tax reforms and their impact on tax revenues. Table 1.5 shows developments within the countries for the period 1995 to 2016 based on the unbalanced panel. Part A of the table explains the changes in tax revenues in percentage changes, while part B of Table 1.5 summarizes the developments of tax base components in percentage points.

Table 1.5 indicates substantial heterogeneity in the developments across the six countries. While tax revenue was rather stable in the United Kingdom over the 22-year period, it increased in Germany, France, and Spain, but decreased in Italy and Sweden. All countries cut their statutory CIT rates between 1995 and 2016, but the cut was most pronounced in Germany (49.63 percent or 29.28 percentage points) and Italy (40.98 percent or 21.80 percentage points). At the same time, the tax base as a share of added value grew in five out of the six countries, the only exception being Sweden. In France and Germany, the share of the tax base in added value more than doubled (+ 172.62 percent and + 120.46 percent respectively). In sum, the changes in CIT rates and the tax base explain the development of revenues relatively well for Germany, Italy, Sweden, and the UK. Revenues in France grew less than one would expect based on CIT rate and tax base changes; in Spain revenues increased, even though one would expect more or less table revenues.

The development of the tax base in added value is decomposed in part B of table 1.5. As discussed in the previous section, the tax base measure ($PLBT$) can be decomposed into

[13] The unbalanced sample covers on average 28.5 percent of added value between 1995 and 2016 for these six countries.

three components: EBITDA, financial profits ($FIPL$), and depreciation ($DEPR$). While the tax base rose in five countries, the driving forces behind this development varied. In Germany, the UK, and France, the tax base increased by around 10 percentage points in added value. While in Germany and the UK, this was due to rising EBITDA and a simultaneous decline in depreciation, the development in France was mainly driven by increasing financial profits.[14] Spain showed a development similar to France, but at slightly lower levels, resulting in an expansion of the tax base by 6.61 percentage points.

Table 1.5: Explaining changes in revenues and the tax base

A: Explaining changes in tax revenues (percentage changes of ratios)				
Country	**CIT rate**	**PLBT**	**Hyp. Revenue**	**Act. Revenue**
Germany	– 49.63	+ 120.46	+ 11.05	+ 13.89
Italy	– 40.98	+ 11.18	– 34.38	– 21.62
France	– 9.17	+ 172.62	+ 147.63	+ 16.14
Spain	– 28.57	+ 39.12	– 0.63	+ 25.83
Sweden	– 21.43	– 40.23	– 53.04	– 67.93
UK	– 39.39	+ 64.63	– 0.23	+ 0.73
B: Explaining changes in the tax base (percentage point changes of ratios)				
	EBITDA	**FIPL**	**DEPR**	**PLBT**
Germany	+ 7.33	– 0.34	– 3.52	+ 10.52
Italy	– 13.70	+ 5.14	– 10.56	+ 2.00
France	+ 0.55	+ 7.55	– 2.67	+ 10.77
Spain	+ 0.07	+ 6.92	+ 0.38	+ 6.61
Sweden	– 24.95	+ 6.45	– 5.08	– 13.41
UK	+ 11.73	0.06	+ 2.62	+ 9.18

Notes: All values are computed using the unbalanced panel. While part A reports changes in percent, part B reports changes in in percentage points.

In Italy and Sweden the share of EBITDA in added value declined between 1995 and 2016 (– 13.70 and – 24.95 percentage points, respectively). The rising financial profits and especially lower depreciation compensated this development in Italy, resulting in a slight

[14]The increase in financial profits in France was again due to a sharp decline in interest payments of – 16.62 percentage points in added value. In the UK, interest payments only declined by 4.29 percentage points; in Germany, they even rose by 0.28 percentage points in the same period.

expansion of the tax base (+ 2 percentage points). In Sweden, financial profits and depreciation also offset some of the effects of declining EBITDA, but overall the tax base still shrunk by 13.41 percentage points.

Looking at individual countries, allows to investigate the effects of specific tax reforms. Germany introduced several major changes in its CIT system between 1995 and 2016 and is therefore a good case to be discussed in more detail. Between 1999 and 2001, CIT rates were reduced from over 50 percent to 38.4 percent (consisting of a CIT rate of 25 percent, a trade tax of 19.5 percent and the solidarity surcharge of 5.5 percent). Next to the change in the statutory tax rate, the reform introduced further amendments to the tax system such as a uniform taxation for accumulated earnings and dividends. In 2002, the full imputation system was replaced by a half-income system (Schneider, 2000). In 2008, the CIT rate was lowered again, from 38.4 percent to slightly below 30 percent. Again, the reform was accompanied by some base-broadening measures such as an interest stripping rule and the introduction of a withholding tax on capital income like interest and dividends (Stimmelmayr, 2015).

These tax reforms are visible in the top left part of Figure 1.5.[15] At the same time, revenues remained very stable at around 5 percent of added value. Two temporary slips in 2001 to 3.3 percent and 2009 to 4.3 percent can be attributed to economic crises and a corresponding decline in the tax base. Figure 1.5 also shows the development of the components of the tax base (top right), financial profits (bottom left), and the development of hypothetical revenue (bottom right). Table 1.6 summarizes these developments in 5-year intervals.

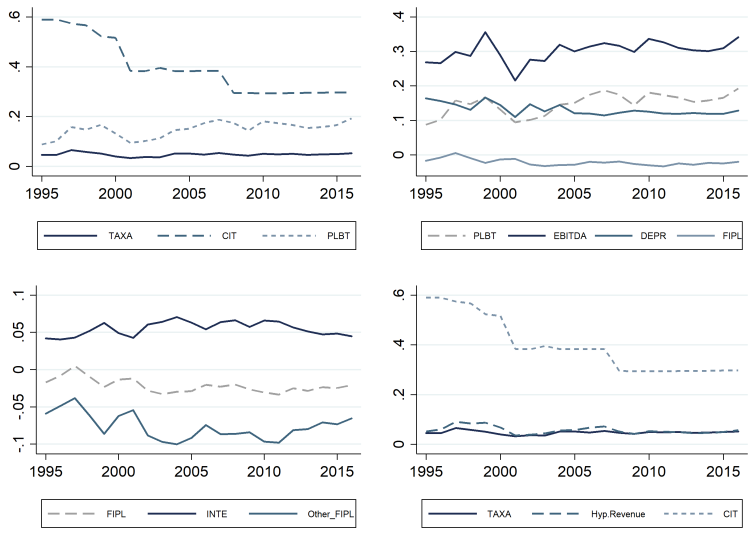
[15]The corresponding Figures for Italy, France, Span, Sweden, and the UK are shown in the Appendix.

Table 1.6: Development over time in Germany

Period	CIT rate	TAXA	PLBT	EBITDA	FIPL	DEPR
1995 – 2016	– 29.3	+ 0.6	+ 10.5	+ 7.3	– 0.3	– 3.5
	(– 49.6 %)	(+ 13.9 %)	(+ 120.5 %)			
1995 – 2000	– 7.4	– 0.6	+ 4.5	+ 2.1	+ 0.4	– 1.9
	(– 12.5 %)	(– 13.3 %)	(+ 51.0 %)			
2000 – 2005	– 13.3	+ 1.2	+ 1.9	+ 1.1	– 1.6	– 2.4
	(– 25.8 %)	(+ 29.6 %)	(+ 14.5 %)			
2005 – 2010	– 8.9	– 0.2	+ 3.0	+ 3.6	– 0.2	+ 0.5
	(– 23.2 %)	(– 3.3 %)	(+ 19.9 %)			
2010 – 2016	+ 0.3	+ 0.2	+ 1.2	+ 0.5	+ 1.0	+ 0.3
	(+ 1.1 %)	(+ 4.8 %)	(+ 6.4 %)			

Notes: Values are percentage point changes computed using the unbalanced panel from 1995 to 2016. Values in parentheses show corresponding changes in percent.

Figure 1.5: Germany



All values are computed using the unbalanced panel. Values are aggregated at the country level and expressed as shares in aggregate added value, except for the CIT rate.

1.4.3 Balanced sample

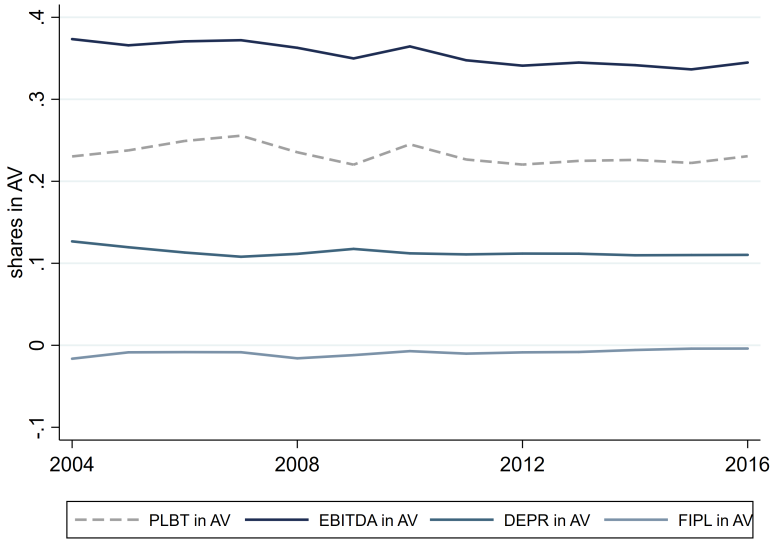
We construct a balanced panel to investigate to what extent our results are driven by a changing firm composition in our sample over time. Due to the limited number of observations in the early years of the sample, we use a shorter period for the balanced sample (2004 to 2016). Figure 1.6 shows the development of the components of the tax base measure $PLBT$ over time. For this sample, we see a slight decline in $EBITDA$ and overall stability of $PLBT$. Regarding $DEPR$ and $FIPL$, we see similar developments as for the unbalanced sample, with $FIPL$ converging towards zero and $DEPR$ declining.

Table A6 in the Appendix compares the ratio levels of our main variables between the unbalanced panel and the balanced panel. When comparing results from the unbalanced and balanced panel, it has to be kept in mind that the country composition of both samples is different. Still, all variables show similar magnitudes in terms of their means. Table 1.7 points out that given our weighted measure of statutory CIT rate changes, the decrease in CIT rates was more pronounced in the unbalanced panel (7.3 percentage points) than in the balanced sample (5.6 percentage points).

One advantage of the balanced panel is that it allows to express changes in CIT revenues and the tax base components in absolute terms. The changes in absolute terms are summarized in Table 1.8.[16] The sum of pre-tax profits ($PLBT$) in 2004 in the balanced sample was 63.2 billion Euros. Over the sample period, revenues increased by 15.3 billion Euros to 78.6 billion Euros in 2016. Table 1.8 also shows the development of total added value (AV) to make the developments in absolute terms comparable with those obtained from expressing variables as shares in added value. While $PLBT$ has been increasing over the period 2004 to 2016, it increased less than AV, which explains the lack of a positive trend in $PLBT$ as a share in AV in Table 1.7. Tax revenues proxied by $TAXA$ decreased by 1.3 billion Euros in total. Therefore, the growth of the tax base did not fully compensate the negative effect of cuts in statutory CIT rates for the countries in the balanced sample.

[16] Summary statistics on absolute values in the balanced panel are reported in the Appendix (see Table A5).

Figure 1.6: Components of the corporate tax base



All values are computed using the balanced panel. Values are aggregated at the country level and expressed as shares in aggregate added value.

Table 1.7: Comparison of percentage point changes in the unbalanced and balanced panel

Period	CIT	TAXA	PLBT	EBITDA	DEPR	FIPL	INTE
A: Balanced panel							
2004 – 2008	–2.9	– 0.4	+ 0.5	– 1.1	– 1.5	0.0	+ 0.9
2008 – 2012	– 1.0	– 1.1	– 1.5	– 2.2	0.0	+ 0.7	– 1.6
2012 – 2016	– 1.7	– 0.4	+ 1.0	+ 0.4	– 0.2	+ 0.5	– 0.9
2004 – 2016	– 5.6	– 1.9	0.0	– 2.9	– 1.6	+ 1.2	– 1.7
B: Unbalanced panel							
2004 – 2008	– 3.6	– 0.7	– 0.3	– 1.0	– 1.1	– 0.4	+ 2.0
2008 – 2012	– 1.1	– 0.1	– 0.3	+ 0.9	+ 0.1	– 0.2	– 1.7
2012 – 2016	– 2.6	– 0.5	+ 1.7	+ 0.6	– 0.5	+ 0.6	– 1.5
2004 – 2016	– 7.3	– 1.4	+ 1.1	+ 0.6	– 0.5	0.0	– 1.3

Notes: The values in this table represent changes in percentage points. Part A reports percentage point changes from the balanced panel, part B reports results on the unbalanced panel in the same time periods for comparison.

Table 1.8: Absolute changes in tax revenues and tax base components

Period	AV	TAXA	PLBT	EBITDA	DEPR	FIPL	INTE
2004 – 2008	+ 29.8	+ 1.0	+ 8.1	+ 7.5	– 0.9	– 0.4	+ 3.9
2008 – 2012	+ 12.9	– 2.6	– 1.6	– 2.0	+ 1.6	+ 2.1	– 4.6
2012 – 2016	+ 24.3	+ 0.3	+ 8.8	+ 9.6	+ 2.2	+ 1.4	– 2.4
2004 – 2016	+ 67.0	– 1.3	+ 15.3	+ 15.1	+ 2.9	+ 3.1	– 3.1

Notes: The values in this table have been computed using the balanced panel and reflect absolute changes within the periods in billion Euros. GDP deflators have been used to account for inflation.

1.4.4 Excluding loss-making firms

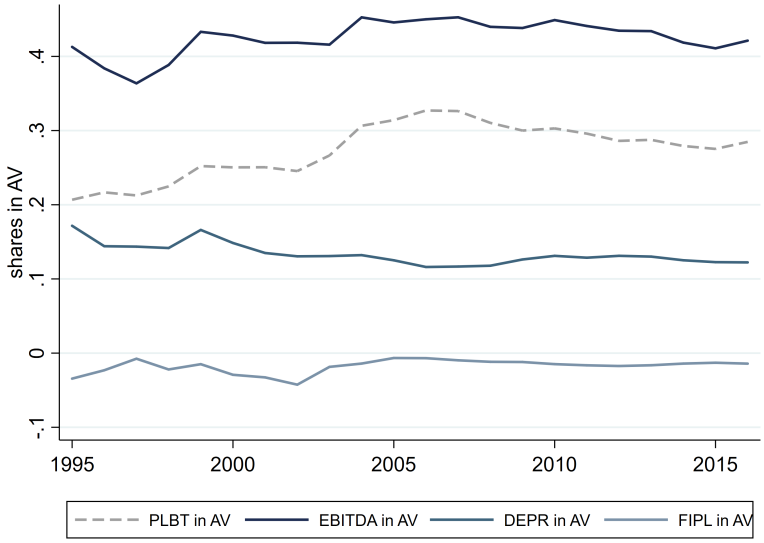
For our sample of non loss-making firms, we exclude all firms that report negative pre-tax profits in one of the years between 1995 and 2016. This leaves us with 6,483,408 observations. Figure 1.7 shows the development of the components of the corporate tax base for this sample. Congruent to our prior results, we see a positive trend in $EBITDA$, a decline in $DEPR$, and $FIPL$ converging towards zero. As for the unbalanced sample including loss-making firms, Table 1.9 shows that tax revenues ($TAXA$) are rather stable over the full period for this sample as well, with a slight decline of – 0.4 percentage points. Again, this development was mainly driven by a strong growth of the tax base during the first 10 years of the sample period.

Table 1.9: Percentage point changes excluding loss-making firms

Period	CIT	TAXA	PLBT	EBITDA	DEPR	FIPL	INTE
1995 – 2000	+ 0.7	+ 0.5	+ 4.4	+ 1.5	– 2.3	+ 0.5	+ 0.8
2000 – 2005	+ 1.4	+ 1.2	+ 6.4	+ 1.8	– 2.3	+ 2.3	– 2.9
2005 – 2010	– 1.1	– 1.5	– 1.1	+ 0.3	+ 0.6	– 0.8	+ 0.1
2010 – 2016	– 1.4	– 0.2	– 1.4	– 2.8	– 0.9	+ 0.1	– 1.3
Full period	– 16.8	– 0.4	+ 7.8	+ 0.85	– 4.9	+ 2.0	– 3.3

Notes: The values in this table represent changes in percentage points and are computed using the unbalanced panel excluding loss-making firms.

Figure 1.7: Components of the corporate tax base (sample without loss-making firms)



1.5 Discussion of results and further relevant factors

As discussed, the increase in the tax base over the last two decades compensated for the decline in CIT rates. In sum, the changes in CIT rates and the tax base approximately offset each other over the period from 1995 to 2016, resulting in stable revenues. In Section 4, we focused on the contribution of firm profits, financial results, and developments in depreciation to explain changes in the corporate tax base. However, there are additional developments that could add to explaining stable revenues and that should be addressed.

So far, we only discussed the development of corporate profitability, but not how it came about. One factor to consider here is the development of the share of profitable firms. As shown, excluding loss-making firms from the analysis does not fundamentally impact results. Still, an increase in the share of profitable firms may have contributed to the increase in corporate profitability. For the sample period of 1995 to 2016, the share of profitable firms in our dataset increases by about 10 percentage points from 76 percent to 86 percent. Therefore, the increasing profitability is only not driven by a small number of firms that were able to raise their profit substantially, but by a broader trend benefiting a large share of the sample.

A second factor contributing to rising profitability could be different sectoral growth rates.

For the sample used in this paper, there is some indication that more profitable industries grew at faster rates than less profitable sectors, adding to the positive trend of mean profitability in our sample. To further investigate this channel, a more representative sample of firms across countries and industries would be needed.
Additionally, it would be beneficial to track developments with regard to market concentration and the profitability distribution of firms. Larger firms in the sample tend to be more profitable than small or medium sized companies. Increasing firm concentration would therefore also increase average profitability. Unfortunately, our sample does not allow for an accurate estimation of the development of firm concentration.

Besides increasing profitability, a rise in the corporate share in GDP could have contributed an expansion of the tax base. Such an development would not be captured by our data, as we only cover the corporate sector. Yet, it is plausible to assume that the part of GDP generated by the corporate sector increases over time. One reason could be income shifting from the personal income tax base to the corporate tax base, as CIT rates are lower than top personal tax rates in many countries. It has been shown in the literature that such income shifting does occur. Clausing (2007), for example, shows in her analysis that an increasing share of income is labeled as corporate income. Data from the OECD Annual National Accounts Statistics gives some initial evidence in this regard and is shown in Figure A7 in the Appendix. Figure A7 shows the sector shares in gross value added as an average across countries. While the household sector's share declined from around 25 percent in 1995 to slightly above 20 percent in gross value added in 2016, the corporate sector's share increased from 60 percent to roughly 65 percent. This is likely to also reflect an increasing capital share of GDP as compared to the labor share.

Lastly, our results should be interpreted with some caution. First of all, the firms in our datasets are unlikely to be perfectly representative. This applies to both the unbalanced and the balanced samples. As previously discussed, book-tax differences result in the fact that the information retrieved from accounting data can only serve as imperfect proxies for actual developments with regard to tax payments and the tax base. Hanlon and Shevlin (2005) even find evidence, that the gap of financial accounting income and taxable income is widening over time. However, this diverging trend is not shown for most countries included in our sample. Moreover, our data does cover a significant part of total economic activity, and the development of tax revenue in our data is very similar to the developments found in the literature based on aggregated tax revenue measures. This suggests that the findings

described above at least partially explain the developments underlying the expansion of the tax base.

1.6 Conclusion

Competitive pressures caused many governments to decrease statutory CIT rates. Nevertheless, CIT revenues to remained a stable source of revenue in most countries. For a firm-level dataset from 33 OECD countries, we show that while the weighted measure of statutory CIT rates fell by 16.5 percentage points over the period from 1995 to 2016, total corporate tax revenue across all countries changed by just 0.07 percent. This was due to a substantial expansion of the tax base.

Our decomposition of the corporate tax base into developments of firm profits from ordinary business activities, financial profits and losses, and depreciation show that all three factors contributed to the observed stability of tax revenues: 36 percent of the increase in the tax base is due to higher net financial income of firms, depreciation has declined by 37 percent, and 27 percent of the expansion of the tax base is due to higher EBITDA.

Looking at six individual countries, we find substantial heterogeneity in developments, with revenues increasing in three countries, decreasing in two countries and remaining stable in one country. While we are aware of some shortcomings to the data (especially regarding the representativeness of firms in the dataset and book-tax differences), we are still confident that the decomposition of the tax base at the firm level offers new insights compared to previous studies based on aggregate data. This contribution therefore adds to the understanding of observed developments and trends in corporate tax revenues.

Appendix

figuresection tablesection

1.A Data sources

CIT rates. Top statutory corporate income tax rates (sum of taxes of all levels of government on January 1 of the respective year, in percent). These rates were taken from several issues of KPMG's Corporate Tax Surveys (1998 to 2006), KPMG's Corporate and Indirect Tax Surveys (2007 to 2014) and KPMG's Corporate tax rates table (2015-2018), complemented with data from EY's Annual Worldwide Corporate Tax Guides (2004 to 2017), data from the Oxford University Centre for Business Taxation and Devereux (2007).

Corporate share. Corporate sector share in value in percent of total value added. `https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE13` (last access August 16, 2018).

Deflators. GDP deflators from the World Development Indicators Database, Worldbank, available at `https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS.AD?view=chart` (last access August 16, 2018).

Share of corporate tax in total tax revenue OECD Revenue Statistics Database, OECD, available at `https://stats.oecd.org/index.aspx?DataSetCode=REV#` (last access August 16, 2018).

Micro data. Bureau van Dijk, Orbis Database. For a description of variables see Table A1.

1.B Additional tables

Table A1: Description and computation of variables in Orbis

Variable name	Description	Computation
AV	Added value	TAXA + PL + STAF + DEPR + INTE
DEPR	Depreciation: total amount of depreciation and amortization of the assets	
EBIT	Earnings before interest and taxes: net profit from operating activities (equal to OPPL)	PLBT - FIPL
EBITDA	Earnings before interest, taxes, depreciation and amortization: operating results and depreciation	EBIT + DEPR
EMPL	Total number of employees included in the company's payroll	
INTE	Interest paid: total amount of interest charges paid	
FIPL	Financial profit/loss: net result from financial activities of the company, defined as financial revenue minus financial expenses	FIRE - FIEX
TAXA	Taxation: all taxes related to the accounting period (paid, accrued or deferred)	
OPPL	Total operating revenues minus all operating expenses	EBIT
PL	Profit/loss for the period: net income of the year	PLAT + EXTR
PLAT	Profit/loss after taxation	PLBT - TAXA
PLBT	Profit/loss before taxation: sum of operating profit and financial profit	EBIT + FIPL
TURN	Turnover: net sales	
FIRE	Financial revenues (from long-term and short-term financial assets, securities revaluation, received interests, sales of securities and shares, change of state of reserves and accounting adjustments in financial area etc.)	
FIEX	Financial expenses (interest paid, write-offs in financial assets etc.)	
STAF	Cost of employees: sum of all employee costs of the company, including pension costs	
FIAS	Fixed Assets: Total amount of non current assets after depreciation	IFAS + TFAS + OFAS
TOAS	Total Assets: sum of fixed assets and current assets	FIAS + CUAS

Source: Orbis User Guide (2011), pp.420-508

Table A2: Steps to the final samples

Step	**Firms**	**Observations**
Starting sample	2,813,844	13,907,376
Dropping consolidated accounts, implausible values and outliers	- 205,066	- 1,806,820
Unbalanced Panel	2,608,778	12,100,556
Keep years 2004 to 2016	- 107,875	- 763,501
Drop firms with missing data for at least two years in a row	- 2,392,272	- 9,924,852
Balanced Panel with imputed values)	108,631	1,412,203
Drop firms with missing data	- 41,390	- 538,070
Balanced Panel (no imputation)	67,241	874,133

Notes: In the balanced sample with imputed values, imputations were made for firms with one-year reporting gaps within the period 2004 to 2016.

Table A3: Number of firms and observations by country in the unbalanced panel

Country	**Firms**	**Observations**	**Obs. in %**
Austria	8,041	39,560	0.33
Australia	2,774	8,493	0.07
Belgium	20,997	117,777	0.97
Canada	448	1,060	0.01
Chile	57	141	0.00
Czech Republic	59,386	264,156	2.18
Denmark	46,341	92,956	0.77
Finland	57,472	243,888	2.02
France	412,812	2,279,937	18.84
Germany	97,197	422,847	3.49
Greece	35	105	0.00
Hungary	16,443	68,772	0.57
Iceland	18	39	0.00
Ireland	4,095	14,543	0.12
Israel	54	148	0.00
Italy	590,281	3,005,661	24.84
Japan	140,042	476,400	3.94
Republic of Korea	153,787	592,625	4.90
Luxembourg	2,198	8,442	0.07
Latvia	266	1,008	0.01
Netherlands	955	3,596	0.03
Norway	90,389	432,078	3.57
New Zealand	612	1,969	0.02
Poland	41,940	180,383	1.49
Portugal	182,469	704,869	5.83
Slovak Republic	45,350	171,355	1.42
Slovenia	24,125	80,274	0.66
Spain	467,849	2,174,122	17.97
Sweden	77,394	426,539	3.52
Switzerland	380	2,704	0.02
Turkey	38	139	0.00
United Kingdom	63,972	282,209	2.33
United States	561	1,761	0.01
Total	2,608,778	12,100,556	100

Table A4: Number of firms and observations by country in the balanced panel

	No imputations			**With imputations**		
Country	**Firms**	**Obs.**	**in %**	**Firms**	**Obs.**	**in %**
Austria	13	169	0.02	65	845	0.06
Belgium	1,298	16,874	1.93	1,812	23,556	1.67
Czech Republic	993	12,909	1.48	1,557	20,241	1.43
Denmark	1	13	0.00	1	13	0.00
Finland	748	9,724	1.11	1,256	16,328	1.16
France	13,417	174,421	19.95	21,309	277,017	19.62
Germany	515	6,695	0.77	825	10,725	0.76
Hungary	201	2,613	0.30	423	5,499	0.39
Ireland	0	0		1	13	0.00
Italy	26,406	343,278	39.27	42,895	557,635	39.49
Republic of Korea	1,452	18,876	2.16	2,859	37,167	2.63
Norway	3,430	44,590	5.10	5,094	66,222	4.69
Poland	615	7,995	0.91	920	11,960	0.85
Portugal	906	11,778	1.35	2,858	37,154	2.63
Slovak Republic	652	8,476	0.97	1,006	13,078	0.93
Slovenia	256	3,328	0.38	420	5,460	0.39
Spain	12,346	160,498	18.36	19,162	249,106	17.6
Sweden	2,653	34,489	3.95	4,037	52,481	3.72
Switzerland	34	442	0.05	46	598	0.04
United Kingdom	1,305	16,965	1.94	2,085	27,105	1.92
Total	67,241	874,133	100	108,631	1,412,203	100

Table A5: Summary Statistics on balance-sheet variables (balanced panel)

	Mean	Std. Dev.	Median	Min.	Max.	Obs.
A: absolute values (firm-level)						
$TOAS$	0.30	5.19	0.05	-431.05	1257.33	874,133
$EMPL$	79.96	861.84	22.00	0.00	195952.00	698,425
AV	4553.96	46982.33	1077.39	4.40	8413770.65	874,133
$PLBT$	1057.26	17715.09	146.00	-459849.00	4243408.78	874,133
$EBITDA$	1611.09	25003.56	281.95	-249002.66	5914145.29	874,133
$FIPL$	-39.70	2577.34	-14.27	-375092.13	516358.22	874,133
$INTE$	156.73	2305.42	23.00	-31495.00	492683.05	874,133
$DEPR$	514.00	7982.62	76.76	0.00	2276240.36	874,133
$TAXA$	303.09	5191.41	48.23	-431045.00	1257334.09	874,133
B: Shares in added value (yearly aggregates)						
$TOAS$	3.20	0.13	3.19	3.02	3.41	874,133
$PLBT$	0.23	0.01	0.23	0.22	0.26	874,133
$EBITDA$	0.36	0.01	0.35	0.34	0.37	874,133
$FIPL$	-0.01	0.00	-0.01	-0.02	-0.00	874,133
$INTE$	0.04	0.01	0.03	0.02	0.05	874,133
$DEPR$	0.11	0.00	0.11	0.11	0.13	874,133
$TAXA$	0.07	0.01	0.06	0.06	0.08	874,133

Notes: $EMPL$ indicates the number of employees in a firm (in persons), all other values in the upper part of the table (A) are in Mio. Euros. Variables in the lower part (B) are shares aggregate shares in added value. Aggregation was done over all firms in a given year.

Table A6: Comparison of summary statistics in ratio levels in the unbalanced and balanced panel

	Mean	Std. Dev.	Median	Min.	Max.	Obs.
A: Unbalanced panel						
$TOAS$	3.59	0.74	3.93	2.45	4.47	12,100,556
$PLBT$	0.21	0.02	0.21	0.09	0.24	12,100,556
$EBITDA$	0.36	0.01	0.36	0.29	0.37	12,100,556
$FIPL$	-0.02	0.01	-0.02	-0.08	-0.01	12,100,556
$INTE$	0.06	0.01	0.06	0.05	0.11	12,100,556
$DEPR$	0.13	0.01	0.13	0.12	0.16	12,100,556
$TAXA$	0.06	0.01	0.05	0.04	0.07	12,100,556
B: Balanced panel						
$TOAS$	3.20	0.13	3.19	3.02	3.41	874,133
$PLBT$	0.23	0.01	0.23	0.22	0.26	874,133
$EBITDA$	0.36	0.01	0.35	0.34	0.37	874,133
$FIPL$	-0.01	0.00	-0.01	-0.02	-0.00	874,133
$INTE$	0.04	0.01	0.03	0.02	0.05	874,133
$DEPR$	0.11	0.00	0.11	0.11	0.13	874,133
$TAXA$	0.07	0.01	0.06	0.06	0.08	874,133

Notes: All variables are aggregate shares in added value. Aggregation was done over all firms in a given year.

Table A7: Percentage changes for the full sample

Period	CIT	PLBT	EBITDA	FIPL	INTE	DEPR	TAXA
1995 – 2016	– 38.35	+ 63.44	+ 6.54	– 62.3	– 53.33	– 19.69	+ 1.34
1995 – 2000	– 9.73	+ 19.69	– 2.26	– 32.79	– 16.39	– 11.12	+ 10.36
2000 – 2005	– 12.79	+ 37.95	+ 7.59	– 58.39	– 32.14	– 11.12	+ 21.51
2005 – 2010	– 14.74	– 6.56	– 7.09	+ 45.30	– 2.62	– 5.21	- 21.44
2010 – 2016	– 8.16	– 1.03	+ 9.04	– 7.23	– 15.52	+ 7.25	- 3.80

Notes: The values in this table represent changes in percent over time (growth rates) for the unbalanced sample. To give an example, the value for CIT in the row representing the full sample period 1995 – 2016 is computed in the following way: $\Delta CIT = \frac{(CIT_{2016} - CIT_{1995})}{CIT_{1995}}$.

Table A8: Changes in percentage points for selected countries

Country	CIT	PLBT	EBITDA	FIPL	INTE	DEPR	TAXA
Germany	– 8.570	+ 0.037	+ 0.014	+ 0.003	– 0.002	- 0.020	- 0.004
Italy	– 5.850	+ 0.024	– 0.027	+ 0.018	– 0.019	– 0.032	- 0.028
France	– 1.030	– 0.017	– 0.033	+ 0.006	– 0.012	– 0.009	– 0.017
Spain	– 10.000	– 0.050	– 0.112	+ 0.028	– 0.025	– 0.035	– 0.034
Sweden	– 6.000	+ 0.033	– 0.011	+ 0.032	– 0.025	– 0.012	– 0.009
United Kingdom	– 10.000	+ 0.026	+ 0.039	– 0.004	– 0.007	+ 0.008	– 0.014

Notes: All values are computed using the balanced panel.

1.C Additional figures

Figure A1: Average ratio of gross value added to GDP across countries

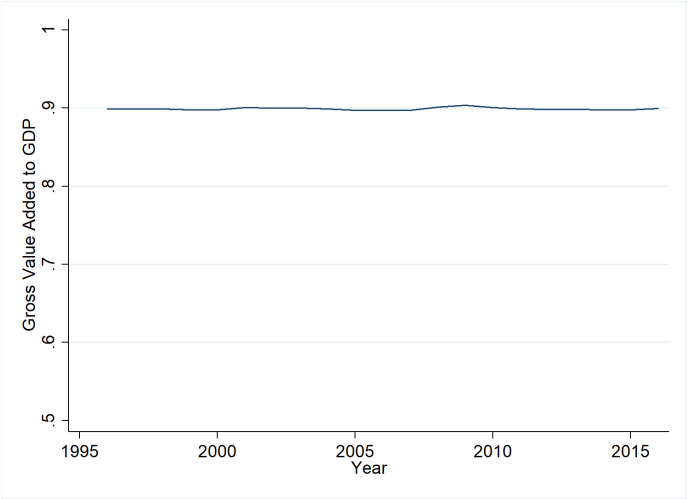


Figure A2: Italy

Figure A3: France

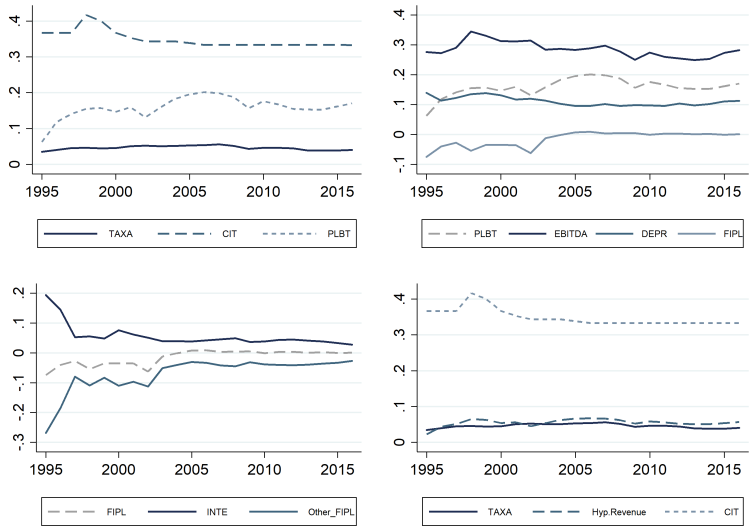


Figure A4: Sweden

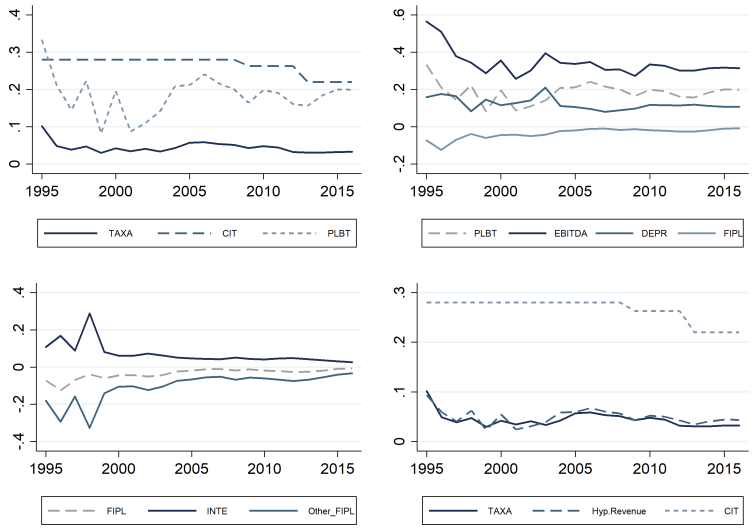


Figure A5: Spain

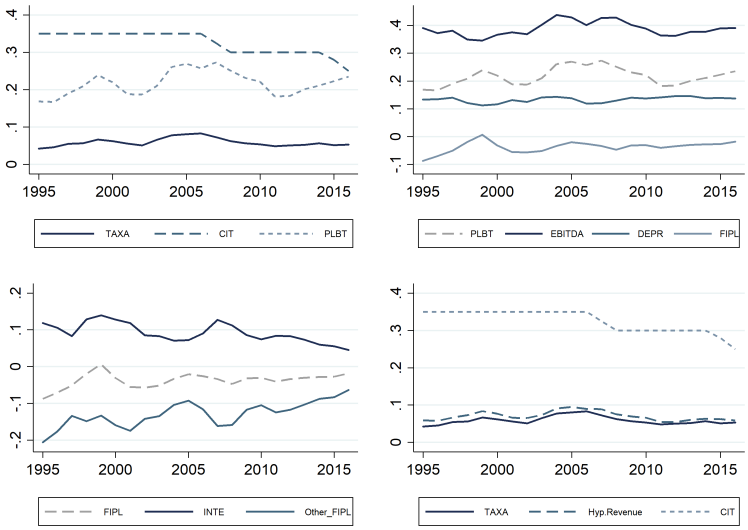


Figure A6: Great Britain

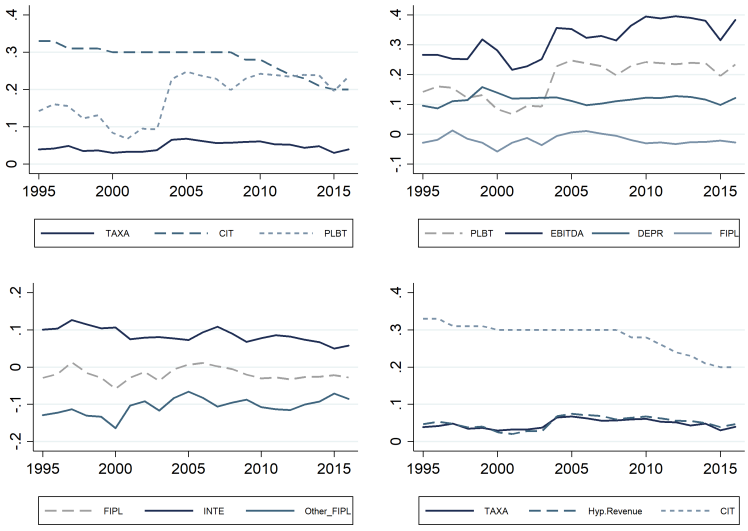
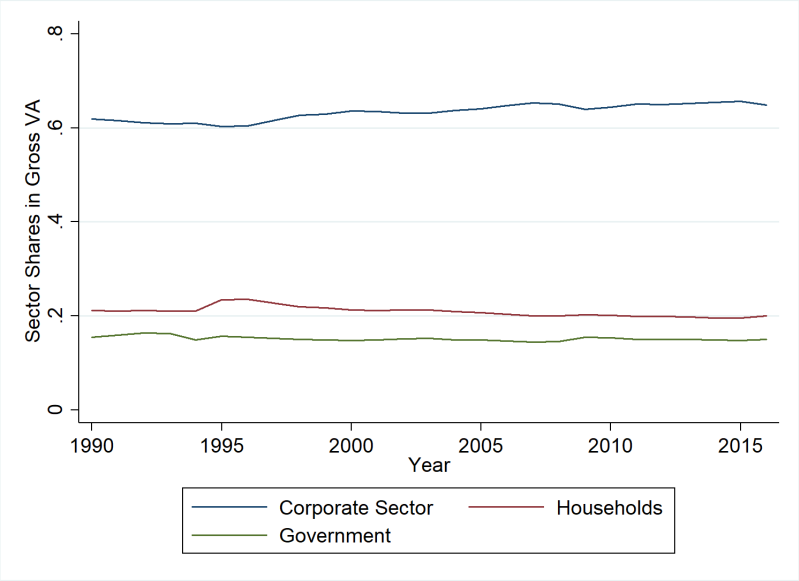


Figure A7: Average sector shares across countries



Sector shares computed by expressing a sector's gross value added as share of total gross value added for each country and computing a yearly average across all countries. Source: OECD Annual National Accounts Statistics

Figure A8: The development of debt in added value

The figure depicts the development of mean long-term debt in added value for the unbalanced sample of firms.

Chapter 2

Do corporate tax cuts pay for themselves? Evidence on the Laffer curve in corporate taxation

"It is a paradoxical truth that tax rates are too high and tax revenues are too low and the soundest way to raise the revenues in the long run is to cut the rates now."[1]

2.1 Introduction

In the recent past, many countries have introduced reforms to their corporate income tax systems. In most cases, reforms entailed pronounced cuts in the top statutory tax rates. A prominent example is the United States, which introduced a comprehensive corporate tax reform in 2017. The "Tax Cuts and Jobs Act" entailed a major cut of the statutory CIT rate from 35 percent to 15 percent. During the negotiations on the plan, the potential revenue

This chapter is joint work with Clemens Fuest and Felix Hugger. We would like to thank participants at the Annual Conference of the International Institute for Public Finance (IIPF) in Tokyo, Japan, for valuable comments and suggestions.

[1] This quote is commonly attributed to John F. Kennedy.

consequences of the reform were a central point of conflict. Supporters of the plan such as Steven Mnuchin claimed that "the tax plan will pay for itself with economic growth" [2] as the United States will become a more attractive location for business. Critics of the plan strongly opposed that view and argued that cutting the rate from 35 percent to 15 percent will result in a drop in revenues and a sharp increase in the government deficit. Given that many countries already face a tense situation with regard to their public budgets, understanding and anticipating revenue consequences from changes in statutory corporate income tax rates is of vital importance. This paper sets out to assess the relationship between corporate income tax rates and corporate tax revenue empirically, using a large macro- and firm-level dataset covering 190 countries and including observations from over 50 years for the period 1965 to 2018.

The negative trend in statutory corporate income tax rates set in during the 1980s as shown by Devereux (2007). At the same time, revenues from corporate taxation as a share of GDP seem to have remained rather stable. This hints at a non-linear relationship between CIT rates and revenues. A first informal approach to characterize this non-linear relationship was made by Arthur Laffer. In 1974, Laffer sketched the idea of a hump-shaped relationship between tax rates and revenues on his napkin during an informal White House dinner. Since then, many economists seized and formalized the concept: Among the first was Fullerton (1982), who develops a general equilibrium model to simulate the effects of tax rate changes on revenues.[3] With regard to more recent contributions, Gruber and Rauh (2007) estimate the impact of CIT rates on corporate taxable income using Compustat data for firms in the United States. They apply the approach of Gruber and Saez (2002) and find an elasticity of the corporate tax base with respect to the corporate income tax rate of - 0.2. Clausing (2007) focuses on estimating revenue-maximizing CIT rates for her sample of OECD countries covering the period 1979 to 2002. She finds a robust hump-shaped relationship between tax rates and revenues, with a revenue maximizing tax rate of around 33 percent. Brill and Hassett (2007) also find empirical evidence of such a relationship. They add to Clausing's (2007) contribution on revenue maximizing CIT rates by analyzing the development of the revenue maximizing rate in the OECD over time. For

[2] Quote by Steven Mnuchin, former Treasury secretary in "Arthur Laffer's Theory on Tax Cuts Comes to Life Once More", New York Times, April 25, 2017.

[3] In this brief overview on the related literature, we will focus on empirical contributions with regard to corporate income taxation. Saez et al. (2012) offer an excellent and more detailed review of the income taxation literature.

the period of 1980 to 2005, Brill and Hassett find it to decline from about 34 percent to around 26 percent. Devereux (2007) offers an analysis over a longer period of time as he looks at data for OECD countries for the years 1965 to 2004. He only finds weak evidence for a statistically significant relationship between tax rates and revenues. However, he concludes, that while there does not seem to be a robust relationship between rates and revenues across the OECD, a hump-shaped relationship might still hold within countries. Lastly, there are two very recent contributions on the topic. Dahlby and Ferede (2018) estimate corporate tax base elasticities using Canadian province-level data. They find four Canadian provinces to be on the negatively sloped side of the Laffer curve. In addition, Dahlby and Ferede compare the economic costs associated with raising tax revenue via corporate income taxation, personal income taxation and sales taxation. They find these costs to be highest for corporate income taxation as the tax base reacts more elastically to rate changes than the personal income tax base or sales tax base. Taken together, the authors conclude that substantial welfare gains could be achieved by substituting tax revenue from corporate taxation with revenue from other sources. Steinmueller et al. (2018) investigate Laffer curve type relationships based on forward-looking measures of average and marginal tax rates computed from firm-level data. By incorporating firm-level data in the analysis on the Laffer curve relationship between tax rates and revenues, their analysis is most closely connected to our approach. Using firm-level data allows them to consider the financial structure and asset composition in the computations of marginal tax rates. Regarding developments of the tax base, they find that around half of the countries in their sample decreased depreciation allowances in the period 2004 to 2016. From falling marginal and average effective tax rates, they conclude that cuts in the statutory rates were more pronounced than the base broadening measures, on average. In terms of their analysis of a Laffer curve relationship, they find a robust inverse U-shaped relationship with maximizing statutory tax rates of 31 percent, 27 percent for effective average tax rates and 17 percent for effective marginal tax rates.

Our paper adds to the literature by expanding the analysis to a wider context. Our panel data set covers 190 countries over a long period of time of up to 53 years. The large dataset allows for comparisons of developments between country groups. We furthermore investigate whether the relationship between CIT rates and revenues observed at the aggregate level is compatible with the relationship between rates and tax payments at the firm level by constructing a large firm-level data based on balance-sheet information from the Bureau van Dijk Orbis database. Firm-level data allows us to control for the influence of

changes in corporate profitability on aggregate tax revenue. Our key results are as follows: First, results from pooled OLS estimations show a strong relationship between corporate tax rates and revenues. This relationship is hump-shaped and robust to the inclusion of time fixed effects, country fixed effects and various control variables. On average, we find a revenue maximizing rate of around 31 percent, which is in line with previous findings in the literature (e.g. Clausing, 2007). We find significant heterogeneity across country groups with varying revenue maximizing tax rates when differentiating results for high income, middle income and lower income countries. While the revenue maximizing rate is lowest for countries with low GDP per-capita, their statutory rates are the highest on average. We find that except for the lower income group, countries are on the positively sloped side of the Laffer curve, on average. Relating to the quote of Steve Mnuchin on whether corporate tax rate cuts are likely to pay for themselves, tax cuts in high income countries such as the United States should therefore not be expected to pay for themselves. Looking at development of the revenue-maximizing rate in the OECD over time, we find that this rate decreased until the mid 2000s and remained rather stable since then at around 30 percent. Revenue maximizing rates obtained from the analysis of the firm-level data are of very similar magnitude and confirm the existence of a Laffer curve in corporate taxation.

The remainder of the paper is set up as follows: in Section 2.2 we discuss the data and relevant descriptive statistics. Section 2.3 explains the empirical approach. In Section 2.4 we discuss our results from both, the macro and micro dataset, while Section 2.5 concludes.

2.2 Data and descriptives

To comprehensively analyze the relationship between statutory CIT rates and revenues, we use both macro and micro data. Our macro dataset includes country-level data for up to 190 countries for the period 1965 to 2018 and includes data from various sources, such as the OECD, the Worldbank as well as tax information from PwC and KPMG. Micro data comes from the Bureau van Dijk (BvD) Orbis database and covers 33 countries over the period 1990 to 2016. A detailed description of data sources is provided in the Appendix 2.A. First, an overview on the macro data will be provided. This will be followed by a description of the firm-level data used in this paper.

2.2.1 Macro data

Data on statutory tax rates is available for all years in the dataset. While information on CIT rates for all 54 years is only available for a sample of 20 OECD countries, coverage increases over time and reaches 190 countries in some years. In total, the dataset contains information on the CIT rates of 3,852 country-year observations, covering all geographic regions and income groups. From 2004 to 2018, the sample contains more than 97 percent of world GDP and over 93 percent of the world's population in each year. The two main data sources for statutory CIT rates are the Corporate Tax Surveys by KPMG and EY's Annual Worldwide Corporate Tax Guides. This data is complemented by information from the Oxford University Centre for Business Taxation and Devereux (2007). All tax rates used are the sum of top statutory CIT rates on all levels of government.[4]

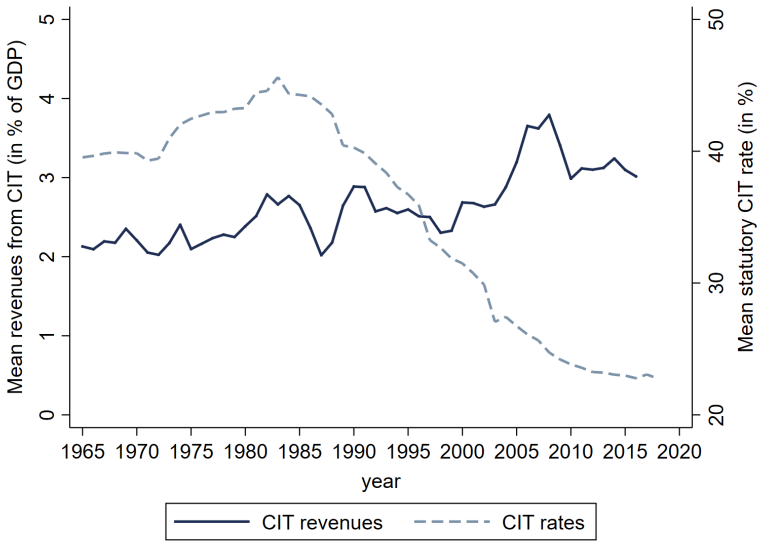
Figure 2.1 shows the aggregate trend in statutory CIT rates across all countries in our sample. As briefly discussed in the introduction, statutory CIT rates have fallen substantially over the last three decades. Over the early and mid 1980s, CIT rates in our sample averaged at around 44 percent, before a rapid decline set in. Between 1986 and 2003, the average CIT rate fell by 17.1 percentage points (from 44.2 to 27.1 percent). Subsequently, rates still declined, but at a slower pace reaching a mean of 23.8 percent in 2010. Since then, until 2018, the average CIT rate remained rather stable at around 23 percent.

We differentiate three groups of countries based on their income level.[5] Figure 2.2 shows the development of average CIT rates for three income groups over the period 1993 to 2018.

[4] In case of different regional or local taxes within countries, averages are used. We are aware of the fact that country differences in tax base definitions and differences in tax enforcement are other relevant explanatory factors for revenue developments that are not captured by statutory CIT rates. Still, statutory tax rates are a key component of CIT schedules and play an important role in attracting investment, especially since most countries rely on flat-tax rate regimes. In addition, some control variables included in the regression should capture at least part of the effects of differences in tax base definitions and enforcement.

[5] A static definition of country groups is used. The grouping is based on the World Bank's income group classification of 2016. "Middle income" refers to the World Bank's Upper middle income countries; Lower middle and Low income countries are combined into one group ("Lower income"). Table B2 in the Appendix provides a list of all countries in the three groups.

Figure 2.1: CIT rates and revenues



In all groups, CIT rates have fallen substantially. High income countries started at the lowest level in 1993 (37.7 percent on average) and showed an almost linear decline until 2010 when rates reached 22.8 percent on average. Between 2010 and 2017, the average CIT rate in high income countries was more or less stable and fluctuated around 22 percent, before dropping to 20.6 percent in 2018. With 40.6 percent, middle income countries had slightly higher CIT rates on average at the beginning of the sample period. However, this average quickly converged to the levels of high income countries and showed a similar trend between 1996 and 2016. From 2016 to 2018, middle income countries on average raised their CIT rates by one percentage point to 22.8 percent.Countries with lower income started out with the highest CIT rates on average in 1993 (43.4 percent), but cut these rates to levels below the two other groups by 1997 (32.1 percent). Since then, CIT rates in lower income countries declined slower than in the other two groups and reached a mean of 25.9 percent in 2018. Since the developments described may be influenced by changing coverage of the sample, Table B1 in the Appendix shows the development of CIT rates for the three income groups between 2004 and 2018 for a balanced sample of 147 countries. The trends apparent for the balanced sample match those described for the unbalanced panel over the corresponding period.

Figure 2.2: The development of statutory CIT rates by income group

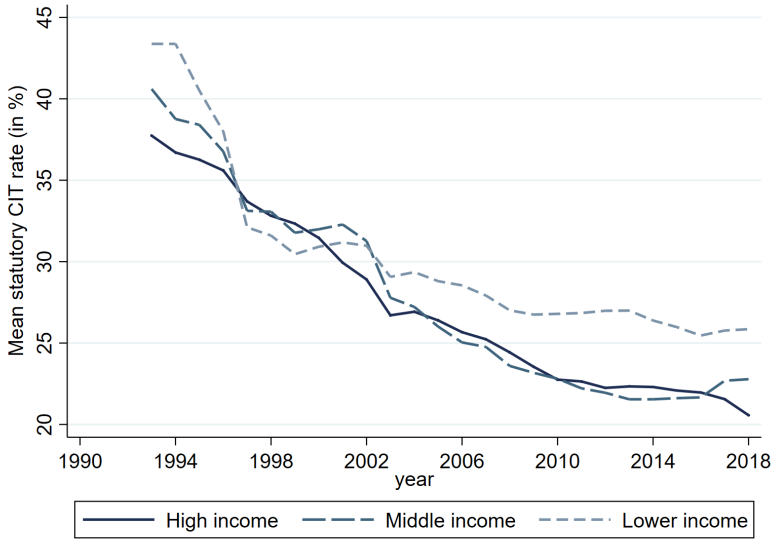


Table 2.1 gives some indication about the dispersion of statutory CIT rates. The CIT rates of the countries in our sample range between 0 percent and 65 percent. The mean value over all countries and years is at 28.78 percent. The standard deviation of CIT rates is highest for the group of high income countries and lowest for the group of lower income countries.

Furthermore, Table 2.1 presents summary statistics on CIT revenues. Revenue data originates from three sources: The OECD's Revenue Statistics, the IMF's World Revenue Longitudinal Dataset, and the Government Revenue Dataset compiled by the International Centre for Tax and Development. The information from these sources is combined with OECD data being preferred when available. Overall, the combined dataset contains information on CIT revenues from up to 166 countries and a total of 4,628 country-year observations. Revenue data on 22 OECD countries is available for the 52 year period from 1965 to 2016. As for CIT rates, coverage increases over time. From 1990 to 2016, the dataset contains revenue data of 138 countries on average. In contrast to the observed negative trend in CIT rates, the share of revenues from corporate taxation in GDP remained relatively stable between 1965 and 2016. Between 1965 and the late 1990s, CIT revenues fluctuated between 2 and 2.5 percent of GDP. From 2000 to 2008, the share increased to 3.8 percent. Over the financial crisis, CIT revenues dropped to about 3 percent of GDP in

2010 and remained at this level until 2016.

Table 2.1: Summary statistics on the macro data set

	Mean	Std. Dev.	Median	Min.	Max.	Obs.	Coverage (Years)
Full sample							
CIT revenue	2.80	2.79	2.19	0.00	35.65	4,628	1965 – 2016
Statutory CIT rate	28.78	11.98	30.00	0.00	65.00	3,852	1965 – 2018
PIT minus CIT	3.97	14.32	1.10	-55.00	55.00	3,319	1981 – 2018
Govt. expenditure	16.28	7.58	15.44	0.00	135.78	7,398	1965 – 2017
Educ. expenditure	4.17	3.01	3.75	0.25	83.97	9,150	1970 – 2016
Resource rents	6.81	10.94	1.95	0.00	89.60	8,097	1970 – 2016
ln(population)	14.80	2.44	15.27	8.48	21.05	11,322	1965 – 2017
ln(GDPPC)	8.28	1.53	8.19	4.75	11.88	8,407	1965 – 2017
GDP growth	3.84	6.64	3.83	-64.05	149.97	8,602	1965 – 2017
Trade share	80.29	54.26	70.23	0.02	860.80	7,948	1965 – 2017
NPV of depr.	0.13	0.05	0.13	0.00	0.32	1,567	2004 – 2016
Corporate share	63.66	7.86	64.55	37.83	80.94	671	1990 – 2017
High income countries							
CIT revenue	3.00	2.92	2.41	0.00	35.65	1,947	1965 – 2016
Statutory CIT rate	31.04	13.36	32.00	0.00	65.00	2,087	1965 – 2018
Middle income countries							
CIT revenue	3.28	3.29	2.45	0.00	31.70	1,119	1965 – 2016
Statutory CIT rate	25.51	9.61	25.00	0.00	54.00	816	1981 – 2018
Lower income countries							
CIT revenue	2.22	2.00	1.72	0.00	24.84	1,551	1980 – 2016
Statutory CIT rate	27.65	7.83	30.00	0.00	52.50	901	1983 – 2018

The development of CIT revenues in GDP between 1990 and 2016 is shown separately for the three country groups in Figure 2.3. The development for high and middle income countries was relatively similar. In both groups, revenues from corporate taxation where at around 2.5 to 3 percent between 1990 and 1999. From 2000 to 2008, the shares rose to about 4.5 percent on average in both groups. Afterwards, revenues declined and reached 3.3 and 3.5 percent of GDP in 2010 for high and middle income countries respectively. While revenues in middle income countries remained at a similar level until 2016, the average in high income countries declined further to 2.8 percent in 2016. CIT revenues in

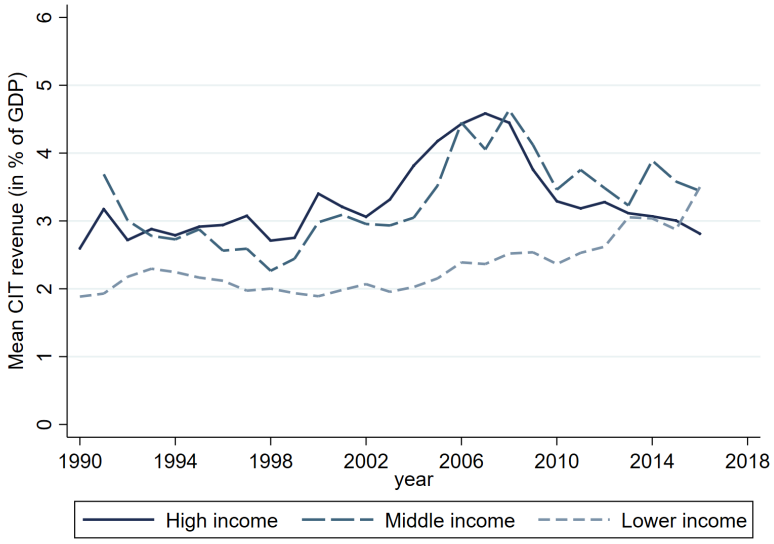
Table 2.2: Summary statistics on key variables in the micro data set

	Mean	**Std. Dev.**	**Median**	**Observations**	**Year availability**
Taxation	257.40	7,289.28	18.00	9,878,715	1990 – 2016
EBITDA	1,448.80	39,119.72	124.53	9,878,715	1990 – 2016
Depreciation	484.11	14,464.33	28.89	9,878,715	1990 – 2016
Interest payments	236.04	15,007.53	10.59	9,878,715	1990 – 2016
Other fin. profits	157.51	14,121.11	1.00	9,878,715	1990 – 2016
Added value	3,786.89	78,255.30	485.19	9,878,715	1990 – 2016

Note: This table presents sample means, standard deviations, and median values for the key variables from the micro data-set. The last column indicates for which years a variable is available.

countries with lower income developed differently. In this group of countries, revenues were at around 2 percent of GDP throughout the 1990s and early 2000s. From 2003 onwards, revenues started to increase and reached 3 percent of GDP in 2013 and 3.5 percent in 2016. As shown in Figure B2 in the Appendix, this last development is not confirmed when investigating a balanced sample. In the balanced sample, lower income countries were not able to increase its revenues any further after 2008. According to this sample, a gap of about 0.6 percentage points persists between the share of CIT revenues in GDP of richer and poorer countries.

Figure 2.3: The development of corporate tax revenues by income group



The control variables included in Table 2.1 give some indication about the levels and dispersion of country size, public sector size, economic activity and development levels of the countries in our sample. Half of the ten control variables are available for more than 50 years from 1965 to 2017 (Government expenditure as a share of GDP, ln of population, ln of GDP per capita, GDP growth, and trade share in GDP). Two more (education expenditure as a share of GNI and resource rents as a share of GDP) are available from 1970 to 2016. The difference between PIT and CIT rates is available from 1981 onwards. The net present value of depreciation allowances is available for on average 121 countries over 13 years (2004 to 2016). Data on the share of the corporate share in total added value is available from 1990 to 2017, but only for a smaller sample of up to 32 countries. A detailed overview on variable definitions and sources is provided in the Appendix.

Table 2.1 shows, that across the countries in our sample the difference between PIT and CIT rates (computed as PIT rate minus CIT rate) is found to be positive, on average. PIT rates tend to be higher than CIT rates. The mean and the median value, however, are quite small. This might reflect that governments are aware of profit shifting activities between the two tax bases and try to limit those by setting similar rates, on average.

On average, the governments of countries in our sample spend 16.28 percent of GDP, with 4.17 percent being spent for education purposes. Education expenditure shows a great variation with a range from 0.25 to 83.97 percent of gross national income (GNI). Given

that our sample covers 190 countries at different development levels, there is also a large dispersion with regard to GDP per capita and GDP growth. On average, the growth rate of the countries in our sample is 3.84 percent.
Almost all countries in our sample are active in international trade. The median value of the trade share is 70.23 percent. The share of resource rents in GDP, however, is relatively low across countries, as the median value of 1.95 percent of GDP indicates. Nevertheless, there is substantial variation across the countries in our sample with the maximum value being 89.6 percent.
The corporate share for the 32 countries we have data for varies between roughly 38 and 81 percent. For most countries, however, the corporate sector is significantly larger than the private and public sector, as the relatively high median and mean values of roughly 64 percent indicate.
To capture differences and changes in the tax base across countries and over time, we add the net present value of depreciation allowances (NPV of depr.) for industrial buildings in some specifications. The depreciation of industrial buildings is roughly comparable across countries, in contrast to the depreciation of many other investments. Devereux's et al. (2002) approach allows to compare incentive effects of different tax depreciation rules.[6]

2.2.2 Firm-level data

Firm-level data is obtained from the BvD Orbis database, which offers comprehensive balance-sheet information for a large set of countries. Expanding our analysis to micro data allows to control more thoroughly for developments within the corporate sector, such as positive trends in firm profitability. Table 2.2 provides summary statistics on the micro variables used. All variables reported are measured in thousand Euros. In total, the firm-level dataset contains a total of almost 10 million firm-year observations from 33 countries over the years 1990 to 2016.[7]

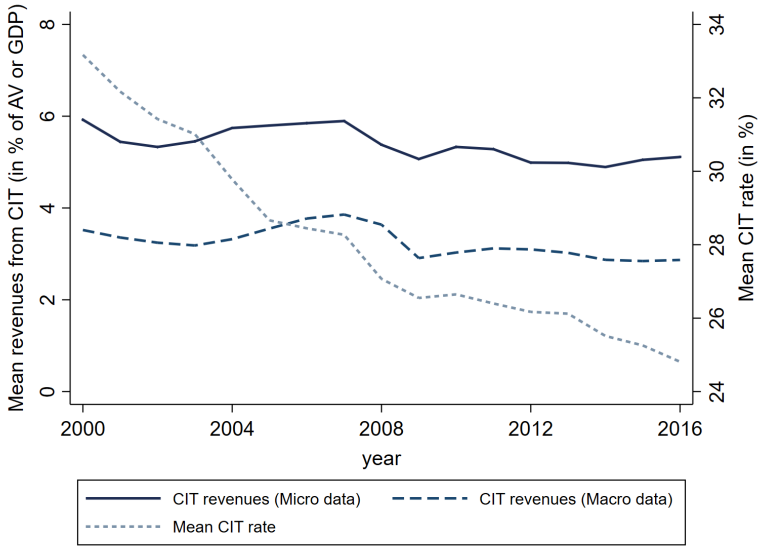
To proxy CIT revenues on the micro level, we compute the share of tax payments in value added. The dataset only contains firms with positive tax payments, as negative taxes often reflect subsidies that are unrelated to CIT rates, but are based on other institutional arrangements of the respective countries or may even be determined on a case by case basis.

[6] We follow the approach of Devereux et al. (2002) and Devereux et al. (2011) in the calculation of the net present value of allowances per unit of investment.

[7] A detailed description of the variables is provided in Appendix 2.A. Table B1 reports the coverage of the firm-level data by country.

The mean value for tax payments of the firms in our micro data set is 257.400 Euro. The tax base for the average firm is 886,160 Euros and can be proxied as the mean value of EBITDA (1,448,000 Euro) minus depreciation (484,111 Euro) and interest payments (236,040 Euro) plus other financial profits (157,510 Euro). This equals a mean effective tax rate of 29 percent, which is very close to our mean value with regard to the statutory CIT rate of 28.8 percent (see Table 2.1). To examine whether the micro data reasonably matches the macro data in terms of CIT revenues, Figure 2.4 plots the development of CIT revenues in GDP from the macro data and taxed paid in added value from the micro data over the period from 2000 to 2016 for a balanced sample of 18 countries.[8] For completeness, the average CIT rate for the corresponding sample is plotted as well. While the level of the two measures is different, the development over time is almost parallel. Both measures are relatively stable over time, with a small peak in 2007 at 3.9 percent (macro data) and 5.9 percent (micro data). At the same time, the average CIT rate for this sample fell from 33.2 to 24.8 percent.

Figure 2.4: CIT revenues: Comparison of macro and micro data



Note: This figure is based on data for a balanced sample of 18 countries.

[8] Figure B4 in Appendix shows the same development for the full sample of 33 countries starting in 1992.

2.3 Empirical approach

The data described in the preceding section is used in various ways to examine the relationship of corporate tax rates and revenues. We start out by analyzing CIT rates and revenues using a pooled OLS regression model for the macro data. Our baseline specification is of the following form:

$$CITrevenue_{i,t} = \alpha + \beta_1\, CITrate_{i,t} + \beta_2\, CITrate\_squared_{i,t} + \gamma\, X_{it} + \psi_t + \epsilon_{it} \quad (2.1)$$

with $CITrevenue$ being the share of revenue from corporate taxation in GDP. i indicates the observational unit in our panel, which is country for the macro data set, and t indicates the time unit, which is year, as our dataset contains annual observations. As we suspect a non-linear relationship between CIT rates and revenues, we include both, the absolute level of the CIT rate (CIT) and its square ($CIT\_squared$). Year fixed-effects (ψ) are included to account for influences over time that affect all countries in the same way. ϵ is the residual in the estimations. In all specifications, standard errors are clustered at the country level to take into account potential within-cluster correlation and heterogeneity.

X is a vector of control variables, that varies depending on the specification. As previously discussed, the controls at the country level include the difference between PIT and CIT rates ($PITminusCIT$), government expenditure ($Govt.exp.$), education expenditure ($Educ.exp.$), the share of resource rents in GDP ($Resourcerents$), the ln of population ($ln(population)$), the ln of GDP per capita ($ln(GDPPC)$), $GDPgrowth$, and the trade share in GDP ($Tradeshare$). We add the difference between PIT and CIT rates as previous research has shown (see for example Mintz 1995, Fuest and Weichenrieder 2002, Slemrod 2004) that corporate taxation serves as a backstop to personal taxation. We include population size as a proxy for the size of the market of the countries in our sample. In the competition for mobile companies, larger countries may be able to exploit some market power due to bigger domestic markets and capital stocks. For example, Bucovetsky (1991) claims that in equilibrium, larger states are able to set higher CIT rates as the elasticity of the tax base with respect to the CIT rate is lower than in smaller states. We consider government expenditure as it provides a more accurate picture of revenue needs than just controlling for population size. Education expenditure is added as following Mintz (1995), public investment in education may be linked to higher CIT rates. At the same time, a better educated workforce could increase profits and/or the efficiency of tax collection

and thereby the share of CIT revenues in GDP. The considerations regarding GDP per capita are the following: tax authorities in less developed countries often face administrative difficulties when it comes to the collection of taxes. On the other hand, according to Abramovsky et al. (2014), corporate taxes are easier to administer than other tax types, especially if most revenue is raised from a small number of large taxpayers. As a result, poor countries may depend stronger on the revenue generated from corporate taxation than developed countries. We also collected information on the trade share as openness may lead to competition between governments for internationally mobile capital, resulting in a negative influence of internationalization on CIT rates and revenues (Zodrow and Mieszkowski, 1986) On the other hand, governments may expand the welfare state to insure citizens against higher economic risks resulting from globalization and thus increase corporate taxation. In addition, an increase in firm mobility may raise corporate profits and thereby increase the tax base, leading to higher CIT revenues (Garrett and Mitchell 2001). Resource rents might be relevant for our estimation as profits in this sector are likely to react more inelastically to taxation compared to other, more mobile sectors (Slemrod 2004).

The relationship between statutory rates and CIT revenues is first analyzed for the full sample. In a second step, the sample is split the three income groups to investigate heterogeneity in the relationship between rates and revenues across high, middle and lower income countries.

The results obtained with the macro data set are then replicated and expanded using the firm-level dataset for OECD countries covering the period 1990 to 2016. For the firm level estimations, the observational unit of our panel i is the firm. We continue to use annual observations so the time unit of the panel remains unchanged. For the micro analysis, we expand our set of included control variables X with relevant balance-sheet items. Firstly, we add earnings before interest, taxes, depreciation and amortization ($EBITDA$), which reflects profitability of firms before considering the financial structure and asset composition of the firm. It is therefore a measure of overall corporate profitability. From EBITDA, the tax base of a firm can be proxied by adjusting for the capital and financial structure in the following way: $Tax\ Base = EBITDA - depreciation - interest\ payments + other\ fin.\ profits$

Using micro data, we estimate equation 2.1 in a modified form: our dependent variable for tax revenue is computed as the sum of corporate tax payments in a given year as a share of added value. As before, country-level variables are included to control for observ-

able macro effects. Next to including time fixed effects, we also include industry fixed effects to account for unobserved industry characteristics. The set of control variables is expanded with our balance-sheet variables, which capture changes in the firm-level composition of the tax base. All firm-level variables are included as shares in added value. Controlling for changes in the tax base composition allows to give some indicatory inference on whether observed tax base changes are due to changes in corporate profitability or changed depreciation patterns. This provides a major advantage as compared to approaches only based on aggregate data.

In Section 2.4.3, we include further control variables in our pooled OLS specifications. Furthermore, we employ a fixed effects panel estimation on our macro dataset to rule out that our presented results are biased by unobserved time-invariant heterogeneity across countries.[9] Estimations (1) to (3) of Table 2.10 summarize the results.

2.4 Results

This chapter reports the results of the baseline regressions. All specification presented in this Section are pooled OLS regressions. Results based on country-level data are presented in Section 2.4.1; Section 2.4.2 reports the results from the firm-level estimations. Robustness checks are described in Section 2.4.3.

2.4.1 The relationship between CIT rates and revenues

Table 2.3 shows the results of the baseline pooled OLS regressions. The dependent variable in all estimations of Table 2.3 is the share of CIT revenues in GDP at the country level. The statutory CIT rate and its square are the explanatory variables of main interest. Standard errors are clustered at the country level in all estimations of Table 3. In column (1), the coefficients of both the statutory rate and its square are highly significant and indicate an inversely U-shaped relationship between CIT rates and revenues. According

[9] Regarding our micro sample, the trade-off on whether to use a fixed-effects estimator versus the pooled-OLS specification is the loss of variance in fixed effects modeling versus relaxing the assumption of no unobserved time-invariant heterogeneity. Our micro dataset is strongly unbalanced. Many companies are only covered for an individual year or a very short period of time. We therefore only apply pooled OLS estimations.

to this estimation, tax revenues are maximized at a rate of 32.1 percent. This result is visualized by Figure 2.5, which shows the predicted CIT revenues in GDP at different tax rates. The vertical line marks the mean CIT rate in the sample used in the corresponding regression at 31.2 percent, which is close to the revenue maximizing rate. The predicted revenue resulting from the revenue maximizing rate is 3.3 percent of GDP, while the actual mean revenue is 3.0 percent of GDP.

Estimation (2) and all subsequent estimations include year fixed-effects. Accounting for such time-effects that influence all countries equally does not change the coefficients substantially. Estimation (3) includes the net present value of depreciation allowances for industrial buildings to control for changes in the tax base definition. Since the variable is only available for the years 2004 to 2016, the number of observations is about halved. The coefficients for the tax rate and its square, however, are largely unchanged. The coefficient of the tax base measure itself is negative, but not statistically significant. To control for potential tax competition effects, estimation (4) includes the unweighted average CIT rate of all other countries. This average is not weighted by GDP, as the shifting of paper profits is not necessarily tied to real economic activity in low tax countries. Since the inclusion of this variable lead to issues regarding multicollinearity, it is not included in any other specifications.[10] The coefficients of main interest remain largely unchanged with a revenue maximizing rate of 32.7 percent. Finally, estimation (5) controls for a number of country-specific characteristics, as discussed in Section 2.2. Of these additional controls, the share of resource rents in GDP, GDP per capita, and the trade share in GDP all yield significant positive coefficients. The coefficient of total government expenditure is positive but insignificant, suggesting that CIT revenues are not central in the in the financing of governments in most countries. The influence of the CIT rate on revenues is robust to the inclusion of these additional controls.

As suggested by column (5) of Table 2.3, GDP per capita of countries does influence their CIT revenues. To further investigate potential differences between countries of different income, Table 2.4 reports estimation results for different income groups. Since data for lower income countries is available only after 1993, only the years 1993 to 2016 are used in all estimations of Table 2.4 to make results comparable. Estimation (1) contains the results for the full sample. Columns (2) to (4) report the estimation results for high, middle, and

[10]The variance inflation factor (vif) for the average CIT rate of others in Estimation (4) is 4,328.06. As a rule of thumb, vif values larger than 10 indicate problems regarding multicollinearity.

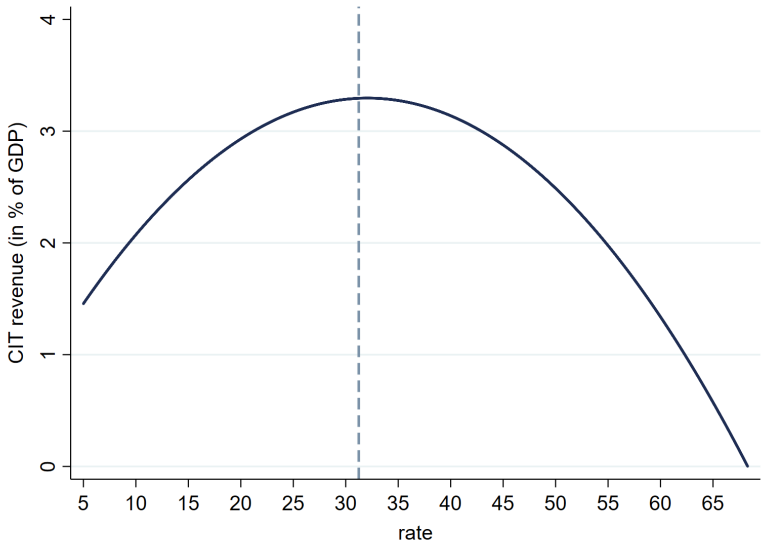
Table 2.3: Pooled OLS regressions (Full sample)

	(1) CIT revenue	(2) CIT revenue	(3) CIT revenue	(4) CIT revenue	(5) CIT revenue
CITrate	0.161***	0.169***	0.286**	0.181***	0.194***
	(0.0296)	(0.0317)	(0.117)	(0.0331)	(0.0469)
CITrate_sq	-0.00251***	-0.00218***	-0.00425**	-0.00276***	-0.00273***
	(0.000488)	(0.000488)	(0.00202)	(0.000666)	(0.000899)
NPV depr			-5.375		
			(6.913)		
avCITrate_others				-1.176	
				(0.770)	
PIT minus CIT					-0.00870
					(0.0147)
Govt exp					0.0152
					(0.0276)
Educ exp					-0.0772
					(0.0970)
Resource rents					0.101**
					(0.0423)
ln(population)					-0.0460
					(0.128)
ln(GDPPC)					0.468***
					(0.150)
GDP growth					0.0628
					(0.0448)
Trade share					0.00733**
					(0.00284)
constant	0.714*	-0.764	-0.283	46.20	-4.950**
	(0.367)	(0.607)	(1.144)	(30.81)	(2.046)
Year FE	No	Yes	Yes	Yes	Yes
N	2,636	2,636	1,142	2,636	2,172
R^2	0.034	0.075	0.040	0.078	0.255

Standard errors in parentheses. Standard errors are clustered at the country level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

lower income countries, respectively. All estimations contain year fixed-effects. The overall pattern is similar for all groups. For middle income countries, the CIT rate coefficients are not statistically significant on their own. However, the coefficients are jointly significant at the 10 percent level. The relationship between CIT rates and revenues is particularly

Figure 2.5: The Laffer curve in corporate taxation



strong for high income countries (Estimation (2)). GDP per capita has a positive influence on CIT revenues also within groups for high and lower income countries. The effect of resource rents in the full sample seems to be primarily driven by middle income countries.

Table 2.6 summarizes the the revenue maximizing rates for the full sample and by income group. The revenue maximizing rate across all countries is 31.3 percent. For high income countries, the revenue maximizing rate is at 34.8 percent. Lower income countries exhibit the lowest revenue maximizing rate (24.2 percent). This seems reasonable, as lower income countries often have lower administrative capacity facilitating tax evasion. A more elastic tax base with respect to tax rates reduces the revenue maximizing rate. The actual mean tax rate of high income countries over the sample period (1993-2016) was 31.0 percent, while low income countries had an average tax rate of 27.7 percent. According to the results of Table 2.4, high income countries should therefore be able to increase their CIT revenues by increasing their CIT rates. In contrast, low income countries should lower their CIT rates to raise more revenue from corporate taxation. Due to the low significance of the coefficients for middle income countries, the results for this group of countries should be treated with caution and are not further discussed.

The dataset used for the above analysis covers more than two decades. Over such long

Table 2.4: Pooled OLS regressions (By income group)

	(1) Full sample	(2) High income	(3) Middle income	(4) Lower income
CITrate	0.250***	0.356***	0.119	0.165**
	(0.0654)	(0.0954)	(0.0755)	(0.0689)
CITrate_sq	-0.00400***	-0.00512**	-0.00141	-0.00341**
	(0.00135)	(0.00192)	(0.00165)	(0.00128)
PIT minus CIT	-0.0149	-0.00272	-0.0367	0.0208
	(0.0179)	(0.0184)	(0.0272)	(0.0160)
Govt. exp.	0.0198	-0.0606	0.105*	0.0274
	(0.0277)	(0.0493)	(0.0549)	(0.0170)
Educ. exp.	-0.0859	-0.207	-0.187	0.236**
	(0.0991)	(0.184)	(0.166)	(0.0942)
Resource rents	0.101**	0.0881	0.201***	0.00707
	(0.0414)	(0.0682)	(0.0407)	(0.0167)
ln(population)	-0.0601	-0.500**	0.225	0.530***
	(0.138)	(0.233)	(0.164)	(0.131)
ln(GDPPC)	0.490***	0.952**	0.196	0.875***
	(0.153)	(0.390)	(0.481)	(0.235)
GDP growth	0.0574	0.0198	0.0262	0.0224
	(0.0482)	(0.107)	(0.0351)	(0.0184)
Trade share	0.00691**	0.000162	0.0256***	0.0142*
	(0.00290)	(0.00341)	(0.00771)	(0.00801)
constant	-5.312**	-2.650	-9.653*	-15.07***
	(2.237)	(3.770)	(4.828)	(2.990)
Year FE	Yes	Yes	Yes	Yes
N	1,878	986	450	442
R^2	0.264	0.300	0.722	0.469

Standard errors in parentheses.
Standard errors are clustered at the country level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

period of time, the position of the Laffer curve might shift. Brill and Hassett (2007) find evidence for such a shift between the late 1980s to 2005. They claim that the revenue maximizing rate declined from 34 to 26 percent for an unbalanced sample of 20 OECD countries. A change in the revenue maximizing over time rate could rationalize the rate cuts seen in many countries. Table 2.7 reports the development of the revenue maximizing rate for 3-year intervals between 1995 and 2015 for a balanced sample of 33 OECD countries. According to these estimations, the revenue maximizing rate is rather stable over time

at around 30 percent. In the period from 2001 to 2003, the revenue maximizing rate was at 30.7 percent. It declined slightly to 29.6 percent for the periods 2004 to 2006 and 2007 to 2009, before rebounding to just above 30 percent (30.5 in 2010-2012 and 30.4 in 2013-2015).

The actual mean tax rate for this group of countries, in contrast, steadily declined from 30.8 percent between 2001 and 2003 to 24.9 percent (2013-15). The difference between the revenue maximizing rate and the actual rate rose accordingly from +0.1 percentage points (2001-2003) to 5.5 percentage points in the last sample. The gradual move away from the revenue maximizing rate could therefore have contributed to the decline in revenues since 2007.

2.4.2 Results from estimations using micro data

The country-level estimations presented show highly significant and robust results for the relationship between CIT rates and revenues. This section now presents estimation results based on firm-level data, which allow for a more thorough control of tax base effects. The micro dataset covers the period from 1990 to 2016 and contains almost 10 million firm-year observations from 33 OECD countries. There are two main questions: First, can the patterns detected in the macro (country-level) data also be found in the micro data? Second, is the relationship robust to the inclusion of firm-level controls of the tax base? The dependent variable in the regression with micro data is the share of (positive) tax payments in value added. Standard errors are clustered at the firm level. All estimations reported contain year and industry fixed-effects.

The estimation results are summarized in Table 2.5. Estimation (1) contains the set of country-level controls that was also used in the macro regressions of the previous section. Since the micro sample predominantly contains firms from high-income countries, the numerical results should be compared to those from Column (2) of Table 2.4. The coefficients for the CIT rate and its square resulting from the firm-level estimation are similar to those of the corresponding country-level estimation for high-income countries. The resulting revenue maximizing rate is only marginally higher than in the regression with macro data (35.3 percent compared to 34.8 percent). Thus, the firm-level data is largely able to reproduce the results from the macro estimations.

Table 2.5: Pooled OLS regressions (Firm-level data)

	(1)	(2)	(3)	(4)
	Tax in AV	Tax in AV	Tax in AV	Tax in AV
CITrate	0.372***	0.574***	0.480***	0.233***
	(0.00466)	(0.00324)	(0.00275)	(0.00328)
CITrate_sq	-0.00527***	-0.00638***	-0.00446***	-0.00253***
	(0.0000723)	(0.0000563)	(0.0000482)	(0.0000525)
PIT minus CIT	-0.0659***			-0.0484***
	(0.000511)			(0.000331)
Govt. exp.	-0.191***			-0.0368***
	(0.00204)			(0.00141)
Educ. exp.	0.0351***			-0.533***
	(0.00751)			(0.00505)
Resource rents	-0.0337***			-0.0895***
	(0.00305)			(0.00188)
ln(population)	-0.485***			-0.687***
	(0.00728)			(0.00462)
ln(GDPPC)	0.584***			1.309***
	(0.0181)			(0.0128)
GDP growth	-0.260***			-0.457***
	(0.00181)			(0.00136)
Trade share	-0.0108***			-0.0150***
	(0.000221)			(0.000139)
EBITDA in AV		0.137***	0.168***	0.171***
		(0.000149)	(0.000178)	(0.000177)
DEPR in AV			-0.129***	-0.141***
			(0.000286)	(0.000286)
INTE in AV			-0.127***	-0.132***
			(0.000366)	(0.000357)
oFIN in AV			0.111***	0.121***
			(0.000379)	(0.000378)
constant	5.656***	-13.48***	-10.29***	-0.538***
	(0.234)	(0.124)	(0.104)	(0.158)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
N	9,878,690	9,878,696	9,878,696	9,878,690
R^2	0.054	0.368	0.463	0.486

Standard errors in parentheses. Standard errors are clustered at the firm level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.6: Revenue-maximizing CIT rates

	All countries	High income	Middle income	Lower income
CITrate	0.250	0.356	0.119	0.165
CITrate_sq	-0.004	-0.00512	-0.00141	-0.00341
max. rate	31.25	34.76	42.19	24.19
actual mean rate	28.78	31.04	25.51	27.65
$\Delta rate$	– 2.47	– 3.72	– 16.68	+ 3.46

Notes: Revenue maximizing rates are computed as $-\frac{\beta_1}{2\beta_2}$ with β_1 being the coefficient on the tax rate and β_2 the coefficient on the tax rate squared.

Table 2.7: The development of the revenue-maximizing rate in OECD countries

	2001 – 2003	2004 – 2006	2007 – 2009	2010 – 2012	2013 – 2015
CITrate	0.2751	0.3166	0.3150	0.3869	0.3203
CITrate_sq	-0.0045	-0.0054	-0.0053	-0.0064	-0.0053
max. rate	30.7	29.6	29.6	30.5	30.4
actual mean rate	30.8	28.4	26.2	25.3	24.9
$\Delta rate$	+ 0.1	– 1.2	– 3.4	– 5.2	– 5.5

Notes: Coefficients from pooled OLS regressions of CIT revenues on the CIT rate and its square for a balanced sample of 33 OECD countries for 3-year time periods. Revenue maximizing rates are computed as $-\frac{\beta_1}{2\beta_2}$ with β_1 being the coefficient on the tax rate and β_2 the coefficient on the tax rate squared.

Estimation (2) now contains the share of EBITDA in added value to control for the influence of firm profitability on CIT revenues. The corresponding coefficient is statistically significant and has a positive sign. Not surprisingly, higher profitability is related to higher tax payments. In estimation (3), three additional control variables are introduced: the shares of depreciation, interest payments, and other financial profits in added value. The coefficients of depreciation and interest payments are both negative, as both are deductible from taxable profits to some degree in all countries. The coefficient of other financial profits is positive, as they increase to a company's taxable profit. In sum, EBITDA, depreciation, interest and other financial profits represent an approximation of the tax base (as a share of added value). The inclusion of the additional firm-level controls leads to some changes in size of the coefficients of the CIT rate and its square. Yet, the inversely u-shaped relationship between rates and revenues remains robust.

Estimation (4) of Table 2.5 contains the firm-level controls as well as the country-level controls. This reduces the resulting coefficients for the CIT rate and its square, but again without changing the fundamental relationship between rates and revenues. The coefficients of the micro control variables also change only very little as compared to estimation (3). In sum, the micro regressions confirm the existence of a Laffer curve for corporate taxation. This relationship between CIT rates and revenues is also robust to the inclusion of controls for the tax base.

2.4.3 Robustness and discussion

In the following, robustness of the obtained results will be discussed. First, we check whether our specification using the squared term of the CIT rate is correct by testing for the the significance of higher order polynomials. Second, we rerun our main specifications using additional control variables, such as the share of the corporate sector as changes in the distribution of economic activity between the public and private sector are likely lead to changes in the share of CIT revenues in GDP. Third, we estimate the relationship between CIT rates and revenues using a more restrictive fixed effects model. Overall, all robustness tests confirm our obtained results. Lastly, we discuss potentially remaining concerns regarding our data.

Alternative specifications

When adding higher order polynomials of the CIT rate to the basic model, they are not statistically significant. Table 2.8 shows the results of a more formal evaluation of alternative specifications up to the degree of four using the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). For both measures, the quadratic function yields the lowest values indicating the preferred model. Steinmueller et al. (2018) find similar results.

Controlling for the size of the corporate sector at the macro level

Figure B3 in the Appendix shows how the corporate share in GDP has developed between 1995 and 2016 for a balanced sample of 24 (mostly OECD) countries. In 1990. the corporate share in GDP was at 60.6 percent. Over the 21-year period it increased in 3 waves

Table 2.8: Test of alternative specifications

Polynomial	AIC	BIC
2	11741.1	11758.5
3	11742.3	11765.6
4	11743.3	11772.4

and stood at 64.8 percent in 2016. After the dot-com crash in the early 2000s and in the aftermath of the the financial crisis of 2007/2008, the corporate share declined for some time, but recovered quickly. In sum, the corporate share in GDP does not seem to be stable over time, creating a source of potential bias.

A set of estimations shown in Table 2.9 assesses the robustness of the previous results when controlling for the corporate share in the different countries. All estimations of Table 2.9 are based on macro data. Estimations (1) to (3) show the baseline results for the set of 32 countries for which the corporate share variable is available. Estimations (4) to (6) include the corresponding control variable. Adding this additional control only leads to minor changes in the coefficients for the CIT rate and its square. On average over the three different specifications, the revenue maximizing rate is 1.6 percentage points higher, when controlling for the share of the corporate sector in added value. The coefficient of the additional control is positive, but only statistically significant in estimations (4) and (5). As expected, a larger corporate share in the economy leads to higher revenues from corporate taxation.

Fixed-effects regressions

To make full use of the panel structure of the macro dataset, the main specifications are rerun using a fixed effects panel estimation.[11] Estimations (1) to (3) of Table 2.10 summarize the results.

While the coefficients in specifications (1) to (3) are substantially smaller in size than those in the pooled OLS estimations, their signs do not change. The inverse u-shaped rela-

[11] Panel estimations for the micro sample are not sensible due to the strongly unbalanced structure of the micro dataset. Many companies are only covered for an individual year or a short period of time.

tionship between CIT rates and revenues remains robust. According to Estimation (1), the revenue maximizing rate is 31.6 percent, which is close to the result from the corresponding pooled OLS estimation of 32.1 percent (see estimation (1) of Table 2.3). The coefficients for the CIT rate and its square are jointly significant at the 10-percent level. When year fixed-effects are included, the corresponding coefficients are jointly significant at the 5-percent level (estimation (2)). Estimation (3) reports the results with additional controls. In this specification, the CIT rate and its square are both significant at the 5-percent level.

Results from both the country-level estimations are therefore robust to the use of fixed-effects panel estimations.

2.4.4 Discussion of endogeneity and data concerns

Overall, this paper argues that the relationship between CIT rates and revenues is inversely U-shaped. While the exact location of the revenue maximizing rate differs between countries, the fundamental relationship seems to be robust. The estimations reported use a variety of controls to rule out potential omitted variable bias. The results from country- and firm-level estimations are also largely consistent. Moreover, we do not think that reverse causality is a central concern for our analysis. First, tax rates are in most cases determined before the revenues of a given year have materialized. Even in well governed countries, it usually takes some time until tax incomes can be precisely determined. Therefore, tax rates can - at best - be determined at the basis of last year's revenues. Second, the insignificant or in some specifications even negative coefficient of total government expenditure suggests that CIT revenues do not play a key role in the financing of governments in most countries. This may be interpreted as an argument against reverse causality, as rates are probably not set as a reaction to a certain level of revenue if the generation of revenue is not the primary reason for corporate taxation.

Nevertheless, there remain some weaknesses in our data. With regard to the macro data and given that we cover a long period of time (1965 to 2018), it is plausible that the computation and definition of some variables is not perfectly comparable across countries or changed over time. With regard to the micro data, information on taxation and pre-tax profits obtained from balance-sheets does not provide a fully accurate picture of actual tax payments. While balance-sheet items are reported following international financial

Table 2.9: Pooled-OLS regression: controlling for the relative size of the corporate sector

	(1) CIT revenue	(2) CIT revenue	(3) CIT revenue	(4) CIT revenue	(5) CIT revenue	(6) CIT revenue
CITrate	0.181**	0.182**	0.214***	0.198**	0.197**	0.214***
	(0.0830)	(0.0862)	(0.0608)	(0.0774)	(0.0793)	(0.0613)
CITrate_sq	-0.00279**	-0.00261*	-0.00264***	-0.00281**	-0.00264**	-0.00263***
	(0.00127)	(0.00131)	(0.000902)	(0.00117)	(0.00124)	(0.000917)
PIT minus CIT			-0.00510			-0.00569
			(0.0112)			(0.0116)
Govt. exp.			0.00496			0.00797
			(0.0413)			(0.0409)
Educ. exp.			-0.0998			-0.118
			(0.128)			(0.138)
Resource rents			0.325***			0.321***
			(0.0999)			(0.101)
ln(population)			-0.251*			-0.257*
			(0.127)			(0.132)
ln(GDPPC)			0.569**			0.550**
			(0.240)			(0.241)
GDP growth			0.0461*			0.0428
			(0.0272)			(0.0273)
Trade share			0.00452*			0.00416
			(0.00240)			(0.00278)
Corp. share				0.0701**	0.0686**	0.00634
				(0.0302)	(0.03029)	(0.0163)
constant	0.275	-0.322	-4.283	-4.642*	-5.145**	-4.321
	(1.171)	(1.200)	(3.981)	(2.661)	(2.502)	(3.972)
Year FE	No	Yes	Yes	No	Yes	Yes
N	649	649	648	649	649	648
R^2	0.038	0.085	0.600	0.159	0.201	0.600

Standard errors in parentheses. Standard errrors are clustered at the country level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

reporting standards (IFRS) or generally accepted accounting principles (GAAP), actual tax payments are computed following the tax legislation of individual countries. Several contributions in the accounting literature take up on the question on how well actual tax payments are reflected by accounting data. Graham et al. (2012) give a comprehensive overview on research on book-tax differences and conclude that the predictive power of taxation information obtained from firms' financial statements for actual tax payments of

Table 2.10: Fixed-effects panel estimations

	(1) CIT revenue	(2) CIT revenue	(3) CIT revenue
CITrate	0.0596	0.0768*	0.107**
	(0.0396)	(0.0399)	(0.0417)
CITrate_sq	-0.000942*	-0.000609	-0.00100**
	(0.000524)	(0.000491)	(0.000502)
PIT minus CIT			0.0163*
			(0.00862)
Govt. exp.			0.0291*
			(0.0165)
Educ. exp.			0.0153
			(0.0772)
Resource rents			0.155***
			(0.0372)
ln(population)			-0.869
			(1.482)
ln(GDPPC)			1.595***
			(0.387)
GDP growth			0.0511**
			(0.0199)
Trade share			-0.00289
			(0.00356)
constant	2.145***	0.230	-1.495
	(0.683)	(0.943)	(23.98)
Year FE	No	Yes	Yes
Country FE	Yes	Yes	Yes
N	2636	2636	2172
R^2	0.009	0.134	0.256

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

firms is limited.[12] Nevertheless, given the congruence of results obtained from macro data and firm-level data, we are confident that at the aggregate level, balance-sheet data does entail valuable information to depict trends in corporate tax burden and revenue developments.

[12]Hanlon and Heitzman (2010) provide another excellent overview on the accounting literature. In line with Graham et al. (2012), they also stress that taxation indicated in financial statements does not reflect temporary differences, such as accelerated depreciation schemes that would reduce current tax expenses but increase deferred tax expenses by the same amount.

Lastly, some caveats regarding the representativeness of the data have to be mentioned. For this paper, data from a large number of sources was combined to generate a comprehensive dataset on corporate tax rates and revenues. For most indicators, the sample represents every continent and main region in the world, all World Bank income groups, and more than three quarters of world GDP. One potential problem, however, is its unbalancedness due to changes in the composition of the sample. Such changes are almost unavoidable in long panels because of the formation of new countries and the dissolution of others. Important examples are the break-up of the Soviet Union and Yugoslavia. If changes in the sample composition significantly influence the results, it is reported accordingly. Another issue is the underrepresentation of developing countries for most indicators. This is why trends are decomposed by income group so that developments for lower income countries become visible and are not superimposed by trends of other income groups. Our micro data is an unbalanced panel data set. The number of firms included in the Orbis database rises over time, so the number of firms included is much higher for the last years of the sample than prior years. We therefore compute revenues as shares of value added to account for the increasing firm coverage over time. Yet, there might be relevant changes in firm composition over time.

2.5 Conclusion

Tax revenues from corporate income taxation are an important source of revenue for governments. While revenues have remained stable despite pronounced cuts in statutory CIT rates over the last three decades, it is questionable whether the stability in CIT revenues would hold for further CIT rate cuts. Our analysis, which is based on a large panel data set covering up to 190 countries for up to 53 years, shows that most countries are on the positively sloped side of the Laffer curve by now. For the full sample, we find a revenue maximizing CIT rate of 31.25 percent. The actual mean rate across all countries and years lies at 28.78 percent. This relatively low value is predominately driven by the CIT cuts that occurred since the 1990s in many countries. Moreover, we analyze the development of the revenue maximizing CIT rate for OECD countries over time. While it is likely to have declined from the 1980s to early 2000s (see Brill and Hassett, 2007), we find it to be rather stable since the mid 2000s at around 30 percent. These results are informative to policy makers that consider further cuts in statutory CIT rates. Our results from the micro analysis at the firm level complete the picture. Firstly, we find revenue maximizing

rates of very similar magnitude than those obtained by the macro analysis, which confirms that obtained results are robust. Secondly, we find positive trends with regard to firm profitability and the relative size of the corporate sector over time. Next to largely unobserved legal changes of tax base definitions, they are relevant explanatory factors in the observed stability of CIT revenues. Thus, developments within the corporate sector are important to consider.

Appendix

figuresection tablesection

2.A Data sources

CIT revenues. Corporate tax revenues in percent of GDP. These were taken from the OECD's Revenue Statistics database on July 16, 2018, complemented with data from the IMF's World Revenue Longitudinal Data, published in August 2015 (`http://data.imf.org/?sk=77413F1D-1525-450A-A23A-47AEED40FE78`) (last accessed on August 25, 2016) and data from the International Centre for Tax and Development's Government Revenue Dataset, released in May, last accessed on September 5, 2016. (`http://www.ictd.ac/datasets/the-ictd-government-revenue-dataset#core-dataset`).

CIT rates. Top statutory corporate income tax rates (sum of taxes of all levels of government on January 1 of the respective year, in percent). These rates were taken from several issues of KPMG's Corporate Tax Surveys (1998 to 2006), KPMG's Corporate and Indirect Tax Surveys (2007 to 2014) and KPMG's Corporate tax rates table (2015-2018), complemented with data from EY's Annual Worldwide Corporate Tax Guides (2004 to 2017), data from the Oxford University Centre for Business Taxation and Devereux (2007).

Income groups Income groups are defined according to the World Bank definition of July 2016 and taken from `https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups` (last access 28/08/16). Since Argentina was not classified in July 2016, the classification of 2015 is used.

NPV of depreciation allowances. Net present value of depreciation allowances for industrial buildings (in percent). We follow the approach of Devereux et al. (2002) and Devereux et al. (2011) in the calculation of the net present value of allowances per unit of investment. Capital allowances are differentiated in straight line and declining basis systems in the calculation. A real interest rate of 5 percent and an inflation rate of 2 percent

is assumed. We refrain from potential interaction effects with personal taxes. Information on depreciation allowances is taken from several issues EY's Annual Worldwide Corporate Tax Guides (2004 to 2017).

PIT minus CIT. Difference between the maximum statutory individual and corporate tax rates (in percentage points). PIT rate are top statutory rates for personal income taxation as applicable to the top bracket of the personal income tax schedule (in percent). For the period from 1981 to 2005, tax rates were taken from Georgia State University's Andrew Young School World Tax Indicators (`https://aysps.wufoo.com/forms/s7x0x5/`) on August 15, 2016. Tax rates for the years from 2006 to 2018 were taken from KPMG's Individual Income Tax Rates Tables and EY's Worldwide Personal Tax Guides (2013/14 - 2016/17).

Government expenditure. General government final consumption expenditure in percent of GDP. This includes all government current expenditure for purchases of goods and services, including the compensation of employees, and most expenditure on national defense and security. These were taken from the World Bank's World Development Indicators Database `http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators` on July 16, 2018.

Educaction expenditure. Operating expenditure on education in percent of GNI, including wages and salaries, excluding capital investments in buildings and equipment. These were taken from the World Bank's World Development Indicators Database `http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators` on July 16, 2018.

Resource rents. Rents from resources (oil, gas, coal, minerals and forest) in percent of GDP. These were taken from the World Bank's World Development Indicators Database `http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators` on July 16, 2018.

ln(population). Natural logarithm of total number of country residents. These were taken from the World Bank's World Development Indicators Database `http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators` on July 16, 2018.

ln(GDPPC). Natural logarithm of GDP per-capita (in constant 2010 USD). These were taken from the World Bank's World Development Indicators Database `http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators` on July 16, 2018.

GDP growth. Annual growth rate of GDP (in percent). These were taken from the World

Bank's World Development Indicators Database http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators on July 16, 2018.

Trade share. Sum of exports and imports of goods and services in percent of GDP. These were taken from the World Bank's World Development Indicators Database http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators on July 16, 2018.

Corporate share. Corporate sector share in value in percent of total value added. OECD National Accounts at a Glance Dataset, OECD National Accounts Statistics, https://doi.org/10.1787/data-00369-en on July 16, 2018.

Taxation (TAXA). All taxes related to the accounting period (paid, accrued or deferred). Source: Bureau van Dijk, Orbis Database.

Added Value (AV). Sum of Taxes paid, Profit/Loss for period, Costs of employees, depreciation and interest paid. Source: Bureau van Dijk, Orbis Database.

EBITDA. Earnings before interest, taxes, depreciation and amortization. Source: Bureau van Dijk, Orbis Database.

Depreciation (DEPR). Total amount of depreciation and amortization of the assets. Source: Bureau van Dijk, Orbis Database.

Interest payments (INTE). Total amount of interest charges paid. Source: Bureau van Dijk, Orbis Database.

Other fin. profits (oFIN). Net result from financial activities of the company, defined as financial revenue minus financial expenses, excluding interest payments. Source: Bureau van Dijk, Orbis Database.

2.B Additional tables

Table B1: Number of firms and observations by country in the micro data set

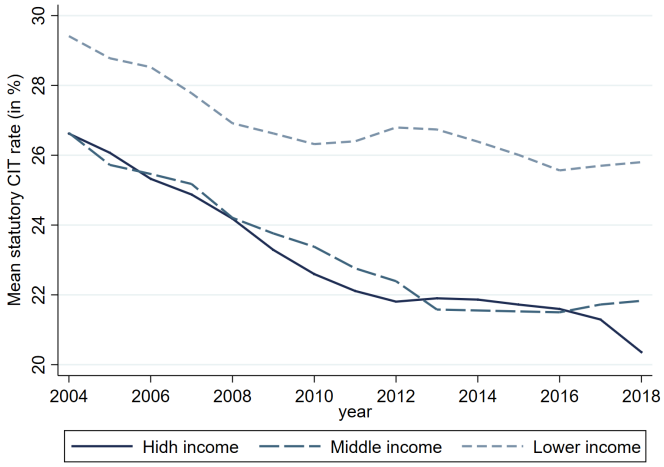
Country	**Firms**	**Observations**
Austria	7,819	37,428
Australia	2,483	6,818
Belgium	19,148	96,248
Canada	361	850
Chile	53	121
Czech Republic	45,307	180,827
Denmark	38540	71,197
Finland	52,136	202,665
France	331,520	1,539,164
Germany	93,638	392,816
Greece	33	93
Hungary	15,258	64,114
Iceland	10	21
Ireland	3,847	12,542
Israel	49	111
Italy	554,352	2,733,302
Japan	132,668	440,101
Latvia	223	792
Luxembourg	2,079	7,677
Netherlands	868	3,004
New Zealand	568	1,679
Norway	72,958	304,833
Poland	38,592	161,839
Portugal	146,042	534,984
Republic of Korea	149,805	569,543
Slovak Republic	40,177	134,402
Slovenia	20,002	66,210
Spain	412,171	1,721,385
Sweden	72,687	358,722
Switzerland	333	2,166
Turkey	33	111
United Kingdom	58,996	231,568
United States	464	1,382
Total	2,313,220	9,878,715

Table B2: List of countries by income group

High income countries			
Andorra	Czech Republic	Republic of Korea	San Marino
Antigua and Barbuda	Denmark	Kuwait	Saudi Arabia
Argentina	Estonia	Latvia	Seychelles
Aruba	Faroe Islands	Liechtenstein	Singapore
Australia	Finland	Lithuania	Sint Maarten (Dutch part)
Austria	France	Luxembourg	Slovakia
Bahamas	French Polynesia	Macao SAR, China	Slovenia
Bahrain	Germany	Malta	Spain
Barbados	Gibraltar	Monaco	St. Kitts and Nevis
Belgium	Greece	Nauru	St. Martin (French part)
Bermuda	Greenland	Netherlands	Sweden
British Virgin Islands	Guam	New Caledonia	Switzerland
Brunei Darussalam	Hong Kong SAR, China	New Zealand	Taiwan, China
Canada	Hungary	N. Mariana Islands	Trinidad and Tobago
Cayman Islands	Iceland	Norway	Turks and Caicos Islands
Channel Islands	Ireland	Oman	United Arab Emirates
Chile	Isle of Man	Poland	United Kingdom
Croatia	Israel	Portugal	United States
CuraÃ§ao	Italy	Puerto Rico	Uruguay
Cyprus	Japan	Qatar	Virgin Islands (U.S.)
Middle income countries			
Albania	Cuba	Kazakhstan	Peru
Algeria	Dominica	Lebanon	Romania
American Samoa	Dominican Republic	Libya	Russian Federation
Angola	Ecuador	Macedonia, FYR	Serbia
Azerbaijan	Equatorial Guinea	Malaysia	South Africa
Belarus	Fiji	Maldives	St. Lucia
Belize	Gabon	Marshall Islands	St. Vincent and the Grenadines
Bosnia and Herzegovina	Georgia	Mauritius	Suriname
Botswana	Grenada	Mexico	Thailand
Brazil	Guyana	Montenegro	Turkey
Bulgaria	Iran, Islamic Rep.	Namibia	Turkmenistan
China	Iraq	Palau	Tuvalu
Colombia	Jamaica	Panama	Venezuela
Costa Rica	Jordan	Paraguay	
Lower income countries			
Afghanistan	Ethiopia	Mauritania	South Sudan
Armenia	Gambia	Micronesia, Fed. Sts.	Sri Lanka
Bangladesh	Ghana	Moldova	Sudan
Benin	Guatemala	Mongolia	Swaziland
Bhutan	Guinea	Morocco	Syrian Arab Republic
Bolivia	Guinea-Bissau	Mozambique	Tajikistan
Burkina Faso	Haiti	Myanmar	Tanzania
Burundi	Honduras	Nepal	Timor-Leste
Cabo Verde	India	Nicaragua	Togo
Cambodia	Indonesia	Niger	Tonga
Cameroon	Kenya	Nigeria	Tunisia
Central African Republic	Kiribati	Pakistan	Uganda
Chad	Korea, DPR	Papua New Guinea	Ukraine
Comoros	Kosovo	Philippines	Uzbekistan
Congo, DR	Kyrgyz Republic	Rwanda	Vanuatu
Congo, Rep.	Lao PDR	Samoa	Vietnam
CÃ´te d'Ivoire	Lesotho	SÃ£o TomÃ© and Principe	West Bank and Gaza
Djibouti	Liberia	Senegal	Yemen, Rep.
Egypt, Arab Rep.	Madagascar	Sierra Leone	Zambia
El Salvador	Malawi	Somalia	Zimbabwe
Eritrea	Mali		

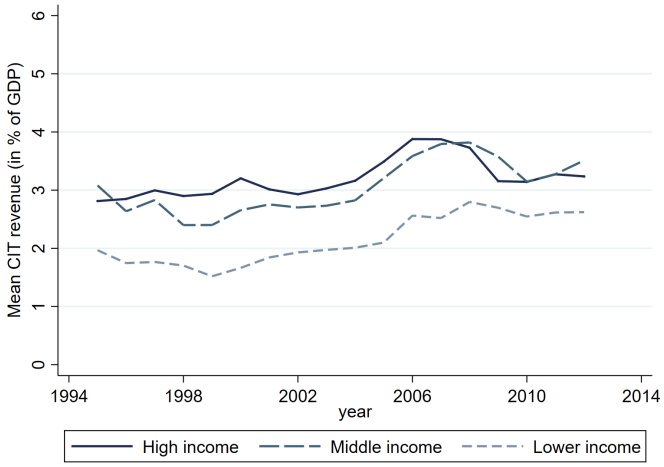
2.C Additional figures

Figure B1: The development of statutory CIT rates by income group



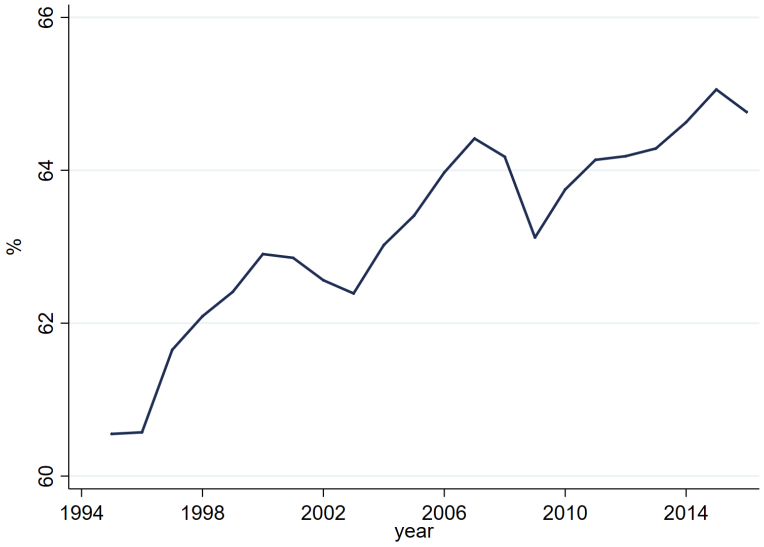
Note: This figure is based on data for a balanced sample of 147 countries.

Figure B2: The development of CIT revenues by income group



Note: This figure is based on data for a balanced sample of 102 countries.

Figure B3: The development of the corporate share in GDP (balanced sample)



Note: This figure is based on data for a balanced sample of 24 countries.

Figure B4: CIT revenues: Comparison of macro and micro data

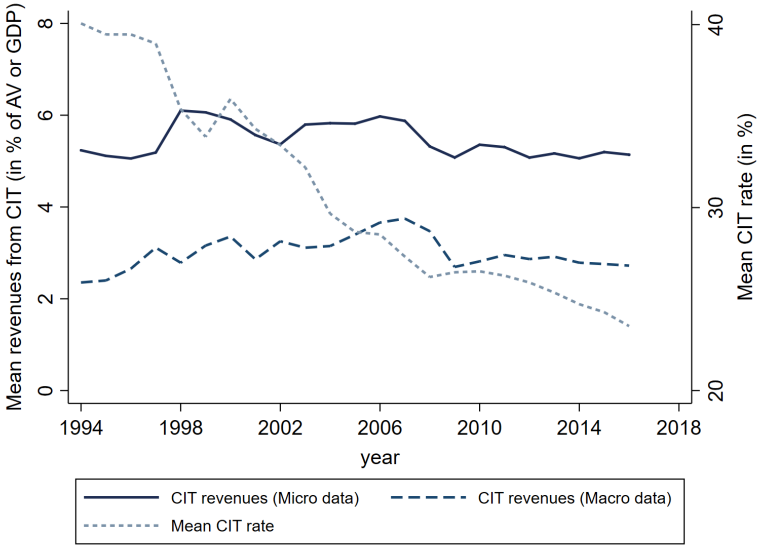
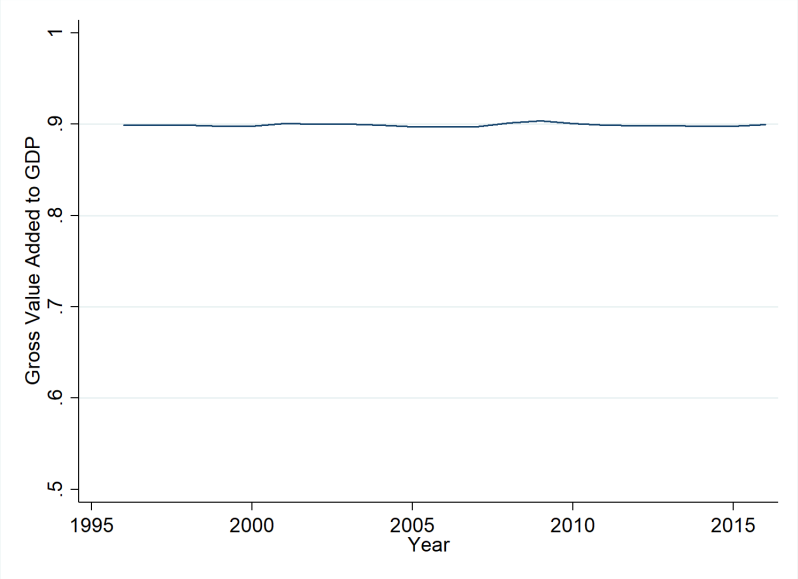


Figure B5: Aggregate value added (micro data) as a proxy for GDP



Chapter 3

Effective tax rates of multinational firms: are digital firms any different?

"You must pay taxes. But there's no law
that says you gotta leave a tip."[1]

3.1 Introduction

Discrepancies between statutory corporate income tax rates and effective tax payments of firms, have caused an intense public debate on the "fairness" of corporate taxation. Especially large and highly successful multinational tech firms such as Alphabet, Amazon, Apple or Facebook are in the center of attention. This has been fueled by a recent proposal of the European Commission to adopt a special taxation regime targeted at "digital companies". The Commission argues that under current international taxation rules, it is especially the group of firms in the digital business sector, that does not pay its "fair share of tax" (European Commission 2018). This argumentation has been shaped by two developments: Firstly, the European Commission is concerned that although a majority of costumers of digital firms is located in its member countries, the tax relevant location of value creation is often stated to be in third countries. Secondly, investigations by the European Commission over the last years have detected some questionable tax practices among its member states that involved digital firms. For example, in August 2016 the European

[1] This quote is taken from a Morgan Stanley Advertisement.

Commission released the results of its investigations on tax rulings granted to Apple by Ireland and found Apple's effective tax rate on its European profits to be at 0.005 percent in 2014 (European Commission, 2016). However, the analysis of a firm's tax payments in individual countries or geographical regions does not allow for any conclusions with regard to a firm's global tax burden.

So far, there is a lack of conclusive evidence on whether the effective tax rates of digital firms on their global income are any different from those of other firms. This paper aims to shed light on this question by analyzing the firm level determinants of effective tax rates for a large sample of firms, containing both digital and non-digital firms. My panel data set contains consolidated financial statement data and covers firms from 138 countries for the period 1984 to 2013. This paper focuses on the analysis of consolidated financial statement data, as I am interested in the tax burden firms face as economic entities, comprising all facets of the corporate structure. Firstly, I explore firm level factors that determine corporate tax payments. I find that larger (in terms of total assets) and more profitable firms face higher average effective tax rates. On the other hand, firms with higher R&D intensity, a higher debt ratio and a higher share of cash holdings face lower average effective tax rates. Secondly, I check for differences in determinants of effective tax rates between digital and non-digital firms. I find that the positive effect of firm size on the effective tax rate is even larger for digital firms. Contrary to non-digital firms, a higher share of intangible assets in total fixed assets is connected to a lower effective tax rate for digital firms. There are no differences with regard to the influence of R&D intensity, the debt ratio and cash holdings. Thirdly, I look at trends in the dispersion of effective tax rates over time. Applying the panel convergence and club clustering test by Philipps and Sul (2007, 2009) on the full sample as well as for the sample of digital firms, I do not find any signs of convergence of effective tax rates across firms over time. This reflects the fact that firms, and especially the group of digital firms, are highly heterogeneous in tax relevant tax characteristics.

Previous results from the literature help to understand general developments in corporate taxation. Several studies have shown a negative global trend with regard to statutory corporate income tax rates over the last decades. For example, Devereux (2007) shows that statutory corporate income tax rates in OECD countries have been declining significantly since the 1960s from an average of slightly above 40 percent to around 33 percent in 2004. Cuts in statutory tax rates were often accompanied by tax base broadening measures in order to moderate the negative effect on tax revenues. However, the base broadening mea-

sures only partially counteracted the decline in statutory tax rates. Therefore, effective tax rates, measured as the share of income taxes paid in pre-tax profits, show a negative trend over time as well. Next to a fall in levels of statutory and effective tax rates, Slemrod (2004) also finds evidence for a decline in the dispersion of statutory and effective tax rates across countries over time. Regis et al. (2015) do not find evidence of an overall convergence of statutory tax rates in European countries but identify four distinct convergence clubs. With regard to effective tax rates, Spengel et al. (2016) finds large heterogeneity in the mean effective average tax rates across European countries. Applying the methodology by Devereux and Griffith (1999,2003), they find the mean average effective tax rate in 2016 to vary between 9 percent (Bulgaria) to 38.4 percent (France).

The tax competition literature offers an approach to explain the observed negative trends in statutory tax rates. Slemrod (2004) argues that the decline in statutory and effective rates since the 1980s is mainly due to competitive pressures rather than changes in the domestic determinants of corporate taxation. Devereux et al. (2002) look at effective tax rates on marginal investment across the EU and G7 countries and find evidence for increased competition for profitable projects, which is reflected in declining effective tax rates on those investments.

In addition to contributions from the tax competition literature, insights from the profit-shifting literature prove helpful in understanding falling trends in effective tax rates, especially in the case of multinational firms. Firms lower their effective tax burden by exploiting differences, mismatches and loopholes in international tax law to optimally allocate capital across countries. Huizinga and Laeven (2008) and Dischinger (2010), for example, show that there is a negative relationship between the statutory corporate tax rate of a country and the share of reported pre-tax profits in that country. Next to contributions quantifying the extent of artificial profit-shifting and estimating the magnitude of tax revenue lost due to (legal) tax avoidance, much effort has been put in disentangling the shifting channels. Heckemeyer and Overesch (2017) find companies to preliminary rely on strategic transfer pricing and licensing, rather than inter-company debt, to artificially shift profits across countries. Besides Heckemeyer and Overesch (2017), Dharmapala (2014) and Riedel (2018) provide excellent and detailed overviews on the profit shifting literature. Next to profit reallocations, strategic location decisions and tax haven activity of firms can help to lower their tax burden as well. For example, Hines, Gumpert and Schnitzer (2016) investigate investments in tax havens based on firm characteristics. They find that larger and more productive manufacturing firms are more likely to own tax haven affiliates.

Most closely related to the research question of this paper, several studies focus on exploring

firm level determinants of effective tax rates. Using consolidated financial accounts data, Markle and Shackelford (2012, 2014) show that headquarter location matters. Analyzing firms from 82 countries for the period 1988 to 2009, they find that Japanese and US based multinationals face significantly higher effective tax rates on their worldwide income than multinationals headquartered in tax havens. Nicodeme (2007b) examines the relationship between firm size and tax payments and finds a robust negative correlation between the total number of employees and the effective tax rates of companies in the European Union. Fuest, Maffini and Riedel (2010) analyze country and firm level determinants of effective tax rates in developing countries. They find that larger firms pay higher effective tax rates, on average. A higher degree of corruption in the country is connected to lower tax payments of firms. Whether the firm belongs to a multinational group or not does not have any influence on its effective tax rate. The latter result is confirmed by Markle and Shackelford (2012), who also do not find significant differences between the effective tax rates of multinational and domestic firms. Markle and Shackelford (2014) furthermore show that the type (financial conduit vs. operating subsidiaries) and location of newly obtained subsidiaries matters for the effective tax rate at the consolidated level. Some papers go beyond the analysis of financial statement information and stress the relevance of typically unobserved factors such as management, corporate culture and compensation schemes. Dyreng et al. (2010) find evidence for individual effects of top executives on effective tax rates. Desai and Dharmapala (2006), Rego and Wilson (2012) as well as Armstrong et al. (2012) show that incentive mechanisms in compensation schemes impact the effective tax rate of firms.

Most of the mentioned papers use unconsolidated financial statement data and focus on the analysis of tax payments within countries. With my focus on consolidated data, I add to the literature by comprehensively analyzing determinants of effective tax rates of firms as economic entities. Next to pooled OLS estimations, I use a fixed effects model to account for the potential influence of unobserved firm characteristics such as management and compensation scheme effects. By exploring differences in the determinants of effective tax rates between digital and non-digital firms, this paper is furthermore informative to the current debate on a fair taxation of firms in the digital business sector.

The paper will proceed as follows: Section 3.2 discusses the conceptual framework and derives hypotheses to be tested in the empirical analysis. Section 3.3 describes the data, while section 3.4 introduces the empirical estimation strategy. Section 3.5 presents the results and section 3.6 concludes.

3.2 Conceptual framework and hypotheses

The focus of this paper lies on the analysis of effective tax rates (ETRs) of firms as economic entities. Assets, liabilities, income and expenses of the parent company and its subsidiaries are therefore considered as those of a single economic entity. The effective tax rate, which a multinational firm i with j subsidiaries in c countries in year t faces, is equal to the ratio of its worldwide reported tax payments to worldwide taxable income and can be expressed in the following way:

$$Effective\ tax\ rate_{i,t} = \frac{\sum\limits_{j,i,c} [\tau_{c,t} \cdot taxable\ income_{j,i,c,t}]}{\sum\limits_{j,i,c} taxable\ income_{j,i,c,t}} \tag{3.1}$$

Tax payments at the subsidiary level in a country are equal to taxable profit within that country multiplied by the respective statutory corporate income tax (CIT) rate. Worldwide tax payments are then equal to the sum of all tax payments over all subsidiaries and countries the firm operates in. Information on taxable income in individual countries, however, is not available as tax return data, which would contain this information, is confidential. Using information from consolidated financial statements, however, the effective tax rate (ETR) of firm i in year t can be approximated in the following way:

$$ETR_{i,t} = \frac{\sum\limits_{j,i,c} [\tau_{c,t} \cdot taxable\ income_{j,i,c,t}]}{\sum\limits_{j,i,c} taxable\ income_{j,i,c,t}} \cdot (1 - \lambda_{c,t}) \approx \frac{TAXA_{i,t}}{PLBT_{i,t}} \tag{3.2}$$

The ETR is computed as the ratio of tax expenses ($TAXA$) to profit/loss before taxation ($PLBT$) as reported in financial statements. Using consolidated financial statement data, this is equal to worldwide tax expenses to worldwide pre-tax profit of the firm. Reported pre-tax accounting income is not equal to taxable income due to book-tax differences, which is reflected by the term $(1 - \lambda)$. Book-tax differences arise, as firms report financial statement information according to IFRS (or GAAP), while taxable income is determined in accordance with the respective national tax laws (Drake et al., 2018). Book-tax differences potentially vary across countries and over time, mainly due to changes in national tax laws. The sign and magnitude of $(1 - \lambda)$ cannot be estimated. A second caveat, that should be kept in mind, arises with regard to the taxation variable in financial statements. Income

tax expenses as reported in financial statements contain both, current and deferred taxes. Ideally, I would like to separately identify current taxes and deferred taxes as they reflect timing differences arising from accounting principles. Despite these difficulties, using taxation information from financial statements holds the advantage, that it is widely available and considerably well comparable across countries due to common accounting principles such as IFRS. Moreover, Markle and Shackelford (2012) show, that total and current tax expense are highly correlated. Therefore, my measure of ETR should be suitable to capture trends in ETR within and across firms.
From equation 3.2, it is evident that the ETR is affected by the statutory tax rates and the share of worldwide profit reported in the respective countries, in which the firm's headquarter and its subsidiaries are located in. Using information from consolidated financial statements doest not allow to attribute shares of reported profit to the different subsidiaries of a firm or to analyze (re-)location decisions of firms. However, it allows for a comprehensive ex-post analysis of the relationship between firm characteristics and the reported tax burden of firms.

I expect the ETR to be influenced by a set of firm characteristics. In the following, I will briefly discuss the hypotheses on the distinct firm characteristics, building on previous findings from the literature. Given that digital firms file their financial statements according to the same accounting rules as other firms, I do not expect to see distinctive trends regarding every discussed factor. However, given the public scrutiny that digital firms face on the one hand, and the special endeavors of many countries to attract them on the other hand, I expect to see differing results for digital firms in some aspects.

The impact of firm size on the ETR has been discussed in the literature before. The sign of the relationship, however, is found to be ambiguous. Some early studies (Rego, 2003; Kraft, 2014) find a positive relation between firm size and ETR. They argue, that larger firms have a greater public visibility and are therefore more in the focus of tax authorities and the government, which might take action to redistribute wealth away from the firm. On the other hand, other studies find a negative relationship (e.g. Richardson and Lanis, 2005) and argue that larger firms tend to have a larger set of possibilities to avoid taxes and more resources to engage in tax planning. Siegfried (1972) introduces a political economy argument by stating that larger firms are more likely to influence the political process in their favor. Another class of studies (such as Liu and Cao, 2007) argues, that there is no systematic relationship between firm size and ETR at all. Two measures are commonly

used to capture the size of a firm: the total number of employees and total assets. In terms of total assets, I expect to see a positive relationship between firm size and the ETR. The recent endeavors by the European Commission, hint towards the public visibility argument. On the other hand, in terms of employees, I expect to see a negative effect due to the political economy argument. Especially firms that employ a large number of people are likely to receive a favorable treatment by politicians and local authorities. With regard to digital firms, I expect the positive effect of firm size in terms of total assets to be more pronounced, given the public attention on those firms.

Corporate tax systems in most countries tend to treat debt and equity financing differently. While interest expenses are often tax-deductible, dividend payouts are usually not. I therefore expect to see a negative relationship between the share of debt financing of a firm and its ETR. I do not expect this effect to differ between digital and non-digital firms.

Previous studies have looked at the relationship between firm profitability and the ETR. The sign of the effect is found to be ambiguous. Armstrong et al. (2012) find a positive relationship between the return on assets (ROA) and the ETR. However, they also find a negative relationship with regard to the standard deviation of ROA. The authors argue that a greater variation in pre-tax profits results in lower ETRs to be paid. Mahenthiran and Kasipillai (2011) find a negative relation and argue that more profitable firms engage more in tax planning. While the sign of the effect could go into both directions, I do not expect to see a difference in the effect between digital and non-digital firms.

Many countries offer special tax treatment to income from intellectual property, such as patents. In Europe, eleven countries offer so-called Intellectual Property Box regimes. (Evers et al., 2013) I therefore expect to see a negative relationship between R&D intensity and the ETR. In a robustness check, a control variable for the level of government support provided in the country the firm is headquartered in is added. I also check for an influence of the share of intangible assets in total fixed assets. Depreciation rules that apply to tangible assets can often not be applied to intangibles. Therefore, I expect to see a positive relationship between the share of intangibles and the ETR. However, I expect to see a differing trend for digital firms. Given that many countries try to attract highly innovative digital firms, that are characterized by a high share of intangible assets, I expect to see a negative relationship between the share of intangibles and the ETR for digital firms.

Lastly, I analyze the relationship between the share of cash that a firm holds and its ETR. I expect to see a negative relationship between the share of cash and the ETR since holding a larger share of cash might indicate a higher propensity of the firm to flexibly reallocate profits across borders. There should not be any difference in the effect with regard to digital firms.

Of course, anti-profit shifting regulations and improvements in tax enforcement at the national and international level impact the influence of the previously discussed firm characteristics on the average tax burden from corporate income taxation. For example, most base-broadening reforms included some form of thin-capitalization regulations that led to a decline in the advantage from debt financing. On the other hand, IP Boxes and R&D tax credits represent relatively new instruments, which were introduced in numerous countries to attract highly innovative firms. They widened opportunities for R&D intensive firms to legally lower their tax burden.

Next to discussing the influence of firm characteristics on ETRs, I also look at trends in the dispersion of ETRs over time. Given that the previously described firm characteristics are likely to influence ETRs at the firm level, a convergence in ETRs across firms could be expected if firms got more similar in relevant firm characteristics. Furthermore, convergence trends could occur if the stated hypothesis in the literature (e.g. Slemrod, 2004) holds, that statutory CIT rates converge across countries over time. I am especially interested if a convergence pattern can be identified with regard to the group of firms that the European Commission classifies as digital firms. Results on the convergence test will be presented in Section 3.5.3, after presenting results for the influence of firm-level characteristics on ETRs in Section 3.5.1.

3.3 Data

3.3.1 Data sources and the sample selection process

Financial statement data used in this paper stem from the BvD Orbis database. Orbis collects balance sheet and profit and loss account data via country specific data providers.[2]

[2]By covering both listed and non-listed firms, Orbis offers a broader coverage than other available firm-level databases, such as Compustat. A list of data providers by country is provided in the Appendix C3. A more detailed report on filing requirements and coverage by country can be found in Kalemli-Ozcan et

The dataset spans the period 1984 to 2013 [3] and includes consolidated financial statements from firms located in 138 countries worldwide. Orbis differentiates types of accounts based on their consolidation level. For the purpose of this paper, a differentiation is made between consolidated accounts (Orbis consolidation level C1 and C2) and unconsolidated accounts (Orbis consolidation level U1 and U2). A consolidated statement is defined as "the statement of a company integrating the statements of its subsidiaries" (Bureau van Dijk, 2011). This paper will use data from consolidated accounts, as the focus of the analysis lies on developments of tax burdens of large (multinational) companies as economic entities. Most contributions in the literature use unconsolidated account information at the subsidiary level, as this allows for within country analyses as well as to track profit shifting activities among subsidiaries of the same firm. Given the extremely complex group structures of large multinational companies, however, it is impossible to get a full picture of a firm's tax burden from unconsolidated account data. This paper aims at filling this gap in the literature by relating firm characteristics to the reported tax burden at the consolidated level. Information on statutory tax rates is collected from the annual tax reports of EY, KPMG and complemented by data from Devereux (2007). Detailed information on the data sources used to compile the statutory tax rates dataset can be found in the Appendix of Chapter 2. Industry classifications are made corresponding to the Statistical Classification of Economic Activities in the European Community (NACE) as well as the International Standard Industrial Classification of All Economic Activities (ISIC).[4] Firms are classified according to their main business activity. For the purpose of this paper, 17 industry groups are formed. Digital firms are identified at the NACE 4-digit level following the definition of the European Commission (2018). It basically comprises firms whose main business segments rely on digital data, technologies or online platforms. Table C6 shows the industry classifications and short descriptions of the respective groups.

Table C1 summarizes the steps to the final sample. The original dataset spans the period 1979 to 2014, with very few observations for the years 1979 to 1983 and 2014. Consequently, those years were dropped. Furthermore, incomplete balance-sheet information with regard to taxation and profit/loss before taxation was dropped as well as micro firms with total assets of less than 2 million USD, as in many countries special CIT rates and tax incentives

al., 2015.

[3] The latest Orbis version used in this data set stems from 2015; Orbis has a reporting lag of about two years on average, 2014 was excluded due to a low number of observations available.

[4] NACE Rev. 2 classifications used to define industry groups are equivalent to ISIC Rev.4 groups at the two-digit level (United Nations, 2008).

exist for very small firms. Moreover, I dropped observations from the agricultural sector, the mining and quarrying sector, firms active in public administration, defense activities or education, art and recreation. Firms, which are active in these areas, are likely to face a special set of tax rules or to receive public support in forms of subsidies, for example. Therefore, their ETR would be hard to compare with firms from the manufacturing or services sector. I dropped observations with obvious accounting mistakes and implausible values. To give one example, I checked whether indicated tax expense ($TAXA$) matches with the reported difference between profit/loss before tax ($PLBT$) and profit/loss after tax ($PLAT$). If reported $TAXA$ deviates by more than 10 percent from ($PLBT - PLAT$), the observation is dropped. I also dropped observations from firms that report tax expenses to be larger than their total assets in the same year as well as observations from firms reporting negative values for intangible assets or R&D expenses as it is unclear whether there is some economic reasoning behind it or if it simply reflects accounting mistakes. For the final sample, the debt ratio of firms is computed as the ratio of the sum of loans ($LOAN$) and long term debt ($LTBD$) to total assets ($TOAS$). R&D intensity is the ratio of R&D expenses (RD) to turnover ($TURN$), alternatively operating revenue ($OPRE$) is used in the denominator. The cash ratio is the share of cash holdings of the firm ($CASH$) in total assets. Return on equity (ROE) and return on assets (ROA) are the two measures that are used to capture profitability of the firm. Return on equity is computed as the ratio of profit/loss for the period (PL) to shareholder funds ($SHFD$) and return on assets relates profit/loss for the period to total assets. Furthermore, the relevance of intangible assets for the firm is captured by the share of intangible fixed assets ($IFAS$) in total fixed assets ($FIAS$). Table C5 gives an overview on the definition and computation of the variables used in the analysis.

3.3.2 Descriptive statistics

The final unbalanced sample contains 539,628 observations from 112,143 firms covering 30 years from 1984 to 2013. Firms in the sample are headquartered in 138 countries. 86 percent of observations and firms in the sample stem from the 15 countries with most observations. These 15 countries include five European countries (Germany, France, Great Britain, the Netherlands and Sweden), the United States, Canada, China, India, four other Asian countries (Japan, Malaysia, Thailand, Vietnam) and interestingly two tax havens (Singapore, Cayman Islands). Countries in the dataset are grouped into six geographical

regions: Europe, South and Central America, North America, Asia, Oceania and Africa. Table C2 in the Appendix indicates the number of observations and firms in the final sample as well as the length of the panel by country and region. Some specifications report graphs and table for a balanced panel covering the years 2004 to 2013. It contains 62,070 observations from 6,207 firms. Summary statistics on the balanced panel are reported in the Appendix in Table C15.

Table 3.1 reports summary statistics on the unbalanced panel, containing the key items from financial statements of firms. In the upper part A of the table, summary statistics are reported for the full sample. The lower part B of table 3.1 shows summary statistics for the group of digital firms. The group of digital firms is defined following the definition of Fuest et al. (2018), which builds on the definition of digital business activities of the European Commission (2018). It contains 2,666 firms from 64 countries and includes major firms such as Apple, Google, Facebook, Alibaba, Twitter and Yahoo.

Table 3.1 reports three distinct values with regard to effective tax rates. ETR is computed including all firms in the sample, also those that report negative or zero tax payments. ETR1 reports summary statistics on the group of firms that report either zero or positive tax payments. ETR2 presents summary statistics for the group of firm that actually pays taxes by excluding firms with zero or negative tax payments. In the full sample, firms pay an ETR of 21 percent, on average. The reported ETR is slightly lower for digital firms with an average ETR of 20 percent. The median firm in the full sample pays 24 percent in corporate income taxes, for the median digital firm it is 21 percent. The share of intangible assets in total fixed assets is 23 percent for the full sample, on average. The share of R&D expenses in operating profit is 2 percent. These values are considerably higher fro the group of digital firms with a ratio of intangibles to total fixed assets of 46 percent and an R&D intensity of 5 percent. Comparing the summary statistics for the return on equity (ROE) and the return on assets (ROA), it is evident that the business activities of digital firms are more volatile. $Loss\_last\_year$ is a dummy variable that takes the value of one if the firm reported a negative value for $PLBT$ in the previous year. On average, 14 percent of digital firms report losses in the previous year while it is only 8 percent of firms across the full sample.

Table 3.1: Summary statistics on financial statement data

	mean	sd	p50	min	max	count
A: Full sample						
ETR	0.21	0.16	0.24	-0.23	0.62	539,628
ETR1	0.23	0.14	0.25	0.00	0.62	493,737
ETR2	0.26	0.12	0.26	0.00	0.62	445,955
TAXA	16.73	217.34	0.28	-0.04	39,943.19	539,628
PLBT	58.85	740.49	1.30	-81,888.96	174,799.30	539,628.00
TOAS	1,281.36	20,719.01	27.74	2.00	2,907,129.25	535,600
Employees	3,983.54	22,740.75	393.00	0.00	2,200,000.00	231,629
Intangibles_ratio	0.23	0.28	0.09	0.00	2.12	227,648
Cash_ratio	0.14	0.18	0.08	-0.15	1.00	395,563
RD_intensity	0.02	0.07	0.00	0.00	1.15	25,5687
Debt_ratio	0.17	0.21	0.08	-0.45	1.00	460,900
ROE	0.11	0.59	0.11	-10.00	9.97	511,589
ROA	0.04	0.13	0.04	-1.00	1.00	530,391
Loss_last_year	0.08	0.27	0.00	0.00	1.00	539,628
Digital	0.03	0.16	0.00	0.00	1.00	539,628
B: Digital firms						
ETR	0.20	0.18	0.21	-0.23	0.62	13,883
ETR1	0.23	0.16	0.25	0.00	0.62	12,060
ETR2	0.27	0.14	0.28	0.00	0.62	10,303
TAXA	16.38	146.38	0.67	0.00	5,541.00	13,883
PLBT	47.10	904.49	2.84	-81,888.96	22,540.00	13,883.00
TOAS	597.15	4,470.83	50.91	2.00	175,940.97	13,536
Employees	2,982.13	16,174.91	352.00	0.00	434,246.00	9,537
Intangibles_ratio	0.46	0.32	0.44	0.00	1.03	10,498
Cash_ratio	0.25	0.22	0.19	0.00	1.00	12,852
RD_intensity	0.05	0.12	0.00	0.00	1.15	9,875
Debt_ratio	0.12	0.17	0.05	0.00	1.00	12,621
ROE	-0.02	0.87	0.10	-9.94	9.92	12,722
ROA	0.02	0.19	0.05	-1.00	0.99	13,139
Loss_last_year	0.14	0.35	0.00	0.00	1.00	13,883

Notes: Values for total assets (TOAS), taxation (TAXA) and profit/loss before taxation (PLBT) are in Million USD. Employees indicates the total number of people working for a firm. ROE and ROA are ratios of profit/loss for the period to total equity and total assets, respectively.

Table 3.2: Growth rates of the key items from financial-statement data

	mean	sd	p50	min	max	count
A: Full sample						
growth_toas	0.14	0.30	0.08	-0.50	2.19	359,819
growth_ifas	0.48	2.64	-0.01	-1.00	37.72	158,038
growth_ebitda	0.13	0.91	0.08	-5.75	6.64	208,483
growth_plbt	0.18	1.39	0.06	-7.72	10.16	362,824
growth_roe	-0.53	0.48	-0.61	-2.32	1.97	338,677
growth_roa	0.04	1.00	-0.05	-4.32	5.55	347,744
growth_taxa	0.56	2.12	0.07	-1.00	23.65	335,897
growth_cash	0.81	3.07	0.08	-0.97	38.07	268,183
growth_rd	0.18	0.71	0.08	-1.00	6.11	45,618
growth_debt	0.37	1.96	0.00	-1.00	27.17	206,962
B: Digital firms						
growth_toas	0.17	0.37	0.09	-0.50	2.19	8,857
growth_ifas	0.69	3.06	0.02	-1.00	37.62	7,150
growth_ebitda	0.14	1.07	0.10	-5.75	6.55	8,570
growth_plbt	0.22	1.47	0.10	-7.72	10.04	9,384
growth_roe	-0.47	0.49	-0.52	-2.32	1.96	8,228
growth_roa	-0.01	1.00	-0.07	-4.24	5.49	8,577
growth_taxa	0.65	2.32	0.10	-1.00	23.47	8,284
growth_cash	0.70	2.81	0.08	-0.97	37.97	8,698
growth_rd	0.26	0.86	0.10	-1.00	6.03	3,113
growth_debt	0.53	2.55	-0.04	-1.00	27.08	6,158

Given the panel structure of the dataset, growth rates of the key variables can be calculated at the firm level. Part A of Table 3.2 reports growth rates for the full sample of firms, part B of the table reports growth rates for the group of digital firms. Digital firms grow faster with respect to total assets as well as absolute values of profit/loss before taxation and earnings before interest, taxation and amortization (EBITDA). Digital firms also show higher growth rates in terms of intangible assets and R&D expenses. While firms in the full sample show, on average, a positive growth rate of 4 percent with respect to the return on assets, digital firms show negative mean values for the growth rates of return on equity and return on assets.

Table 3.3 shows evidence for heterogeneity of firms across geographical regions by presenting selected summary statistics by region. Firms located in Europe face the highest ETR with a mean value of 22 percent. The mean ETR of firms located in South and Central America is considerably lower with 15 percent, which reflects the fact that this geographical region includes several tax havens such as Panama, the Cayman Islands and the British Virgin Islands.[5] R&D intensity is highest among firms located in North America with a mean value of 12 percent. The other regions show significantly lower mean values between 0 and 2 percent. The top 15 companies in the dataset with respect to R&D intensity are all from the North American region and include large biotech and pharmaceutical companies such as Biotransplant Inc. and Regeneron Pharmaceuticals. North American firms also show the largest mean in terms of employees, which is partly driven by Walmart with its 2.2 Million employees. Cash holdings as a share of total assets are highest among North American and South and Central American firms. The debt ratio is highest for firms located in Europe with a mean value of 23 percent and the median firm showing a debt ratio of 19 percent. Asian firm show the lowest values in this regard with a mean debt ratio of 14 percent and a median value of 0 percent.

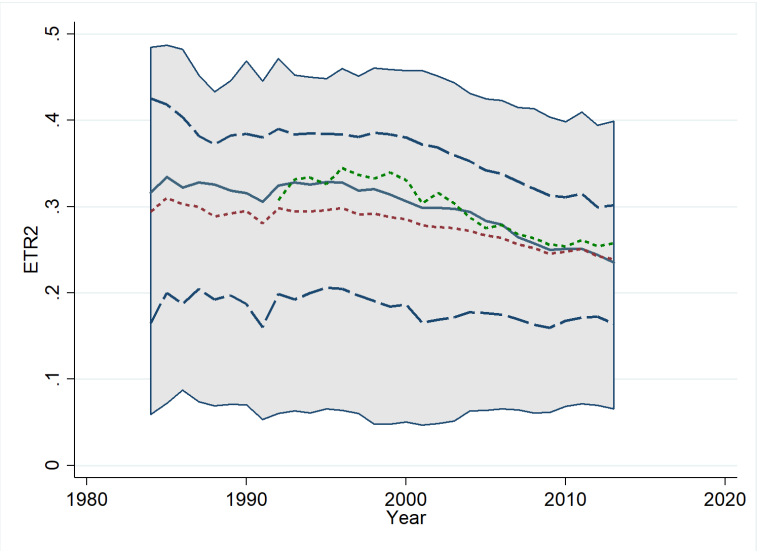
[5] A full list of countries included in the respective geographical regions is provided in the Appendix in Table C4.

Table 3.3: Summary statistics by region

	mean	sd	p50	min	max	count
Africa						
ETR	0.19	0.14	0.21	-0.23	0.62	6,801
TOAS	483.84	7528.92	57.54	2.01	610935.75	6,793
Employees	5468.27	17353.92	1246.50	1.00	530200.00	1,560
Intangibles_ratio	0.21	0.26	0.09	0.00	0.99	3,114
Cash_ratio	0.13	0.16	0.08	-0.02	1.00	6,467
RD_intensity	0.00	0.01	0.00	0.00	0.41	5,431
Debt_ratio	0.17	0.18	0.12	0.00	0.98	5,709
ROA	0.07	0.11	0.06	-0.99	0.91	6,773
Asia						
ETR	0.21	0.15	0.24	-0.23	0.62	317,465
TOAS	377.58	3,725.84	12.90	2.00	402,892.31	316,084
Employees	3,296.72	13,412.05	650.00	0.00	366,937.00	73,191
Intangibles_ratio	0.10	0.17	0.03	0.00	2.12	96,056
Cash_ratio	0.13	0.16	0.08	-0.08	1.00	183,605
RD_intensity	0.01	0.03	0.00	0.00	1.15	171,432
Debt_ratio	0.14	0.20	0.00	-0.45	1.00	285,689
ROA	0.05	0.11	0.04	-1.00	1.00	315,065
Europe						
ETR	0.22	0.16	0.25	-0.23	0.62	140,077
TOAS	2,897.33	38,564.74	54.02	2.00	290,7129.25	140,049
Employees	3,168.24	18,022.19	209.00	0.00	648,254.00	113,734
Intangibles_ratio	0.29	0.31	0.15	0.00	1.00	82,728
Cash_ratio	0.13	0.16	0.07	-0.15	1.00	136,619
RD_intensity	0.02	0.06	0.00	0.00	1.14	38,267
Debt_ratio	0.23	0.22	0.19	-0.05	1.00	101,514
ROA	0.04	0.13	0.04	-1.00	1.00	139,103
Oceania						
ETR	0.19	0.16	0.25	-0.23	0.62	7,621
TOAS	961.92	4,460.95	98.97	2.00	100,863.66	7,618
Employees	2,348.53	10,299.10	345.50	1.00	200,000.00	2,164
Intangibles_ratio	0.39	0.33	0.32	0.00	1.00	4,968
Cash_ratio	0.14	0.19	0.06	-0.07	1.00	6,944
RD_intensity	0.02	0.08	0.00	0.00	1.14	4,544
Debt_ratio	0.20	0.19	0.16	0.00	1.00	6,535
ROA	0.01	0.19	0.05	-1.00	0.81	7,148
South Central America						
ETR	0.15	0.15	0.15	-0.23	0.62	14,021
TOAS	1,301.63	18,889.31	183.15	2.00	1,160,328.88	14,017
Employees	4,091.58	13,344.47	1,057.00	1.00	460,000.00	8,593
Intangibles_ratio	0.20	0.26	0.08	0.00	1.00	8,448
Cash_ratio	0.22	0.20	0.16	0.00	1.00	13,981
RD_intensity	0.01	0.04	0.00	0.00	0.90	13,409
Debt_ratio	0.18	0.17	0.15	0.00	1.00	13,339
ROA	0.04	0.16	0.05	-1.00	1.00	13,849
North America						
ETR	0.17	0.19	0.13	-0.23	0.62	53,643
TOAS	2,592.57	14,676.42	156.63	2.00	797,769.00	51,039
Employees	8,407.90	45,380.73	831.00	0.00	2,200,000.00	32,387
Intangibles_ratio	0.41	0.30	0.36	0.00	1.00	32,334
Cash_ratio	0.21	0.24	0.10	-0.02	1.00	47,947
RD_intensity	0.12	0.18	0.05	0.00	1.15	22,604
Debt_ratio	0.18	0.21	0.10	0.00	1.00	48,114
ROA	-0.04	0.23	0.03	-1.00	1.00	48,453

Figures 3.1 and 3.2 give an indication on developments with regard to the dispersion of ETRs of firms over time. Figure 3.1 shows the dispersion of ETRs over time, including only observations from firms that report positive tax payments. Figures on the dispersion of ETRs, which also include observations from firms reporting zero or negative tax payments can be found in the Appendix (see Figures C3 and C1). In Figure 3.1, the solid line between the two dashed lines represents the median value of the ETR for each year from 1984 to 2013. The dashed line represents ETRs of firms at the 25th and 75th percentile of the distribution, respectively. The shaded grey area comprises the ETRs of firms from the 10th to the 90th percentile in each year. The dotted red line shows the mean ETR of firms that report positive tax payments for each year, the green dotted line shows the mean ETR among digital firms. With regard to digital firms, the mean was only calculated for years, in which the group of digital firms consists of over 50 firms. From 1984 to the late 1990s, the ETRs of firms at the indicated percentiles seem to have been rather stable. From the late 1990s to 2013, the ETR of firms at the 90th percentile, the 75th percentile and the 50th percentile declined steadily. While the median firm faced an ETR of about 32 percent in 1984, the median firm in 2013 faces an ETR of about 23 percent. ETRs in the bottom half of the distribution did not experience a downward trend but continued to be rather stable. Firms at the 10th percentile of the ETR distribution in 1984 paid approximately 8 percent of corporate income taxes on their pre-tax profit. In 2013, firms at the 10th percentile still pay a very similar ETR. This is also reflected in Figure 3.2. Figure 3.2 summarizes the mean trend of ETR over time as well as different measures of dispersion. Graph I in Figure 3.2 shows the negative trend in the mean ETR from the late 1990s onward. Graph II shows a decline in the standard deviation. However, looking at the coefficient of variation in Graph III, which relates developments in the standard deviation to the mean, an increasing trend is visible since the mid 1990s. Graph IV shows that the range of ETRs between the 90th and 10th percentile declined over time. As previously discussed, this is driven by the decreasing ETR of firms at the 90th percentile while the ETR at the 10th percentile remained rather stable.

Figure 3.1: The development of the distribution of ETR over time



Notes: ETR2 reports effective tax rates of firms that report tax expenses > 0. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively. The red dotted line shows the mean ETR for the full sample and the green dotted line shows the mean ETR for the group of digital firms.

3.4 Empirical strategy

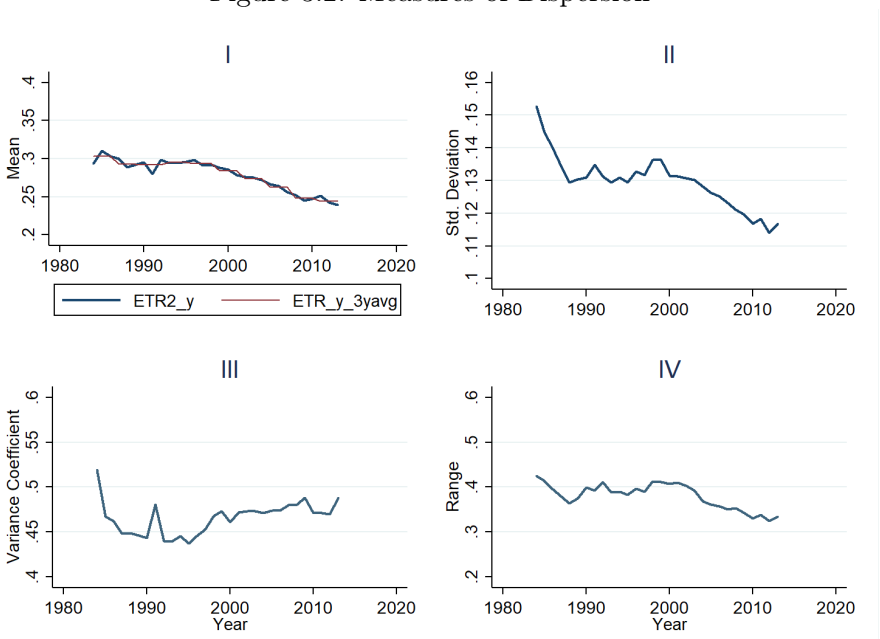
3.4.1 Firm-level characteristics of ETRs

In a first step, firm-level determinants of ETRs will be analyzed by estimating a pooled OLS regression model:

$$ETR_{i,t} = \alpha + \beta_1 toas_{i,t} + \beta_2 empl_{i,t} + \beta_3 roe_{i,t} + \beta_4 rd_{i,t} + \beta_5 ifas_{i,t} + \beta_6 digital_i + \gamma \mathbf{X}_{i,t} + \eta_t + \mu_c + \epsilon_{i,t} \tag{3.3}$$

The dependent variable in the baseline specification is the ETR of firm i in year t, which is equal to the ratio of taxation to pre-tax profits. It is regressed on a set of firm characteristics introduced in the conceptual framework section as well as additional macro controls $\mathbf{X}$ such as GDP, GDP per capita, the unemployment rate and a measure for institutional quality (Freedom House Index).Year fixed effects (η_t) are included to capture the influence of common trends over time. Additionally, fixed effects at the country level (μ_c) are included to control for potential unobserved time-invariant country characteristics that

Figure 3.2: Measures of Dispersion



Notes: Graph I shows the development of the mean ETR2 (only firms with tax expenses larger zero) across the sample over time. The dashed line shows a 3-year average, computed at the firm level to account for fluctuations during the business cycle and timing differences due to deferrals etc. Graph II depicts the standard deviation of the ETR2 measure. Graph III shows the coefficient of variation. The coefficient of variation is computed as the ratio of the standard deviation measure to the sample mean. Graph IV represents the range, which is computed as the difference between the 90th and 10th percentile of the ETR measure per year.

might be correlated with both the firm characteristics and the ETR. It is plausible, that the level of taxation a firm faces influences its level of investments over time and therefore its size (see for example Fernandez-Rodriguez and Martinez-Arias, 2014). In order to deal with these reverse causality concern, the lagged level of the total assets variable is used in some specifications. Results indicate whether the included firm-level characteristics are relevant explanatory factors in the reported ETR of a firm. Observed correlations do not necessarily imply causality between firm-level characteristics and the ETR. Potential channels of the observed correlations between the firm's ETR and its characteristics will be discussed in Section 3.5.2.

A potential concern with the specification in Equation 3.3 is the potential existence of

firm specific unobserved effects. If unobserved firm-level effects exist and they influence both, the included explanatory variables and the ETR, the estimated coefficients will be biased due to this omitted variables problem (Greene, 2017). One example would be the quality of management within a firm. A good management is likely to have a positive impact on the profitability and growth of a firm. At the same time, savvy managers might be better at identifying and exploiting loopholes and mismatches in corporate tax systems, which will result in a lower ETR of the firm. Research has shown (e.g. by Armstrong et al., 2012) that unobserved firm-specific effects do play a role. The inclusion of firm fixed effects controls for a potential bias arising from unobserved firm heterogeneity. In Section 3.5, results from both pooled OLS regressions and the fixed effects model are presented.

Furthermore, there might be a concern regarding the a dynamic nature of the panel. Most corporate tax systems allow for temporary adjustments of taxation, for example via tax deferrals. Therefore, it might be necessary to include a lagged level of the ETR as an explanatory variable in the regression. In the literature, some contributions in the context of effective tax rates have opted for the application of the Arellano-Bond estimator (see for example Fernandez-Rodriguez and Martinez-Arias (2014) or Fuest, Maffini and Riedel, 2010). The Arellano-Bond estimator combines a first difference generalized method of moments (GMM) estimation with an instrumental variable (IV) strategy. The estimation in first differences deals with time invariant unobserved heterogeneity across firms. The IV strategy instruments potentially endogenous variables with lags of their levels. In the literature, this estimation strategy is applied in panel regressions with a large number of observations and few periods (large N, small T) as fixed-effects estimations are likely to be biased in these settings due to the Nickell bias (Nickell, 1981). The Nickell bias occurs due to a correlation of order $(1/T)$ between the explanatory variables and the error term. However, given that the bias diminishes as T grows and that I am using a long panel with up to 30 annual observations[6], I expect the Nickel-bias to be negligible and the fixed effects estimation to be suitable in the context of this paper. Results for the fixed effects model including lagged levels of the dependent variable are reported in Section 3.5. Results of the dynamic panel Arellano-Bond system GMM estimation approach are reported in Table C9 and discussed in Section 3.5.2.

[6]Judson and Owen (1999) recommend to use the fixed effects estimator for the unbalanced panel case of T>20 instead of a dynamic panel estimation. For a balanced panel, they recommend the fixed effects estimator even for the case of $T \leq 10$. Also Kiviet (1995) stresses the relative efficiency of the fixed effects estimator compared to GMM methods.

3.4.2 Cluster analysis and panel convergence

Next to analyzing firm-level determinants of ETRs of firms, I am interested in investigating trends with regard to convergence patterns of the ETRs. I apply the approach proposed by Phillips and Sul (2007, 2009), who introduce a nonlinear time varying factor model for the analysis of transition and convergence trends in micro panel data. Regis et al. (2015) have used the same methodology of cluster analysis and convergence testing to analyze trends in statutory CIT rates in Europe. To the best of my knowledge, this paper is the first one to apply the Phillips and Sul (2007, 2009) methodology in the context of effective corporate tax rates. Philipps and Suls' model contains a simple panel regression based convergence test, which I will apply to see if ETRs of firms at the consolidated level converge over time. The advantage of the Phillips and Sul (2007, 2009) methodology is that it allows to look at the evolution of the whole distribution rather than a measure of central tendency (Regis et al. 2015). The methodology also allows to test for the existence of convergence clubs without previously defining assumptions on the underlying characteristics of the clubs. It is tested, whether idiosyncratic components within endogenised groupings of firms converge to a common factor. Therefore, the Philipps and Sul approach allows to check for a distinct trend of ETRs for the group of digital firms.

The Philipps and Sul (2007,2009) approach decomposes the panel data on ETRs as:

$$ETR_{i,t} = \gamma_{i,t}\nu_t \tag{3.4}$$

This dynamic factor model is based on the assumption that the development of ETRs over time is driven by a common trend across all firms ν_t (for example, globally decreasing statutory tax rates) and an individual component $\gamma_{i,t}$ (based on the identified firm characteristics).

Convergence of ETRs in the context of the approach of Phillips and Sul implies relative convergence[7]:

$$\lim_{t\to\infty} \frac{ETR_{i,t}}{ETR_{j,t}} = 1, \quad for\ all\ i\ and\ j \tag{3.5}$$

This is equivalent to convergence in the individual component:

$$\lim_{t\to\infty} \gamma_{i,t} = \gamma, \quad for\ all\ i \tag{3.6}$$

[7]Focusing on relative convergence holds the advantage, that it allows for nonstationary stochastic trends in the common trend component ν_t (Phillips and Sul, 2009).

The tested null hypothesis is that there is convergence in the individual component of the ETRs across firms over time: $H_0 : \gamma_i = \gamma$

Econometric details on the approach are provided in the Appendix. The convergence test requires a balanced panel data set. I construct a balanced panel focusing on the last 10 years of the sample, 2004 to 2013. The balanced panel data set contains 62,070 observations from 6,207 firms, among those 151 digital firms. Given that the sample size with regard to digital firms is rather small in the balanced sample, results to the convergence tests are to be seen as indicatory evidence.

3.5 Results

Tables 3.4 and 3.5 present the results from the pooled OLS and fixed effects estimations on firm-level determinants of ETRs. I find that firms with a higher R&D intensity, a higher debt ratio and more cash holdings pay a lower ETR, on average. Furthermore, evidence from the Philipps and Sul (2007, 2009) clustering and club convergence tests with respect to effective tax rates will be discussed. I do not find evidence of convergence in ETRs across the firms in our sample. There is also no evidence of convergence among digital firms, reflecting that this group comprises firms that are highly heterogeneous in tax relevant firm characteristics.

3.5.1 Explanatory factors of ETRs

Table 3.4 presents results from pooled OLS estimations. The dependent variable in these estimations is ETR and all specifications include year and country level fixed effects. In column (1), the coefficient for employees is positive and highly significant, however, small in magnitude. Column (2) adds total assets.[8] Total assets is better suited to capture firm size as research showed that the labor share is declining across many industries. The coefficient for total assets is positive and significant at the 1 percent level, indicating that a one percent increase in total assets increases the ETR of the firm by 0.9 percentage points, on average. This is in line with the argument discussed in Section 3.2 that larger firms are under more intense public scrutiny. Firms that reported a loss last year face lower ETRs,

[8] I use the logarithm of total assets, to limit the influence of outliers.The dataset contains very large yet plausible values as they can be attributed to the largest firms in the world, such as BNP Paribas or Walmart.

which is coherent with the possibility of loss-carry-forwards in many corporate tax systems. The difference in ETRs between firms reporting a loss last year and profitable firms is 14.2 percentage points, on average. Column (4) adds a dummy indicating whether the observation stems from a digital firm or not. The coefficient is significant at the 1 percent level and indicates that digital firms do face lower ETRs: the expected mean difference between digital and non-digital firms is 0.6 percentage points. However, once industry fixed effects at the industry group level are included, the significance of the digital firm dummy disappears, reflecting that within industry groups, digital and non-digital firms do not show different ETRs.[9] Column (5) adds macro controls that capture the potential influence of observable country characteristics. The coefficients for the statutory CIT rate of the country of the parent company, the unemployment rate and value of the freedom house index for this country are statistically significant. In column (6), which adds the lagged value of the ETR of the firm, the only country-level variable that remains significant is the statutory CIT rate. A one percentage point increase in the statutory CIT rate of the country the parent company is located in leads to an increase in the reported ETR of the firm of 0.07 percentage points.

Congruent to previous findings in the literature, the coefficient on firm profitability, return on equity, is positive and significant at the 1 percent level. Similar results are obtained when using return on assets as profitability measure. In the robustness section, I also check for an effect of the volatility of reported profits by including the standard deviation of the profitability measure in the regression. Results are discussed in Section 3.5.2. The coefficient for the share of intangible assets in total fixed assets is positive and significant at the 1 percent level. This indicates, that firms with a higher share of intangible assets face a higher ETR, on average, which is surprising. However, as the discussion of results from Table 3.5 will show, the coefficient is not significant anymore when controlling for unobserved firm-level effects. The coefficients for R&D intensity, the firm's debt ratio and share of cash holdings show the expected signs in the pooled OLS regressions.

[9] It should be kept in mind that also the classification of digital and non-digital firms depends on industry classifications. Yet, it is done at the 4-digit level while industry groups are broader defined at the 2-digit level.

Table 3.4: Results from Pooled OLS Estimations

	(1) ETR	(2) ETR	(3) ETR	(4) ETR	(5) ETR	(6) ETR
empl	0.0000184***	-0.0000229***	-0.0000181***	-0.0000180***	-0.0000190***	-0.0000117***
	(1.79e-08)	(1.97e-08)	(1.91e-08)	(1.91e-08)	(1.98e-08)	(1.80e-08)
ifas_fias	0.00238	0.00964***	0.0133***	0.0146***	0.0193***	0.00866***
	(0.00223)	(0.00219)	(0.00211)	(0.00214)	(0.00234)	(0.00214)
cash_toas	-0.0578***	-0.0416***	-0.0376***	-0.0364***	-0.0364***	-0.0211***
	(0.00340)	(0.00336)	(0.00319)	(0.00320)	(0.00347)	(0.00306)
rd_intensity	-0.302***	-0.299***	-0.211***	-0.211***	-0.188***	-0.127***
	(0.00777)	(0.00776)	(0.00758)	(0.00757)	(0.00768)	(0.00649)
debt_ratio	-0.0575***	-0.0788***	-0.0616***	-0.0620***	-0.0687***	-0.0382***
	(0.00324)	(0.00327)	(0.00315)	(0.00316)	(0.00337)	(0.00321)
roe	0.000664***	0.000608***	0.000483***	0.000482***	0.000482***	0.000327***
	(0.0000178)	(0.0000170)	(0.0000149)	(0.0000149)	(0.0000155)	(0.0000149)
ln_toas		0.0127***	0.00929***	0.00920***	0.00919***	0.00424***
		(0.000312)	(0.000303)	(0.000304)	(0.000324)	(0.000304)
losslastyear			-0.142***	-0.142***	-0.149***	-0.0244***
			(0.00228)	(0.00228)	(0.00245)	(0.00291)
digital				-0.00643***	0.00171	0.00190
				(0.00208)	(0.00284)	(0.00260)
CIT					0.130***	0.0742***
					(0.0216)	(0.0215)
gdp_consus					-7.66e-16	3.86e-16
					(8.19e-16)	(8.32e-16)
gdp_pc_consus					-0.000000837	0.000000126
					(0.000000583)	(0.000000630)
unemployment					-0.00110***	0.0000490
					(0.000424)	(0.000414)
freedomhouse					0.00840***	0.00378
					(0.00234)	(0.00249)
L.ETR						0.498***
						(0.00532)
_cons	0.117***	-0.0477	-0.00177	-0.000537	-0.110***	-0.100***
	(0.0442)	(0.0439)	(0.0439)	(0.0439)	(0.0352)	(0.0346)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Industry FE	NO	NO	NO	NO	YES	YES
N	95,847	95,847	95,847	95,847	86,386	65,987
R^2	0.264	0.278	0.319	0.319	0.326	0.512

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. To make the table more compact, in these specifications, the effect of the number of employees is measured as the marginal effect of an increase by 100 employees.

However, there might be a problem of unobserved heterogeneity at the firm level, that is not captured by the included fixed effects at the aggregate country or industry level. Thus, a fixed effects model is estimated. The fixed effects estimator makes use of within panel estimation over time and is therefore robust to unmeasured correlation between the firm specific effect and the exogenous variables included in the model. Results are reported in Table 3.5. The robustness of the model comes at the price of its inability to estimate coefficients for time invariant variables. Therefore, I add the concrete size of the loss last year instead of the previously discussed loss dummy in column (3). Column (4) adds the previously discussed macro controls. In the fixed effects model, the coefficient of GDP is statistically significant, albeit very small. It indicates that firms from larger countries show slightly larger ETRs, while controlling for other influencing factors such as the country's statutory CIT, institutional quality as captured by the freedom house index, and relevant firm characteristics. In Column (5), the coefficients for the number of employees, the share of intangible assets, cash holdings and reported losses in the previous year are not statistically significant. The coefficients for R&D intensity, the firm's debt ratio, return on equity and firm size, however, are significant at the 1 percent level and show the same signs as discussed before. The coefficients on firm profitability and the R&D intensity of the firm are smaller in magnitude than in the pooled OLS specification, the coefficients for firm size and the debt ratio are larger than before. Results from both the pooled OLS and fixed effects show that certain firm characteristics such as its R&D intensity, the firm's debt ratio, its profitability and size are relevant factors in explaining the ETR that a firm faces at the consolidated level.

Table 3.5: Results from the Fixed Effects Model

	(1) ETR	(2) ETR	(3) ETR	(4) ETR	(5) ETR
empl	0.000000151	-6.12e-08	-6.20e-08	-8.23e-08	2.18e-08
	(9.26e-08)	(8.39e-08)	(8.38e-08)	(8.69e-08)	(8.50e-08)
ifas_fias	0.0167***	0.00479	0.00475	0.0110*	0.00922
	(0.00539)	(0.00537)	(0.00533)	(0.00574)	(0.00585)
cash_toas	-0.0105*	-0.0144**	-0.0148**	-0.0116*	-0.00610
	(0.00584)	(0.00582)	(0.00578)	(0.00612)	(0.00610)
rd_intensity	-0.118***	-0.126***	-0.126***	-0.126***	-0.0804***
	(0.0146)	(0.0145)	(0.0144)	(0.0147)	(0.0139)
debt_ratio	-0.0712***	-0.0927***	-0.0909***	-0.0955***	-0.0571***
	(0.00681)	(0.00691)	(0.00686)	(0.00722)	(0.00751)
roe	0.000344***	0.000327***	0.000325***	0.000327***	0.000236***
	(0.0000179)	(0.0000175)	(0.0000175)	(0.0000183)	(0.0000202)
ln_toas		0.0267***	0.0261***	0.0235***	0.0162***
		(0.00157)	(0.00155)	(0.00177)	(0.00196)
loss_size			5.89e-09	5.71e-09	-2.86e-09
			(6.91e-09)	(6.90e-09)	(7.13e-09)
CIT				0.197***	0.215***
				(0.0297)	(0.0317)
gdp_consus				2.86e-15**	3.94e-15***
				(1.19e-15)	(1.25e-15)
gdp_pc_consus				0.000000940	0.000000152
				(0.000000733)	(0.000000820)
unemployment				-0.000637	-0.000416
				(0.000517)	(0.000554)
freedomhouse				0.00589***	0.00572**
				(0.00229)	(0.00258)
L.ETR					0.0661***
					(0.00771)
_cons	0.363***	0.110*	0.115**	-0.0328	-0.00484
	(0.0568)	(0.0585)	(0.0586)	(0.0340)	(0.0368)
Year FE	YES	YES	YES	YES	YES
N	95,847	95,847	95,847	87,007	66,473

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results from column (4) in Table3.4 indicate that digital firms pay a slightly lower ETR, on average. To further investigate differences between digital and non-digital firms,

Table 3.6 includes interaction terms of relevant firm-level characteristics with the dummy variable, that indicates digital firms. Columns (1) and (3) in Table 3.6 present results from pooled OLS regressions, Columns (2) and (4) are obtained from the fixed effects model. Congruent to the results obtained before, the coefficient for firm size (total assets) is positive and significant in both, the pooled OLS and fixed effects specification and the coefficients for debt ratio and R&D intensity are significant and negative. The interaction terms of the digital dummy with R&D intensity and the debt ratio are not significant, indicating that digital firms are not any different from other firms. However, three interaction terms show significant coefficients: Firstly, the coefficient for the share of intangible assets in total fixed assets is significant at the 1 percent level (5 percent level in the fixed effects model). Its interaction term with the digital dummy is negative yet smaller than the intangibles coefficient, indicating that the positive effect of the share of intangibles on the ETR is less pronounced for digital firms. Secondly, the interaction term of the digital dummy with firm size is significant and positive. This means that the positive effect of firm size in terms of total assets is even more pronounced for digital firms, potentially reflecting that they are under special public pressure. Thirdly, the coefficient for the profitability measure (return on equity) is positive and significant in both, the pooled OLS and fixed effects specification. Its interaction term, is statistically significant and negative. Yet again, smaller in magnitude and therefore indicating that the effect of profitability on the ETR is positive but less pronounced as compared to other firms.

Table 3.6: Adding interaction terms

	(1) ETR	(2) ETR	(3) ETR	(4) ETR
L.ETR	0.501***	0.0825***	0.498***	0.0826***
	(0.00504)	(0.00717)	(0.00532)	(0.00754)
empl	-0.000000114***	3.74e-09	-0.000000117***	1.90e-08
	(1.72e-08)	(8.08e-08)	(1.80e-08)	(8.38e-08)
ifas_fias	0.00726***	0.00698	0.00994***	0.0133**
	(0.00211)	(0.00591)	(0.00221)	(0.00628)
ifas_digital	-0.00995	-0.0311*	-0.0125*	-0.0357**
	(0.00625)	(0.0166)	(0.00649)	(0.0175)
cash_toas	-0.0195***	-0.0127**	-0.0214***	-0.00748
	(0.00300)	(0.00596)	(0.00316)	(0.00634)
cash_digital	-0.00190	0.0237	-0.000831	0.0192
	(0.0108)	(0.0216)	(0.0114)	(0.0231)
rd_intensity	-0.130***	-0.0796***	-0.125***	-0.0789***
	(0.00655)	(0.0146)	(0.00664)	(0.0150)
rd_digital	-0.0152	-0.0496	-0.0218	-0.0499
	(0.0194)	(0.0417)	(0.0199)	(0.0434)
debt_ratio	-0.0362***	-0.0563***	-0.0376***	-0.0601***
	(0.00312)	(0.00740)	(0.00327)	(0.00773)
debt_digital	-0.00974	-0.00331	-0.0107	-0.00298
	(0.0162)	(0.0348)	(0.0170)	(0.0368)
ln_toas	0.00432***	0.0200***	0.00404***	0.0162***
	(0.000296)	(0.00176)	(0.000309)	(0.00207)
toas_digital	0.00269***	0.00614	0.00320***	0.00983**
	(0.00103)	(0.00441)	(0.00107)	(0.00473)
roe	0.000338***	0.000245***	0.000336***	0.000248***
	(0.0000155)	(0.0000213)	(0.0000162)	(0.0000223)
roe_digital	-0.0000653**	-0.0000864*	-0.0000751**	-0.000103**
	(0.0000320)	(0.0000488)	(0.0000323)	(0.0000471)
losslastyear	-0.0197***		-0.0243***	
	(0.00269)		(0.00291)	
digital	-0.0230*		-0.0283**	
	(0.0138)		(0.0144)	
_cons	-0.0170	0.0715	-0.0976***	-0.0158
	(0.0316)	(0.0495)	(0.0346)	(0.0371)
Macro Controls	NO	NO	YES	YES
Year FE	YES	YES	YES	YES
Country FE	YES	NO	YES	NO
Industry FE	YES	NO	YES	NO
N	72,879	73,383	65,987	66,473

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.5.2 Robustness and discussion

In order to alleviate endogeneity concerns due to a potential reverse causality between firm level characteristics such as total assets and the ETR, Table C8 uses lagged values of the share of intangibles, cash holdings, R&D intensity, the debt ratio, total assets and return on equity. The coefficients show the same statistical significance and are very similar in magnitude. Thus, I conclude reverse causality to not present a major issue in the analysis. To deal with concerns about a potentially dynamic nature of the panel, I rerun the main specifications using the Arellano-Bond estimator. Results are reported in Table C9. Congruent to the results from the pooled OLS and fixed-effects estimations, R&D intensity and the debt ratio show positive and highly significant coefficients, whereas the coefficients for firm size (total assets) and profitability (return on equity) are positive. With respect to the interaction terms, all interactions are statistically insignificant except for the interaction between return on equity and the digital dummy. As before, this interaction term is negative yet smaller in size than the coefficient for profitability.

Table C10 adds several control variables, which are potentially of interest but only available for a limited number of observations and/or countries and thus not added in the main specifications. Column (1) in Table C10 adds the age of the firm. Age of the firm is computed as 2014 (presenting the last year in the original sample) minus the year of incorporation, which is available in the Orbis database. The coefficient for firm age is positive and significant at the 5 percent level. Many countries provide a special tax treatment to start-ups and young firms, leading to a lower tax burden for this group. Columns (2) and (3) control for the influence of policies and tax incentive with regard to R&D. R&D support is a variable obtained from the OECD Research and Development Statistics and measures total government support for R&D activities as a share of GDP. It is available for the year 2006 and comprises direct funding as well as tax incentives in 39 OECD countries. It ranges from zero percent (Chile) to 54 percent (Russia). Column (2) reports results from the pooled OLS specification including the R&D support measure and interacting it with the R&D intensity of the firm. The R&D support variable enters the regression with a negative and highly significant coefficient. The higher the R&D support of the country the parent firm is located in, the lower its reported ETR. The coefficient for R&D intensity is highly significant and of similar magnitude than before. The interaction term is not statistically significant, indicating that the influence of R&D intensity on the reported ETR of the firm does not depend on the level of R&D support in the country of the parent firm.

Column (3) reports results on the same specification for the fixed effects model and results in the same outcome. Column (4) checks for a relationship between reported ETR and the administrative burden of paying corporate income taxes, measured in the amount of hours per year spent on preparing and paying taxes. The measure comes from the Doing Business Database of the World Bank and is obtained for the period 2006 to 2013 for 15 European countries and ranges between 76 hours (Ireland, 2006-2012) and 866 hours (Czech Republic, 2006). Its mean value decreases from 143 hours in 2006 to 129 hours in 2013. However, results from Column (4) indicate no significant relationship between the administrative burden in the country of the parent company and the ETR of the firm. Column (5) includes a measure for tax honesty obtained from the World Value Survey. It is available for 9 European countries and was collected in five waves of the survey (1990, 1995, 1999, 2005, 2010). The tax honesty measure is scaled from 1 to 10. A higher average value of this measure in a country indicates that cheating on taxes is socially more accepted in this country, compared to countries with lower average values.[10] A negative and significant coefficient on that coefficient would indicate that the higher the tax honesty measure (meaning the lower the average tax honesty in a country), the lower the reported ETR of firms located in that country. Although the coefficient shows the expected negative sign, it is not statistically significant.

Table C11 reports pooled OLS and fixed effects estimations for the samples excluding observations from firms with zero and/or negative tax payments. Results obtained from these samples are similar to the previously discussed results in many regards, yet there are some interesting differences: The debt ratio does not show a significant coefficient in the pooled OLS estimations and a positive coefficient in the fixed effects specifications. Therefore, the negative effect of the debt ratio on the ETR seems to be driven by loss-reporting firms. The coefficient for the profitability measures is now negative and highly significant in all specifications. Among the profitable firms, higher profitability is connected to a lower reported ETR. Interaction terms with the dummy for digital firms are mostly insignificant, with exceptions with regard to intangibles and firm size.

[10] The exact phrasing on the respective question in the World Value Survey is the following: *Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between, using this card. (Read out and code one answer for each statement): Cheating on taxes if you have a chance.* More information can be found at `http://www.worldvaluessurvey.org/WVSOnline.jsp`, V200 (Wave 5).

Moreover, I estimate the main specifications by region to investigate heterogeneity in the ETR determinants across geographical regions. Results are presented in Tables C12 and C13. Results should be interpreted with caution with regard to Africa, Oceania and South and Central America due to the relatively small sample size ($<$ 1000 observations). For Asia, Europe and North America a negative influence of R&D intensity and the debt ratio can be seen. Coefficients with regard to firm size and profitability are positive. Obtained effects with respect to R&D intensity and profitability are significantly stronger in Asia. The negative influence of the debt ratio is most pronounced in Europe, while the positive effect of firm size is strongest in North America. Table C14 adds interaction terms to the regressions by region. For North America, the coefficients on the interaction of firm size and profitability with the digital dummy are significant and of the same sign as previously discussed. With regard to Europe, only the interaction term for firm size is significant at the 5 percent level. While there is some evidence for heterogeneity across geographical regions, the main results prove to be robust to dividing the sample and separately estimating firm level determinants within geographical regions.

Finally, some remarks should be made about the appropriateness of financial statement data when it comes to analyzing firm level characteristics of digital firms. While I have discussed general caveats of tax information obtained from financial statements before, the nature of digital businesses provides additional challenges to the analysis. Assets reported on a balance sheet have to fulfill strict criteria that are laid out by internationally accepted accounting principles: they have to be owned and held by the company and they have to be physical in nature. These criteria are not adequate for digital companies mainly relying on intangible assets such as brands, customer and social relationships and human capital. While purchased brands and intangibles can be reported as assets on balance sheets, intangibles resulting from R&D investments only show up as expenses. While physical assets depreciate with use, intangible assets often rather increase in value over time. Looking at stock market valuations and merger and acquisition deals of digital companies, it is clear that these problems attached to balance sheets and income statements are well known by investors. For example, in 2014 Facebook was willing to pay 19 Billion USD for WhatsApp, although WhatsApp did not report any revenues or profits. Walmart's ratio of its stock market valuation to its balance sheet volume is 1.9, for Facebook the ratio is almost 30 times higher (55.6). (Govindarajan et al., 2018). While balance sheet information might give a blurred picture of the size and economic value of a digital firm, the discussed distortions are constant over time. The panel structure of my data set allows

to track developments within firms over time. Therefore, I am confident that results from my analysis, especially the specifications controlling for firm fixed effects, provide valuable insights, despite the prevalent short-comings of accounting information.

3.5.3 Testing for convergence

Research with regard to statutory corporate tax rates has found evidence for convergence of statutory rates for Europe (Regis et al., 2015) and Asia, respectively (Chen et al., 2016). While both studies do not find strong convergence trends across their full samples, they both identify several convergence clubs within the respective regions. Following the methodology by Philipps and Sul (2007,2009), I test for convergence in ETRs. Potentially, the observed convergence trends in statutory rates could translate into convergence trends of ETRs at the firm level. Regression results show, that the statutory rate in the country of the parent company is a significant explanatory factor of firm level ETR. Convergence tests are conducted on a balanced sample of firms, covering the years 2004 to 2013. Summary statistics on this balanced sample are provided in Table C15.

First, I check for convergence in ETRs across the full sample of firms. The value of the t-statistic of the one-sided t-test for the null hypothesis of convergence across the full sample is -21.2597 and the null hypothesis is strongly rejected. Thus, I find no evidence of convergence of ETRs across the full sample of firms. Second, I check for convergence among digital firms. The reasoning by the European Commission (2018) in the context of the proposed interim tax on revenues from digital business activities implicitly assumes, that this group of firms homogeneously pays a lower ETR that can be counterbalanced by the proposed 3 percent revenues tax. However, also for the group of digital firms, no convergence trend with regard to the development of ETRs can be identified and the null hypothesis of convergence is rejected ($t - stat = -5.9923 < -1.65$).

This result reflects that the group of digital firms is highly heterogeneous in the characteristics that determine the ETR at the firm level. Figure C6 in the Appendix shows the dispersion in financial statement variables that were identified as tax relevant for the group of digital firms.[11]. Figure C6 shows no signs of dispersion as the range between the 10th and 90th percentile with regard stays is rather stable over time.

[11]Figure C5 shows the dispersion in these variables for the whole balanced sample

3.6 Conclusion

The results of this paper show that firm characteristics impact the tax burden a firm faces as an economic entity. The relationship between the ETR and the R&D intensity, the debt ratio and the share of cash holdings of a firm is found to be negative, respectively. On the other hand, larger firms (in terms of total assets) as well as more profitable firms (in terms of ROA and ROE) face higher ETRs. Checking for differences between digital and non-digital firms, I find that the positive size effect is more pronounced for digital firms. This is congruent with the hypothesis that large digital firms are under special public scrutiny. The relationship between the share of intangibles in total fixed assets and the ETR is negative for the group of digital firms. This might reflect that the most attractive digital firms are characterized by particularly high shares of intangibles and that they benefit from special tax treatment by governments. Moreover, making use of the rich panel structure of the data set, I test for convergence and clustering trends in ETRs for a balanced sample of firms. I do not find any evidence for convergence across firms as well as within the group of digital firms. Both groups of firms show a similar magnitude of dispersion of ETRs across firms, that stays rather constant over time.

Putting this paper in context of the current political debate, results from estimations on consolidated financial statement data reflect the distortions, that current corporate tax systems entail with regard to debt financing and R&D support. However, from the analysis there is no evidence that digital firms pay particularly low ETRs nor that the development of their ETRs over time is different from that of other firms. It is certainly true that current corporate taxation principles are improper in the light of the rising importance of digital business models. As previously explained, accounting rules entail many flaws in their ability to correctly depict the economic situation of firms with digital business models. Moreover, the current corporate tax systems' focus on physical presence of a corporation rather than the location of interaction with customers proves increasingly inept. However, firms act within the currently given set of rules. Considering that there is a lack of evidence of unequable behavior by digital firms, it is highly questionable to phrase the debate as a matter of "fairness".

Appendix

figuresection tablesection

3.A Details on the Phillips and Sul Approach (2007,2009)

Phillips and Sul (2009) as well as Du (2017) provide a detailed description of the convergence test developed by Phillips and Sul (2007, 2009) and its implementation in Stata. The following provides a summary of those two sources to enable a deeper understanding of the underlying econometric considerations of the approach.
The approach by Phillips and Sul allows for more heterogeneity in the transition paths compared to conventional convergence tests. To be more specific, they decompose $\gamma_{i,t}$ is decomposed to allow for heterogeneity in the transition across individuals (firms) and over time:

$$b_{i,t} = b_i + \frac{\sigma_i \eta_{i,t}}{L(t)t^{\alpha}} \tag{3.7}$$

with $\eta_{i,t}$ being i.i.d. across i and L(t) being a slowly varying function. α indicates how fast the cross-section variation over the transitions converges towards zero over time. Therefore, the model allows for temporary divergence and transitional heterogeneity. Monte Carlo simulations indicated that L(t) is best approximated by $L(t) = log(t)$. Thus, the hypothesis test is implemented with the following regression model:

$$ETR_{i,t} = \frac{H_1}{H_t} - 2log(log(t)) = a + \beta log(t) + \epsilon_t, for t = T_0..., T. \tag{3.8}$$

with $H_t = \frac{1}{N}\sum_{i=1}^{N} > (h_{i,t} - 1)^2$. $H_{i,t}$ indicates the cross-sectional variance of the relative transition parameter $h_{i,t}$:

$$H_{i,t} = \frac{1}{N}\sum_{i=1}^{N} > (h_{i,t} - 1)^2 \lim_{t \to \infty \gamma_{i,t} = \gamma, for all i} \tag{3.9}$$

The individual transition parameter $h_{i,t}$ identifies the transition path of each firm relative to the cross-section average, thereby capturing deviations from the common trend. Thus, the individual transition path can be expressed in the following way:

$$h_{i,t} = \frac{\gamma_{i,t}}{1/N \sum_{i=1}^{N} \gamma_{i,t}} \tag{3.10}$$

In case the test statistic of the one-sided t test rejects the null hypothesis of convergence for the whole panel, Phillips and Sul (2007) developed an algorithm to check for the existence of convergence clusters. Convergence test within potential subgroups are conducted as previously described. Details on the club convergence and panel clustering tests can be found in Phillips and Sul (2007) and Schnurbus et al. (2016).

3.B Additional Tables

Table C1: Steps to the final sample

Step	**Firms**	**Observations**
Starting sample	155,293	979,610
Keep years 1984 – 2013	155,160	974,402
Drop micro firms	126,638	717,800
Drop certain industries	118,412	670,732
Drop accounting mistakes, implausible values and outliers	112,143	539,628
Final unbalanced sample	112,143	539,628
Final balanced sample (2004–2013)	6,207	62,070

Notes: Micro firms are firms with total assets $<$ 2 million USD. Firms from the following industries were dropped: NACE Rev. 2 $<$ 1000, NACE Rev. 2 $>$ 8400. Outliers in terms of ETR include the highest and lowest 5 % of observations; identified accounting mistakes comprise cases where reported after tax profit differs by more than 10 % from (profit before tax – taxation). Implausible values include among others cases where reported total fixed assets are larger than total assets, negative R&D expenses and if reported taxation is larger than total assets.

Table C2: Number of firms and observations by country and region

Country	Firms	Observations	Year availability
Top 15 countries			
Canada	1,834	7,913	1984 – 2013
Cayman Islands	1,017	5,850	1988 – 2013
China	3,516	21,328	1995 – 2013
France	1,291	6,511	1984 – 2013
Germany	1,977	9,228	1984 – 2013
Great Britain	12,072	52,395	1984 – 2013
India	3,226	18,485	1984 – 2013
Japan	3,033	20,842	1988 – 2013
Malaysia	30,936	133,803	1985 – 2013
Netherlands	7,393	37,084	1984 – 2013
Singapore	1,415	7,492	1985 – 2013
Sweden	1,308	6,029	1984 – 2013
Thailand	14,556	72,683	1984 – 2013
United States	7,561	45,730	1984 – 2013
Vietnam	5,422	19,752	2002 – 2013
Total	96,557	465,125	1984 – 2013
B: World regions			
Africa	1,267	6,801	1984 – 2013
Asia	66,235	317,465	1984 – 2013
Europe	31,355	140,077	1984 – 2013
Oceania	1,459	7,621	1984 – 2013
South & Central America	2,432	14,021	1984 – 2013
North America	9,395	53,643	1984 – 2013
Total	112,143	539,628	1984 – 2013

...

Table C3: Data providers for the top 15 countries in the sample

Country	**Data provider**
Canada	Icarus, Dun & Bradstreet
Cayman Islands	Dun & Bradstreet
China	Bureau of Industry & Commerce, SinoSure
France	Coface Services
Germany	Creditreform, Creditreform Rating AG
Great Britain	Jordans Limited
India	CMIE (Centre for Monitoring Indian Economy)
Japan	Dun & Bradstreet TSR Ltd
Malaysia	World'Vest Base Inc.
Netherlands	LexisNexis Benelux, Graydon, Chambers of Commerce
Singapore	DP Information Group
Sweden	UC AB
Thailand	World'Vest Base Inc.
United States	Dun & Bradstreet, Reuters, WVB, HUAXIA, KIS
Vietnam	Jordans Limited, World'Vest Base Inc.

Notes: Bureau van Dijk's Orbis database provides financial and ownership information on firms worldwide. Balance sheet and profit and loss account data is collected by independent national data providers. Information on data providers is obtained from Orbis User Guide (Bureau van Dijk, 2011) and Kalemli-Ozcan et al. (2015) and refers to data providers during the period covered in the dataset.

Table C4: World regions

Region	List of countries
Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Congo (Democratic Republic of), CÃ´te d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland ,Tanzania (United Republic of), Togo, Tunisia, Uganda, Zambia, Zimbabwe
Asia	Afghanistan , Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, **China**, Georgia, Hong Kong, **India**, Indonesia, Iran, Iraq, Israel, Jordan, **Japan**, Kazakhstan, Republic of Korea, Kyrgyzstan, Kuwait, Lao People's Democratic Republic, Lebanon, Macau, **Malaysia**, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Philippines, Saudi Arabia, **Singapore**, Sri Lanka, Syrian Arab Republic, Taiwan, Tajikistan, **Thailand**, Turkmenistan, United Arab Emirates, Uzbekistan, **Vietnam**, Yemen
Europe	Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, **France**, **Germany**, Gibraltar, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia (FYROM), Malta, Moldova, Monaco, **Netherlands**, Norway, Republic of Montenegro, Poland, Portugal, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, **Sweden**, Switzerland, Turkey, Ukraine, **United Kingdom**
Oceania	Australia, East Timor, Fiji, Kiribati, Marshall Islands, Micronesia (Federated States of), Nauru, New Zealand, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu
South & Central America	Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, **Cayman Islands**, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela and Virgin Islands (British)
North America	**Canada**, **United States of America**

Notes: Classification following Orbis User Guide (2011). Countries in bold letters indicate the 15 most frequent countries in the data.

Table C5: Description and computation of variables in Orbis

Variable name	Description	Computation
TAXA	Taxation: all taxes related to the accounting period (paid, accrued or deferred)	
PLBT	Profit/loss before taxation: sum of operating profit and financial profit	EBIT + FIPL
EMPL	Total number of employees included in the company's payroll	
TOAS	Total Assets: sum of fixed assets and current assets	FIAS + current assets
FIAS	Fixed Assets: Total amount of non current assets after depreciation	IFAS + tangible fixed assets + other fixed assets
IFAS	Intangible Fixed Assets (intangible assets with long-term effect such as goodwill, R&D expenses)	
RD	R&D expenses	
CASH	Cash and Cash Equivalents (Cash-in-hand, Central Bank Balances, Bank Balances and Cheques)	
LOAN	Loans due within 1 year + Liabilities to credit institutions due within 1 year, (convertible) bonds if due within one year	
LTDB	Long Term Debt (Financial debt : Due between 2 and 5 years + Financial debt : Due beyond five years)	
ROE	Return on equity	(PL/SHFD)*100
ROA	Return on assets	(PL/TOAS)*100
SHFD	Shareholder funds (total equity, including minority interests)	
PL	Profit (Loss) for the Period (Net profit or loss)	
OPRE	Operating revenue (Sales + Increase or decrease in finished goods inventories and work in process + Own work capitalized + Other operating income)	
EBIT	Earnings before interest and taxes: net profit from operating activities	OPPL
OPPL	Total operating revenues minus all operating expenses	EBIT
PLAT	Profit/loss after taxation	PLBT - TAXA
FIPL	Financial profit/loss: net result from financial activities of the company; financial revenue minus financial expenses	

Source: Orbis User Guide (2011); variables are named as they can be found in the Orbis database.

Table C6: Industry Classification with Corresponding NACE and ISIC Codes

Sector	Industry Group	Description	NACE Rev.2 2-digit (Orbis)
Manufacturing		**Manufacturing of...**	
	1	..food, beverages, tobacco	10-12
	2	..textiles, apparel, leather	13-15
	3	..wood and paper; printing	16-18
	4	..coke, refined petroleum products, chemicals, chemical products pharmaceuticals, rubber and plastics	19-23
	5	..basic metals, fabricated metals	24-25
	6	..computer, electronic, optical products (electrical) equipment, machinery n.e.c.	26-28
	7	..transport equipment	29-30
	8	..other manufacturing, repair and installation of machinery and equipment	31-33
Others	9	Electricity, gas,steam, water supply, sewerage, waste, remediation	35-39
	10	Construction	41-43
	11	Wholesale and retail trade, repair of motor vehicle	45-47
	12	Transportation and storage	49-53
	13	Accommodation, food service	55-56
	14	Publishing, broadcasting, telecommunications, IT and other information services	58-63
	15	(Finance and insurance)	64-66
	16	Real estate	68
Service	17	Legal, accounting, management, scientific research and development, engineering, technical testing	69-75
Digital		Firms with main business segments relying on digital data, technologies or platforms as targeted by the digital tax proposal of the European Commission. See OECD (2018), Fuest et al. (2018), European Commission (2018) for a more detailed definition.	4791, 5811 – 5819, 6201, 6209, 6311, 6312

Notes: NACE Rev. 2 classifications are equivalent to ISIC Rev.4 groups at the two-digit level. Agriculture, mining and public sector activities are excluded (this corresponds to dropping observations from Nace Rev. 2 industries 01 to 09 and 77 to 99). In most specifications, the finance and insurance industry is excluded as well.

Table C7: Growth rates by region

	mean	sd	p50	min	max	count
Africa						
growth_toas	0.12	0.29	0.06	-0.49	2.15	4,857
growth_ifas	0.46	2.28	-0.01	-1.00	26.29	2,291
growth_ebta	0.15	0.89	0.06	-5.55	6.64	3,914
growth_plbt	0.17	1.22	0.06	-7.52	9.58	4,886
growth_taxa	0.48	2.01	0.05	-1.00	22.29	4,328
growth_cash	0.82	3.31	0.05	-0.96	37.98	4,599
growth_rd	-0.17	0.84	-0.17	-1.00	4.99	163
growth_loan_ltdb	0.42	2.05	-0.00	-1.00	26.37	3,402
Asia						
growth_toas	0.14	0.29	0.09	-0.50	2.19	214,245
growth_ifas	0.52	2.71	-0.01	-1.00	37.71	69,567
growth_ebta	0.13	0.89	0.08	-5.74	6.64	83,875
growth_plbt	0.18	1.37	0.06	-7.72	10.16	213,993
growth_taxa	0.56	2.13	0.08	-1.00	23.65	205,889
growth_cash	0.80	3.01	0.09	-0.97	38.07	128,653
growth_rd	0.14	0.73	0.05	-1.00	6.04	19,665
growth_loan_ltdb	0.35	1.89	0.01	-1.00	27.17	108,141
Europe						
growth_toas	0.11	0.28	0.07	-0.50	2.19	91,347
growth_ifas	0.40	2.47	-0.03	-1.00	37.72	53,966
growth_ebta	0.11	0.82	0.06	-5.71	6.64	70,196
growth_plbt	0.17	1.34	0.05	-7.72	10.16	91,366
growth_taxa	0.51	2.04	0.05	-1.00	23.64	86,804
growth_cash	0.76	3.04	0.07	-0.97	38.02	87,392
growth_rd	0.13	0.61	0.07	-1.00	6.08	7,630
growth_loan_ltdb	0.35	1.88	0.00	-1.00	27.00	58,735
Oceania						
growth_toas	0.22	0.37	0.14	-0.49	2.18	9,746
growth_ifas	0.66	3.13	0.00	-1.00	37.01	6,015
growth_ebta	0.14	1.06	0.11	-5.73	6.63	9,226
growth_plbt	0.17	1.50	0.10	-7.71	10.07	9,907
growth_taxa	0.69	2.26	0.15	-1.00	23.58	9,238
growth_cash	0.83	2.85	0.13	-0.96	37.89	10,036
growth_rd	0.35	0.95	0.19	-1.00	6.00	2,373
growth_loan_ltdb	0.50	2.14	0.06	-1.00	26.57	8,029
South Central America						
growth_toas	0.22	0.37	0.14	-0.49	2.18	9,746
growth_ifas	0.66	3.13	0.00	-1.00	37.01	6,015
growth_ebta	0.14	1.06	0.11	-5.73	6.63	9,226
growth_plbt	0.17	1.50	0.10	-7.71	10.07	9,907
growth_taxa	0.69	2.26	0.15	-1.00	23.58	9,238
growth_cash	0.83	2.85	0.13	-0.96	37.89	10,036
growth_rd	0.35	0.95	0.19	-1.00	6.00	2,373
growth_loan_ltdb	0.50	2.14	0.06	-1.00	26.57	8,029
North America						
growth_toas	0.16	0.39	0.07	-0.50	2.19	34,521
growth_ifas	0.54	2.69	0.00	-1.00	37.62	22,731
growth_ebta	0.15	1.03	0.08	-5.75	6.61	36,586
growth_plbt	0.19	1.57	0.07	-7.71	10.15	37,474
growth_taxa	0.61	2.25	0.10	-1.00	23.50	25,470
growth_cash	0.91	3.38	0.07	-0.97	38.00	32,772
growth_rd	0.23	0.68	0.11	-1.00	6.11	15,019
growth_loan_ltdb	0.43	2.28	-0.01	-1.00	27.09	24,944

Table C8: Pooled OLS estimations using lagged firm-level characteristics

	(1) ETR	(2) ETR	(3) ETR	(4) ETR	(5) ETR
L.empl	-0.000000239***	-0.000000151***	-0.000000151***	-0.000000158***	-0.000000115***
	(2.28e-08)	(2.16e-08)	(2.14e-08)	(2.19e-08)	(2.03e-08)
L.ifas_fias	0.00635**	0.0121***	0.0164***	0.0186***	0.00361
	(0.00250)	(0.00228)	(0.00230)	(0.00249)	(0.00223)
L.cash_toas	-0.0339***	-0.0282***	-0.0325***	-0.0328***	-0.0133***
	(0.00377)	(0.00338)	(0.00338)	(0.00363)	(0.00318)
L.rd_intensity	-0.308***	-0.166***	-0.152***	-0.124***	-0.126***
	(0.00869)	(0.00711)	(0.00745)	(0.00740)	(0.00605)
L.debt_ratio	-0.0730***	-0.0395***	-0.0348***	-0.0412***	-0.0352***
	(0.00371)	(0.00347)	(0.00340)	(0.00361)	(0.00331)
L.ln_toas	0.0113***	0.00559***	0.00482***	0.00456***	0.00450***
	(0.000353)	(0.000334)	(0.000331)	(0.000352)	(0.000316)
L.roe	0.000511***	0.0000584***	0.0000582***	0.0000492***	0.000125***
	(0.0000202)	(0.0000130)	(0.0000130)	(0.0000134)	(0.0000126)
losslastyear		-0.188***	-0.170***	-0.180***	-0.0322***
		(0.00266)	(0.00260)	(0.00282)	(0.00315)
digital			-0.00464**	-0.000705	0.00125
			(0.00220)	(0.00299)	(0.00270)
CIT				0.164***	0.0777***
				(0.0246)	(0.0223)
gdp_consus				-1.02e-15	7.04e-16
				(9.79e-16)	(8.90e-16)
gdp_pc_consus				-0.00000125*	3.42e-08
				(0.000000680)	(0.000000646)
unemployment				-0.000150	0.000105
				(0.000458)	(0.000422)
freedomhouse				0.00488	0.00251
				(0.00317)	(0.00267)
L.ETR					0.501***
					(0.00557)
_cons	-0.0327	0.0649*	0.0732**	-0.0444	-0.100***
	(0.0379)	(0.0347)	(0.0347)	(0.0411)	(0.0360)
N	70041	70041	69880	62943	63104
R^2	0.288	0.369	0.377	0.387	0.496

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C9: Results from the Arellano-Bond estimation

	(1) ETR	(2) ETR	(3) ETR
L.ETR	0.174***	0.352***	0.171***
	(0.0115)	(0.0160)	(0.0122)
empl	-8.43e-08	-4.62e-08	-2.65e-08
	(0.000000101)	(9.77e-08)	(0.000000102)
ifas_fias	0.00542	0.0122	0.0125
	(0.00720)	(0.00760)	(0.00780)
cash_toas	-0.0105	-0.00653	-0.0106
	(0.00670)	(0.00753)	(0.00735)
rd_intensity	-0.0684***	-0.0546***	-0.0538***
	(0.0176)	(0.0175)	(0.0172)
debt_ratio	-0.0380***	-0.0456***	-0.0389***
	(0.00867)	(0.00932)	(0.00918)
ln_toas	0.0119***	0.0117***	0.00849***
	(0.00249)	(0.00294)	(0.00294)
roe	0.000207***	0.000132***	0.000232***
	(0.0000221)	(0.0000215)	(0.0000255)
ifas_digital			-0.0225
			(0.0200)
cash_digital			0.0534*
			(0.0294)
rd_digital			-0.121
			(0.0745)
debt_digital			-0.00266
			(0.0475)
toas_digital			-0.00650
			(0.00686)
roe_digital			-0.000147***
			(0.0000527)
_cons	0.152***	-0.0892*	0.0417
	(0.0578)	(0.0506)	(0.0481)
Macro Controls	NO	YES	YES
Year FE	YES	YES	YES
N	49,744	45,076	45,076

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Arellano-Bond test for serial correlation structure rejects no autocorrelation of order 1 and cannot reject no autocorrelation of order 2. This indicates that Arellano-Bond model assumptions are satisfied.

Table C10: Additional variables

	(1) ETR	(2) ETR	(3) ETR	(4) ETR	(5) ETR
L.ETR	0.461***	0.493***	0.0959***	0.463***	0.454***
	(0.0142)	(0.00596)	(0.00803)	(0.0126)	(0.0182)
empl	-3.75e-08	-0.000000139***	-6.21e-08	-5.06e-08*	-2.86e-08
	(2.65e-08)	(1.89e-08)	(7.33e-08)	(2.64e-08)	(4.89e-08)
ifas_fias	0.0170***	0.00841***	0.00729	0.0163***	0.0132**
	(0.00418)	(0.00231)	(0.00616)	(0.00381)	(0.00593)
cash_toas	0.00919	-0.0235***	-0.00661	-0.00279	-0.00664
	(0.00835)	(0.00336)	(0.00649)	(0.00772)	(0.0103)
rd_intensity	-0.105***	-0.0948***	-0.154***	-0.113***	-0.0923***
	(0.0162)	(0.0195)	(0.0537)	(0.0137)	(0.0190)
debt_ratio	-0.0233***	-0.0420***	-0.0648***	-0.0323***	-0.0145
	(0.00877)	(0.00381)	(0.00856)	(0.00800)	(0.0106)
ln_toas	0.00280***	0.00503***	0.0172***	0.00355***	0.00143
	(0.000714)	(0.000337)	(0.00207)	(0.000635)	(0.000906)
roe	0.000238***	0.000330***	0.000242***	0.000271***	0.000317***
	(0.0000349)	(0.0000160)	(0.0000215)	(0.0000297)	(0.0000440)
losslastyear	-0.0479***	-0.0256***		-0.0404***	-0.0539***
	(0.00750)	(0.00328)		(0.00662)	(0.00971)
CIT	0.253***	0.0758***	0.254***	0.185***	0.0873
	(0.0681)	(0.0250)	(0.0357)	(0.0641)	(0.0880)
digital	0.0104**	0.00505*		0.00782	0.00695
	(0.00512)	(0.00278)		(0.00485)	(0.00714)
age	0.0000539**				
	(0.0000263)				
rd_interaction		-0.144	0.405		
		(0.0965)	(0.261)		
rd_support		-0.842*			
		(0.475)			
PayingTaxesTimehourspery				0.0000557	
				(0.0000409)	
tax_honesty					-0.00992
					(0.0401)
_cons	-0.205**	0.148***	-0.0719	-0.113	0.156
	(0.0901)	(0.0542)	(0.0453)	(0.0893)	(0.125)
Macro Controls	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	NO	YES
Industry FE	YES	YES	YES	NO	YES
N	9328	55230	55437	11618	5961
R^2	0.380	0.517	0.040	0.397	0.402

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C11: Results from pooled OLS and fixed effects estimations excluding firms with negative and/or zero tax payments

	(1) ETR1 Pooled	(2) ETR1 FE	(3) ETR1 Pooled	(4) ETR1 FE	(5) ETR2 Pooled	(6) ETR2 FE	(7) ETR2 Pooled	(8) ETR2 FE
empl	-4.82e-08***	-5.26e-08	-4.87e-08***	-5.38e-08	-1.79e-08	-1.22e-08	-1.82e-08	-1.41e-08
	(1.41e-08)	(7.34e-08)	(1.41e-08)	(7.30e-08)	(1.40e-08)	(7.47e-08)	(1.41e-08)	(7.42e-08)
ifas_fias	0.0122***	0.00553	0.0130***	0.00975*	0.0136***	0.00642	0.0146***	0.0102*
	(0.00181)	(0.00508)	(0.00188)	(0.00545)	(0.00190)	(0.00527)	(0.00196)	(0.00559)
cash_toas	-0.00770***	-0.0178***	-0.00695***	-0.0176***	-0.00635**	-0.0173***	-0.00475*	-0.0173***
	(0.00258)	(0.00508)	(0.00267)	(0.00525)	(0.00277)	(0.00525)	(0.00287)	(0.00538)
rd_intensity	-0.0816***	-0.0590***	-0.0836***	-0.0581***	-0.116***	-0.0450*	-0.124***	-0.0409
	(0.00570)	(0.0109)	(0.00582)	(0.0117)	(0.0112)	(0.0256)	(0.0117)	(0.0287)
debt_ratio	-0.00407	0.0148**	-0.00384	0.0152**	0.000772	0.0334***	0.00139	0.0342***
	(0.00264)	(0.00638)	(0.00269)	(0.00650)	(0.00274)	(0.00659)	(0.00279)	(0.00666)
ln_toas	0.000547**	0.00826***	0.000451*	0.00699***	-0.000901***	-0.000123	-0.000961***	-0.00131
	(0.000254)	(0.00185)	(0.000258)	(0.00193)	(0.000259)	(0.00192)	(0.000264)	(0.00195)
roe	-0.0000249**	-0.000186***	-0.0000317***	-0.000203***	-0.000306***	-0.000567***	-0.000306***	-0.000563***
	(0.0000100)	(0.0000242)	(0.0000111)	(0.0000272)	(0.0000354)	(0.000104)	(0.0000357)	(0.000106)
digital	-0.00320		-0.0194		-0.00620***		-0.0105	
	(0.00217)		(0.0127)		(0.00230)		(0.0139)	
ifas_digital			-0.00957*	-0.0404***			-0.00933*	-0.0393**
			(0.00535)	(0.0147)			(0.00560)	(0.0162)
cash_digital			-0.00977	0.00312			-0.0184*	0.00460
			(0.00948)	(0.0192)			(0.0102)	(0.0200)
rd_digital			0.0180	0.00159			0.0596*	-0.0321
			(0.0173)	(0.0321)			(0.0356)	(0.0614)
debt_digital			-0.00442	0.00407			-0.0150	-0.0172
			(0.0146)	(0.0344)			(0.0152)	(0.0366)
toas_digital			0.00187**	0.0116***			0.00106	0.0136**
			(0.000937)	(0.00441)			(0.000989)	(0.00557)
roe_digital			0.0000541***	0.000152***			0.00000922	-0.000106
			(0.0000181)	(0.0000496)			(0.000198)	(0.000574)
_cons	-0.0908***	0.0497	-0.0888***	0.0570*	-0.0161	0.176***	-0.0153	0.183***
	(0.0279)	(0.0331)	(0.0279)	(0.0332)	(0.0414)	(0.0341)	(0.0414)	(0.0340)
N	60,175	60,633	60,175	60,633	57,040	57,456	57,040	57,456
R^2	0.604	0.030	0.604	0.031	0.554	0.038	0.554	0.038

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include macro controls and year fixed effects. Pooled OLS estimations include country and industry fixed effects.ETR1 excludes firms with negative tax payments, ETR2 excludes firms with negative and zero tax payments.

Table C12: Pooled OLS estimations by region

	(1) Africa	(2) Asia	(3) Europe	(4) Oceania	(5) SCA	(6) NA
L.ETR	0.309***	0.505***	0.444***	0.338***	0.346***	0.563***
	(0.0554)	(0.00698)	(0.0103)	(0.0526)	(0.108)	(0.0156)
empl	-0.000000107*	-0.000000186***	-3.92e-08*	0.000000236*	0.00000197*	-0.000000210***
	(6.19e-08)	(4.60e-08)	(2.29e-08)	(0.000000136)	(0.00000105)	(4.01e-08)
ifas_fias	-0.00163	0.00304	0.0136***	-0.0243	0.0486	0.00000286
	(0.0195)	(0.00418)	(0.00328)	(0.0164)	(0.0495)	(0.00449)
cash_toas	0.0177	-0.0188***	-0.00903	-0.0350	0.240**	-0.0170**
	(0.0405)	(0.00412)	(0.00647)	(0.0355)	(0.113)	(0.00670)
rd_intensity	-0.0140	-0.201***	-0.115***	-0.166***	0.106	-0.0856***
	(0.438)	(0.0222)	(0.0120)	(0.0633)	(0.273)	(0.00830)
debt_ratio	-0.0986***	-0.0436***	-0.0372***	-0.0341	0.0241	-0.0102
	(0.0368)	(0.00420)	(0.00623)	(0.0316)	(0.0501)	(0.00869)
ln_toas	0.00108	0.00521***	0.00303***	0.00265	-0.000763	0.00443***
	(0.00281)	(0.000463)	(0.000526)	(0.00283)	(0.00680)	(0.000769)
roe	0.000195	0.000492***	0.000294***	0.000404***	-0.000670	0.000180***
	(0.000354)	(0.0000370)	(0.0000243)	(0.000124)	(0.000534)	(0.0000157)
losslastyear	-0.00700	0.00613	-0.0441***	-0.0676**	-0.177***	-0.0494***
	(0.0566)	(0.00469)	(0.00537)	(0.0263)	(0.0505)	(0.00592)
CIT	0.517**	0.114***	0.0799**	0.546	0.307	0.119
	(0.259)	(0.0312)	(0.0373)	(0.493)	(0.628)	(0.720)
digital	0.0115	-0.00498	0.00551	0.0403	0	0.00724
	(0.0191)	(0.00432)	(0.00433)	(0.0306)	(.)	(0.00524)
gdp_consus	1.91e-13	3.73e-15***	-9.90e-15	4.17e-13	-2.14e-13*	-2.57e-15
	(3.69e-13)	(1.37e-15)	(1.57e-14)	(3.17e-13)	(1.17e-13)	(2.42e-14)
gdp_pc_consus	0.0000423	-0.000000613	0.000000111	-0.0000341	0.0000386	0.0000359
	(0.0000374)	(0.000000949)	(0.000000979)	(0.0000220)	(0.0000265)	(0.0000522)
unemployment	-0.00340	-0.00105	-0.000209	0.00698	0.0252*	-0.00791
	(0.00592)	(0.00170)	(0.000596)	(0.0110)	(0.0149)	(0.0176)
freedomhouse	-0.0407*	0.00321	-0.00591	-0.0460	-0.0472	0
	(0.0247)	(0.00279)	(0.0119)	(0.0480)	(0.0568)	(.)
_cons	0.0598	-0.153	0.0572	0.828	-0.694	-1.130
	(0.284)	(0.102)	(0.0438)	(0.728)	(0.459)	(2.063)
N	616	37,331	18,831	740	213	8,256
R^2	0.331	0.544	0.387	0.432	0.514	0.621

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C13: Results from the fixed effects model by region

	(1) Africa	(2) Asia	(3) Europe	(4) Oceania	(5) SCA	(6) NA
L.ETR	-0.0243	0.0826***	0.0651***	-0.0458	-0.114	0.126***
	(0.0752)	(0.00989)	(0.0137)	(0.0704)	(0.144)	(0.0236)
empl	-0.000000105***	0.000000172	3.23e-08	0.000000364	-0.00000364	-0.000000287*
	(3.87e-08)	(0.000000210)	(0.000000142)	(0.000000784)	(0.00000777)	(0.000000174)
ifas_fias	0.0118	0.0144	0.0209**	-0.0729	0.325	-0.0101
	(0.0748)	(0.00988)	(0.0100)	(0.0498)	(0.203)	(0.0106)
cash_toas	0.00900	-0.00673	0.00330	-0.143**	-0.223	-0.000466
	(0.0770)	(0.00785)	(0.0152)	(0.0689)	(0.215)	(0.0132)
rd_intensity	0.660	-0.209***	-0.0675**	-0.739**	12.22	-0.0685***
	(0.785)	(0.0468)	(0.0294)	(0.319)	(10.69)	(0.0157)
debt_ratio	-0.0501	-0.0591***	-0.0711***	-0.0208	0.115	-0.0315*
	(0.102)	(0.0104)	(0.0144)	(0.0628)	(0.148)	(0.0181)
ln_toas	-0.0254	0.0202***	0.0109***	0.0363*	-0.136	0.0228***
	(0.0239)	(0.00287)	(0.00368)	(0.0205)	(0.132)	(0.00454)
roe	-0.000465	0.000370***	0.000212***	0.000257	-0.00210**	0.000114***
	(0.000702)	(0.0000432)	(0.0000381)	(0.000200)	(0.000974)	(0.0000219)
loss_size	-0.000000904***	3.61e-08	-1.32e-08	-0.000000323	0.00000182	-7.96e-09
	(0.000000154)	(2.45e-08)	(1.92e-08)	(0.000000283)	(0.00000503)	(5.98e-09)
CIT	0.570**	0.108***	0.349***	0.623	0.567	-0.961
	(0.225)	(0.0409)	(0.0577)	(0.444)	(0.932)	(1.917)
Macro Controls	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
_cons	0.513	-0.0872	0.0688	0.826	1.520	-4.093
	(0.439)	(0.100)	(0.0772)	(0.892)	(1.945)	(2.569)
N	619	37,632	19,013	740	213	8,256

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C14: Pooled OLS estimations by region with interaction terms

	(1) Africa	(2) Asia	(3) Europe	(4) Oceania	(5) SCA	(6) NA
L.ETR	0.299***	0.505***	0.443***	0.334***	0.346***	0.562***
	(0.0560)	(0.00698)	(0.0103)	(0.0527)	(0.108)	(0.0156)
empl	-9.86e-08	-0.000000190***	-3.53e-08	0.000000234*	0.00000197*	-0.000000213***
	(6.12e-08)	(4.61e-08)	(2.30e-08)	(0.000000134)	(0.00000105)	(4.05e-08)
ifas_fias	-0.00594	0.00927**	0.0147***	-0.0193	0.0486	0.00164
	(0.0209)	(0.00435)	(0.00338)	(0.0141)	(0.0495)	(0.00470)
ifas_digital	-0.0566	-0.0467***	-0.0200	-0.148	0	-0.00671
	(0.0558)	(0.0134)	(0.0127)	(0.257)	(.)	(0.0156)
cash_toas	0.0225	-0.0200***	-0.00962	-0.0422	0.240**	-0.0212***
	(0.0427)	(0.00420)	(0.00680)	(0.0363)	(0.113)	(0.00704)
cash_digital	0.0298	0.00173	0.00633	-0.0641	0	0.0373
	(0.161)	(0.0166)	(0.0216)	(0.186)	(.)	(0.0232)
rd_intensity	0.341	-0.194***	-0.110***	-0.162**	0.106	-0.0828***
	(0.724)	(0.0226)	(0.0120)	(0.0697)	(0.273)	(0.00874)
rd_digital	-0.342	-0.0510	-0.0715	0.0652	0	-0.0195
	(0.817)	(0.0757)	(0.0506)	(0.413)	(.)	(0.0221)
debt_ratio	-0.0927**	-0.0428***	-0.0365***	-0.0453	0.0241	-0.0128
	(0.0400)	(0.00425)	(0.00636)	(0.0323)	(0.0501)	(0.00914)
debt_digital	0.0203	-0.0271	-0.0215	0.397	0	0.0295
	(0.124)	(0.0261)	(0.0300)	(0.336)	(.)	(0.0308)
ln_toas	-0.0000709	0.00517***	0.00277***	0.00241	-0.000763	0.00404***
	(0.00307)	(0.000469)	(0.000537)	(0.00276)	(0.00680)	(0.000782)
toas_digital	0.0000834	0.00137	0.00483**	-0.0169	0	0.00484**
	(0.00751)	(0.00170)	(0.00211)	(0.0314)	(.)	(0.00206)
roe	0.000278	0.000485***	0.000293***	0.000547***	-0.000670	0.000198***
	(0.000351)	(0.0000385)	(0.0000251)	(0.000196)	(0.000534)	(0.0000184)
roe_digital	-0.00473***	0.0000888	0.0000127	-0.000204	0	-0.000105***
	(0.00159)	(0.000119)	(0.0000763)	(0.000247)	(.)	(0.0000263)
losslastyear	-0.0118	0.00625	-0.0443***	-0.0691***	-0.177***	-0.0492***
	(0.0555)	(0.00468)	(0.00537)	(0.0263)	(0.0505)	(0.00590)
CIT	0.541**	0.114***	0.0794**	0.578	0.307	0.115
	(0.262)	(0.0312)	(0.0373)	(0.489)	(0.628)	(0.720)
digital	0.121	-0.00765	-0.0352	0.304	0	-0.0633**
	(0.0957)	(0.0229)	(0.0263)	(0.289)	(.)	(0.0317)
Macro Controls	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
_cons	0.0522	-0.154	0.0597	0.906	-0.694	-1.106
	(0.287)	(0.102)	(0.0438)	(0.723)	(0.459)	(2.063)
N	616	37,331	18,831	740	213	8,256

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C15: Summary statistics for the balanced panel

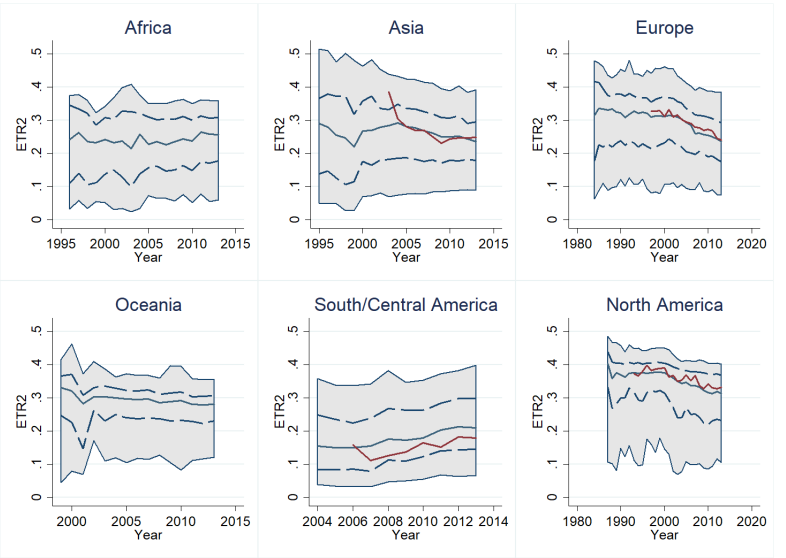
	mean	sd	p50	min	max	count
Full balanced panel						
ETR	0.25	0.12	0.27	-0.23	0.62	62070.00
ETR1	0.26	0.12	0.27	0.00	0.62	60996.00
toas_mio	1722.36	10282.16	97.81	2.00	410527.47	62044.00
empl	6803.93	41165.46	926.00	1.00	2200000.00	35420.00
ifas_fias	0.17	0.24	0.06	0.00	1.18	35709.00
cash_toas	0.15	0.16	0.10	-0.08	1.00	58297.00
rd_intensity	0.01	0.04	0.00	0.00	1.12	45336.00
debt_ratio	0.17	0.18	0.12	0.00	1.00	55987.00
roe	16.07	35.11	12.54	-955.88	961.11	61551.00
losslastyear	0.03	0.17	0.00	0.00	1.00	62070.00
digital	0.02	0.15	0.00	0.00	1.00	62070.00
Digital firms						
ETR	0.26	0.14	0.28	-0.19	0.62	1510.00
ETR1	0.27	0.13	0.28	0.00	0.62	1469.00
toas_mio	974.86	3105.08	136.65	2.00	34238.30	1510.00
empl	6149.23	19950.37	994.00	1.00	300464.00	1139.00
ifas_fias	0.41	0.31	0.36	0.00	0.97	1305.00
cash_toas	0.23	0.18	0.18	0.00	0.93	1480.00
rd_intensity	0.02	0.06	0.00	0.00	0.80	1332.00
debt_ratio	0.11	0.14	0.04	0.00	0.97	1468.00
roe	14.49	32.18	14.98	-607.40	361.70	1488.00
losslastyear	0.04	0.20	0.00	0.00	1.00	1510.00
Growth rates full balanced panel						
growth_toas	0.12	0.21	0.09	-0.37	1.26	54722.00
growth_ifas	0.37	1.85	0.00	-1.00	23.89	31377.00
growth_ebta	0.14	0.49	0.08	-1.88	3.36	39460.00
growth_plbt	0.19	0.78	0.09	-3.06	5.62	54752.00
growth_taxa	0.29	1.01	0.08	-0.94	10.08	52784.00
growth_cash	0.58	2.08	0.10	-0.95	25.03	50936.00
growth_rd	-1.00	0.00	-1.00	-1.00	-1.00	371.00
growth_loan_ltdb	0.31	1.67	0.01	-1.00	22.64	39569.00
Growth rates digital firms						
growth_toas	0.13	0.23	0.09	-0.37	1.22	1332.00
growth_ifas	0.54	2.17	0.04	-1.00	23.50	1158.00
growth_ebta	0.13	0.44	0.09	-1.78	2.81	1271.00
growth_plbt	0.14	0.65	0.10	-2.99	4.54	1334.00
growth_taxa	0.30	1.01	0.08	-0.93	9.18	1292.00
growth_cash	0.36	1.32	0.10	-0.94	20.37	1317.00
growth_rd	-1.00	0.00	-1.00	-1.00	-1.00	23.00
growth_loan_ltdb	0.37	1.90	-0.02	-1.00	18.23	971.00

3.C Additional Figures

Figure C1: Dispersion of ETRs for the full sample and digital firms

Notes: The figure shows the dispersion of effective of tax paying firms (including only firms with tax payments > 0). The graph on the left-hand side is identical to Figure 3.1. The graph on the right-hand side shows the dispersion of ETRs for the group of digital firms. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively. The dotted red line indicates the mean value. While the trend in means and median values is very similar, the decline of the ETR for the 25th and 10th percentile is more pronounced for the group of digital firms.

Figure C2: Dispersion of ETRs by region

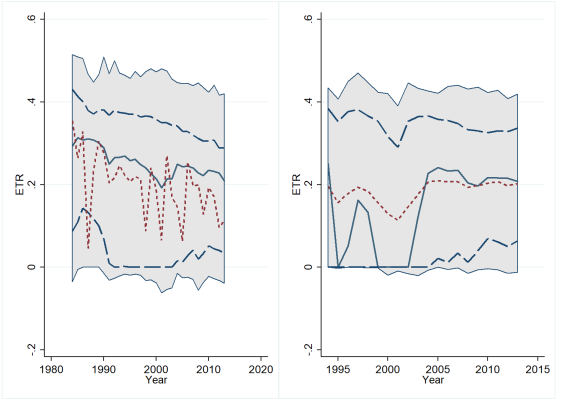


Notes: The figure shows the dispersion of effective of tax paying firms (the measure ETR2 excludes zero or negative tax payments). The sample is split by regions. Countries included in the respective regions are listed in Table C4. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively. The red line indicates the median value for digital firms.

Figure C3: Dispersion of ETRs including non tax paying firms

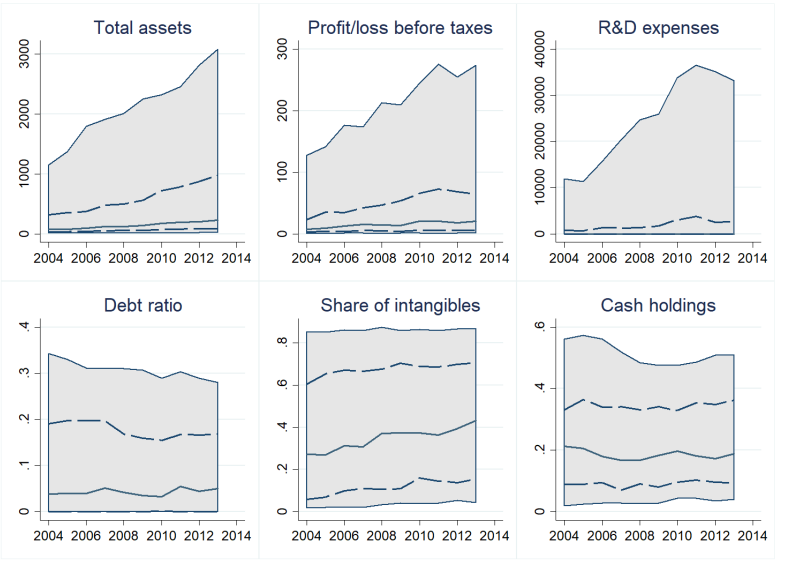
Notes: The graph on the left-hand side shows the dispersion of ETRs, using ETR1 as measure for effective tax rates. It includes observations from firms that report zero tax payments. The graph on the right-hand side shows the dispersion of ETRs for the group of digital firms. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively.

Figure C4: Dispersion of ETRs including negative and zero tax payments



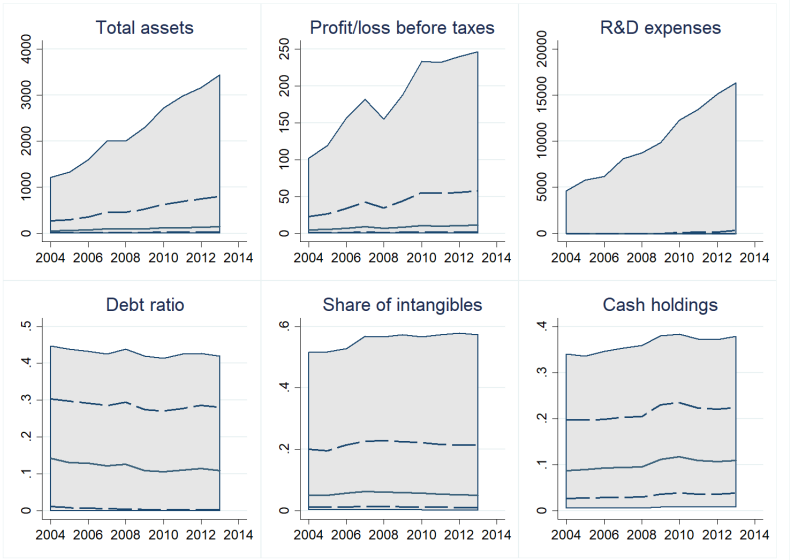
Notes: The graph on the left-hand side shows the dispersion of ETRs, using ETR as measure for effective tax rates. It includes observations from firms that report zero or negative tax payments. The graph on the right-hand side shows the dispersion of ETRs for the group of digital firms. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively. The dotted red line indicates the mean value.

Figure C5: Dispersion of firm characteristics over time



Notes: The figure shows the dispersion of tax relevant firm characteristics for the balanced sample. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively.

Figure C6: Dispersion of firm characteristics over time



Notes: The figure shows the dispersion of tax relevant firm characteristics for the balanced sample of digital firms. The shaded area represents the dispersion within the 10th and 90th percentile, the solid line indicates the median ETR by year. The dashed lines show the 25th and 75th percentile, respectively.

Chapter 4

Effects of the removal of a banking sector government guarantee on the corporate sector: firm-level evidence from Germany

4.1 Introduction

Up until 2001, public banks in Germany were protected by a longstanding federal government guarantee, which had existed since the emerging days of the German banking sector. The decision to remove it was made at the European level following a formal complaint, as non-public banks saw it to be in violation of European anti-subsidy rules. We take up on this event to analyze the effects of this regulatory change in the (public) banking sector on German firms. The analysis of potential effect of regulatory changes in the banking sector on the corporate sector is relevant for a number of reasons: Government guarantees continue to be a popular policy tool during crisis times. Many countries reacted to the

This chapter is based on joint work with Dr. Christa Hainz. We are thankful to participants at the Annual Conference of the International Institute of Public Finance (IIPF) in Lake Tahoe, the Annual Meeting of the German Economic Association in Vienna, the ESCS meeting in Budapest as well to participants at internal seminars at the LMU Munich, the University of Augsburg and the ifo Institute for valuable comments and suggestions.

financial crisis of 2008 by either nationalizing financial institutions or providing blanked guarantees. These interventions in the banking sector usually happen with two main aims: firstly, to increase confidence and trust of market participants in the banking sector and secondly, to attenuate credit crunches and ensure firms' access to credit during times of economic distress. Public guarantees in banking are therefore to not only meant to have direct effects on the banking sector but it is anticipated that they are transmitted to the real economy via firms depending on external finance. The analysis of this transmission to the real economy is therefore especially relevant for heavily bank dependent systems such as Germany and other countries in the European Union. While the direct effects on bank behavior have been analyzed in the literature extensively, the effects on firms have received less attention so far.
Moreover, most public guarantees introduced during times of banking sector distress are designed as temporary measures. It is therefore of vital importance to not only analyze effects of their introduction but to be aware of effects of their subsequent removal. The case of the German guarantor's liability offers a favorable setting for the analysis. The guarantor liability was a longstanding legal institution and granted to every public bank in Germany, regardless of its systemic importance or economic performance. This presents an advantage compared to the analysis of state guarantees introduced in crisis times, which are almost always directed at troubled institutions and whose analysis therefore suffers from endogeneity problems. Furthermore, there were no major policy changes with regard to non-public banks such as cooperative banks and private banks during that time. The event allows for the natural identification of a group of bank and firms, which is affected by the removal of the guarantee and a group that remains entirely unaffected.

Our research is related to two strands of the literature. Firstly, our paper builds on research discussing the effects of state interventions and regulatory changes on bank behavior. Secondly, our paper adds to contributions that discuss effects of regulatory changes and state interventions in the banking sector on the real economy. Regarding the first point, there is preponderant consent in the empirical literature, that significant effects on bank behavior exist. Using data from a sample of German banks, Berger et al. (2016) find, that regulatory interventions and capital injections lead to decreased risk taking by German banks. At the same time, however, public interventions also lead to decreases in liquidity creation and therefore entail a social cost. Gropp et al. (2014), Fischer et al. (2014) and Körner and Schnabel (2013) use the removal of the guarantor liability to analyze effects on bank behavior. Gropp et al. (2014) use savings banks data and come to the conclusion,

that the removal led to decreased risk-taking, as savings banks cut off their riskiest borrowers and abolished risk-sensitive debt instruments from their portfolios after 2001. On the contrary, focusing on Landesbanken, Fischer et al. (2014) find that the removal of the guarantor liability in 2001 led to increased risk taking due to a predominant charter-value effect. Körner and Schnabel (2013) exploit the distinct structure of the German banking sector and take into account network effects between savings banks and their superordinate Landesbanken. They find that especially those savings banks, whose Landesbank suffered from a strong deterioration of their credit ratings following the formal removal of the guarantee in 2005, increased their risk-taking.

Regarding contributions focussing on the transmission of shocks and changes in the banking sector to the real economy, most papers focus on the analysis of real effects in times of financial distress. Levintal (2013) investigates shocks to banks' balance sheets in 18 OECD countries for the period 1979 to 2003 and find that real effects on the economy exist, but that their economic significance is restricted to sufficiently large shocks. Dell'Ariccia et al. (2008) provide evidence that financially dependent sectors perform worse during banking crises relative to sectors being independent of external finance. Buch and Neugebauer (2011) show that idiosyncratic shocks to loan growth at large banks have significant short-run impacts on GDP growth. Using data from the recent financial crisis, Buca and Vermeulen (2017) add to the previous findings by showing that credit tightening of banks led to decreased investment by firms in Europe, especially those in bank dependent industries. Campello et al. (2010) use survey data to study whether credit constraints during the recent global financial crisis affected corporate spending plans: constrained firms undergo deeper cuts in employment and tech spending as well as postpone or cancel investment projects. Some contributions look at the real effects of government interventions in the banking sector. Giannetti and Simonov (2013) investigate the effects of bank bailouts on credit supply and firms' performances in Japan and find that capital injections only have positive effects on the supply of credit if they are sufficiently large. Laeven and Valencia (2013) study the effect of bank recapitalization policies on firm growth during the recent financial crisis and show that the bank recapitalization policies have a disproportionately large effect on firms, which depend on external finance.

Lastly, our paper is related to the contribution by Gropp et al. (2015). Congruent to our analysis, they also look at real effects of the removal of the guarantee at the firm level. Yet, they focus on a different research question by discussing effects on restructuring decisions.

Our paper brings the previously discussed strands of the literature together as we ana-

lyze the effects of a guarantee removal in the banking sector on firms in the economy. With our focus on the effects on firms we differ from the papers by Körner and Schnabel (2013), Fischer et al. (2014) and Gropp et al. (2014) that use the same event for identification. Furthermore, we add to their approach by accurately disentangling the timing of events: we differentiate the effects between 2001 and 2005 by considering that actual changes in funding conditions for public banks are likely to have occurred only after the transition period ended. Our panel data set combines information from the ifo Investment Survey with data from the Bureau van Dijk (BvD) Amadeus and BvD Markus data bank. The biannual ifo Investment Survey entails questions about undertaken and planned investments, the perceived financing situation of firms and the influence of political and economic factors on investment decisions over a long time horizon. Merging this survey data with data obtained from the Amadeus and Markus database allows us to add balance-sheet information as well as data on bank connections of the firms in our sample. We identify the effect of the removal of the public guarantee on firms by conducting a difference-in-differences analysis. Focusing on the 10-year period between 1998 and 2007, we find that, compared to firms being affiliated with non-public banks, public bank firms perceived a deterioration in their financing situation following the effective removal of the guarantee 2005. In 2001, when the the removal was decided but not enacted due to an agreed four year transition period, we do not find any effects. Therefore, obtained results are in line with the findings by Fischer et al. (2014) and Körner and Schnabel (2013) as we find no evidence at the firm level that banks tightened their lending as a response to the Brussels accord in 2001. Furthermore, we check for effects at the firm level with regard to total investment and employment. We find that the effective removal at the end of 2005 did not lead to statistically significant negative effects in terms of total investment and employment of firms. This is most likely due to the fact that especially Landesbanken made extensive use of the favorable funding conditions that persisted during the grandfathering period and did not yet restrict their lending during the period that is covered in our sample. Although the particular institutional arrangements of the removal of the guarantor's liability are likely to have counteracted real effects that would have occurred in the absence of the grandfathering period, the robust results in terms of firms' perceptions of their financing situation show that firms suspected a deterioration in their financing situation following the removal of the public guarantee for their banks.

The paper proceeds as follows: Section 4.2 gives an overview on the composition of the German banking sector and details on the institutional setting. Section 4.3 introduces

our hypotheses regarding the effect of the removal of the guarantee on firms. Section 4.4 describes the data set and estimation strategy applied, while section 4.5 explains the empirical approach. Section 4.6 presents the results and discusses the institutional peculiarities of the case that might impact the analysis. Section 4.7 concludes.

4.2 Institutional Setting

The banking sector and firm-bank relationships in Germany are characterized by three distinctive features: Firstly, public banks play a major role and build, together with private banks and cooperative banks, the three main pillars of the German banking sector. Our analysis will focus on the two major types of public banks: Landesbanken and savings banks (Sparkassen). Secondly, firms in Germany largely depend on external finance provided by banks and usually maintain stable long-term relationships with their main banks. Thirdly, both public and private banks play a major role in providing access to finance for the corporate sector. Furthermore, this section will introduce details on the guarantor liability and the terms and timing of its removal.

4.2.1 The composition of the German banking sector

The German banking sector is characterized by a large number of institutions and the prevalence of three main categories of banks: private banks, cooperative banks and public banks. The emergence of savings banks dates back to the 18th century. They were founded with the explicit goal of alleviating poverty by ensuring access to financial services for everybody and promoting the development of small-scale enterprises and regional businesses. This social mandate of savings banks was the main reason to grant them with a public guarantee in the first place. The first Landesbanken emerged in the 19th century and from the 20th century onward, Landesbanken started acting as "central banks" for the savings banks of a given region (Detzer et al., 2013). This is the structure that still characterizes the interconnectedness of savings banks and Landesbanken today: Landesbanken are owned by the respective federal states and the savings banks located in the state. Savings banks are universal banks but the geographical range of their activities is set by the regional principle, which is laid down by law: savings banks are not allowed to operate outside the geographical area of their chartering municipalities (OECD, 2010b). Landesbanken serve as clearing houses for savings banks as they offer savings banks access to large scale credit

and hold their excess liquidity reserves.[1]

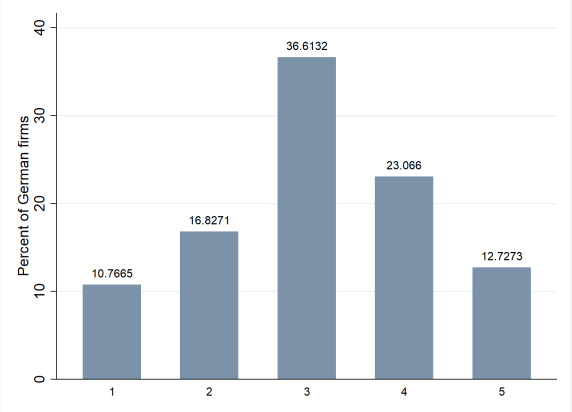
Public banks still play a central role in the German banking sector today. However, the overall number of public credit institutions has been declining over the last decades. This reflects a general trend towards more concentration in the banking sector as also private and cooperative banks showed a pronounced decline in the total number of credit institutions. Overall, this was mainly due to mergers and acquisitions of very small credit institutions. Figure D2 in the Appendix depicts the development of the total number of banks in Germany over the period 1998 to 2007. While the total number of credit institutions was close to 3,500 in 1998, it declined to roughly 2,000 credit institutions towards the end of 2007. The number of savings banks declined from 595 to 438, the number of Landesbanken from 13 to 10. With 451 institutions in total, public banks had a share of about 25 percent in the total number of banks in Germany at the time. In terms of total size measured as the balance sheet sum of the sector, the German banking sector grew from roughly 4,500 billion Euro to close to 8,000 billion Euro. Public banks make up for roughly one third of the overall size of the German banking sector as Figure D1 shows. In international comparison, the German banking sector is one of the least concentrated markets in Europe and characterized by a high level of competition and a relatively low level of profitability (Detzer et al. 2013)

4.2.2 Firm-bank relationships in Germany

Most German firms depend on access to external finance provided by banks. According to evidence from the EU-EFIGE Bruegel-Unicredit data set, 89 percent of participating German firms state that firms depend on external finance in their industry sector as indicated in Figure 4.1.

[1] See Körner and Schnabel (2013) for a detailed discussion of the relationship between Landesbanken and savings banks.

Figure 4.1: Dependency on external finance among German firms



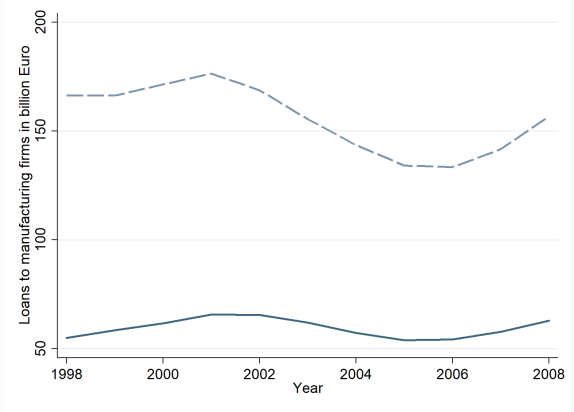
Notes: Categorical survey question on the dependency of firms on external finance in the respective industry sector of the firm with 1: not dependent at all, 5: very dependent. Distribution of answers plotted for participating firms from Germany. The bar graph shows that only 10.7 percent of firms state that firms in their industry sector do not depend on external finance. **Source:** EU-EFIGE/Bruegel-Unicredit Dataset, 2012. Data available upon request.

External finance can be obtained from various sources. Hainz and Wiegand (2013) show that bank credit is the main source of external finance for firms in Germany. For their sample of firms, they find that 73 percent of firms use bank credit. Alternative sources such as capital market financing or inter-company loans are less frequently used. The ifo Investment survey focuses on firms from the manufacturing sector. Figure 4.2 shows that public bank credit does play a substantial role for the manufacturing sector, with the total lending volume varying between 53 and 67 billion Euros.

4.2.3 The guarantor liability and the maintenance obligation

The public mandate of public banks from the days of the emergence of the German banking sector explained the existence of explicit state guarantees in the form of two legal institutions, the guarantor liability (*Gewährträgerhaftung*) and a maintenance obligation (*Anstaltslast*). The maintenance obligation defines the obligations of the owner of the bank (the federal states or municipalities) to enable the bank to fulfill its functions. This implicitly defined a bail-out guarantee for public banks in times of financial turmoils (Körner and Schnabel, 2013). If the owners of the bank decided to dissolve a bank, the guarantor liability became effective. The guarantor liability stated that in the event of a resolution of a savings bank (Landesbank), the municipalities (federal states) are directly liable to the

Figure 4.2: Lending to manufacturing firms by bank type



Notes: The dashed line shows total lending volume to the manufacturing sector by all banks in billion Euro. The solid line shows public bank lending to the manufacturing sector. **Data Source**: Time series data base of the Deutsche Bundesbank: `https://www.bundesbank.de/Navigation/EN/Statistics/Time_series_databases/time_series_databases.html?https=1` (last access 20/07/2018).

creditors of the banks. Taken together, both mechanisms guaranteed creditors of public banks a default risk of basically zero. As Körner and Schnabel (2013) point out, the only hypothetical event, that would imply losses for the creditors of public banks was the default of an owner of a public bank. It would therefore require a municipality or federal state to default on its debt.

While the structure of the interplay between savings banks and Landesbanken is still largely preserved from the emerging days of the banks, the public banks' focus on the public mandate got blurred. Landesbanken got increasingly engaged in international wholesale activities and their investment portfolios did not show significant differences from those of large private banks. At the same time, the public guarantee guaranteed led to public banks having a zero default risk. This secured them high ratings from the main rating agencies and therefore very favorable refinancing conditions. Among the 27 financial institutions with a "triple-A" ranking in the European Union in 2000 were 22 German public banks (Die Welt, 2000). Therefore, it was plausible, that the legal institutions of the guarantor liability and maintenance obligation led to an unfair competitive advantage of public banks in the banking sector. Considering this likely breach of European competition law, non-public banks demanded to abolish the special treatment pf public banks to level the playing field in the banking sector.

4.2.4 Timing of events

A formal complaint of the European Banking Federation was filed at the European Commission in 1999. In the complaint, the formal argument brought forward was, that the guarantor liability constitutes a form of illegal state aid and is therefore in breach of the EC Treaty. News reports and articles from the late 1990s show, that there was already a public debate going on at this early stage (see for example: Der Spiegel, 1997; Die Welt, 2000). Yet, at this point it was far from certain that the removal of the guarantee would be pushed through as several German politicians took sides with the public banks (Der Spiegel, 1997).

After intense negotiations in Brussels, an accord was reached on July 17, 2001. The so-called Brussels Agreement determined the abolishment of the guarantor liability (and a de facto abolishment of the maintenance obligation) after a transition period of four years. The grandfathering clause in the Brussels Agreement stated that public banks' debt already existing in 2001 would continue to be covered by the guarantor liability. Newly created liabilities, which are issued before the end of the transition period on 18 July 2005, are to be covered if they mature before 1 January 2016. Any other kind of liabilities not covered by these two exceptions is not protected by the government guarantee anymore (Moser et al., 2002).

4.3 Hypotheses

A firm's perceived financing situation depends on the interest rate it pays on its loans and how easy access to credit is. This, in turn, is determined by the banks' lending decisions. Therefore, we argue in a first step how the removal of the guarantor's liability is likely to have influenced the interest rates public banks pay for refinancing and their risk taking. This in turn influences loan rates and access to credit. We assume that the managers of public banks have an objective function that consists of the bank's current and future profits, i.e. its franchise value. The announcement that guarantees will be removed reduces the franchise value and increases risk taking incentives (Keeley, 1990). As the franchise value decreases with the announcement of the removal, the risk taking incentive increases immediately with the announcement in July 2001. The risk-taking can be contained by the banks' creditors and owners. Creditors will exert market discipline only after 2005 when

their investment is no longer protected by the public guarantee. The governments as owners and guarantors should monitor the bank's risk taking at least until 2005 because they are liable for all liabilities issued until the end of the transition period. However, governments need to be aware that the risk taking incentives of bank managers increase already in 2001 without being contained by market discipline. This means that the governments need to adjust their monitoring so as to counteract the bank management's increased risk taking incentives.

Based on these arguments we can derive the testable hypothesis. Between 2001 and 2005 the lending rates do not change for firms. However, the risk taking incentives of the bank management increase, but can be contained by governments if they adjust their monitoring. For the firms this implies that the lending policy of public banks either does not change or they are more willing to take risk, rendering access to credit easier. The following hypothesis summarizes the effects.

Hypothesis 1: Public bank firms do not perceive their financing situation as worse after 2001.

After 2005 the public banks face higher refinancing costs and as a result should increase their lending rates. Risk taking incentive are higher than in the period before 2001. However, in 2005 the creditors of public banks should start exerting market discipline. For the public bank firms this means that they have to pay higher interest rates on loans rendering the perception of the financial situation more difficult. The effect on access to credit depends on whether market discipline can counteract the higher risk taking incentives of the bank manager. This means that access either does not change or be-comes easier. In the latter case, the financing situation of the firm is affected by two opposing effects which leads to the following hypothesis.

Hypothesis 2: Public bank firms do not perceive their financing situation as better after 2005.

Interestingly the empirical literature on the changes of the public banks' behavior does support only some of our predictions and its results are sometimes contradictory. For the Landesbanken, Fischer et al. (2014) show that they demand lower interest rates and increase risk taking after 2001. For the savings banks, Körner and Schnabel (2013) provide

evidence that their refinancing rates increase after 2001 and that there is a further increase after 2005. With respect to the interest margin a decrease after 2001 is found that can be compensated after 2005. Körner and Schnabel (2013) derive the result by using cooperative banks as control group but note that due to a structural break in the time series data on cooperative bank reliability of results might be limited. Gropp et al. (2014) compare savings banks' lending through time-series variation and find an increase in interest rate spreads and a decrease in loan size. The latter decrease is also found when comparing lending by savings banks in a difference-in-differences analysis with lending by other German banks, including cooperative banks. Whereas Körner and Schnabel (2013) argue that the increase in refinancing rate is transmitted to savings banks by their Landesbank, Gropp et al. (2014) find that savings banks had to pay higher interest rates on their bonds after 2001.

4.4 Data and descriptives

The final sample includes 28,619 observations from 4,404 firms for the period 1998 to 2007. This gives an average of 6.5 observations per firm. Our dataset is therefore an unbalanced panel data set. The removal of the guarantor liability was decided upon in 2001 and enacted by the end of 2005. For the two groups of firms, roughly 30 percent of the total observations stems from the period before the policy change (1998-2000) and 70 percent from the period 2001-2007. Table 4.1 shows the number of firms and observations in the two groups. Non-public bank firms comprise all firms that were not affiliated with any public bank (Landesbank and/or savings bank) in the year 2000. Public bank firms are firms, that reported at least one public bank among their bank connections. In total, our sample contains 4,404 firms, of which 58.8 percent are public-bank firms and 41.2 percent belong to the non-public bank group, that is not affected by the removal of the guarantee. The firms in our sample have participated in the ifo Investment Survey for 26 years, on average. The legal form of firms in the sample is representative for the German private sector with most firms being organized in a legal form with limited liability (GmbH). Our data set allows us to track the bank connections of individual firms across three points in time: 2000, 2006 and 2010, which lies outside our main period of interest but gives an indication whether further bank switches happened after 2006. No data on bank connections could be obtained for the years prior to 2000. We therefore assume, that bank connections of firms were constant in the period 1998 to 2000. Research on bank-firm relationships has shown that the majority of firms in Germany maintains rather long-term relationship with its banks and annual switches are unlikely to occur. For example, participating German

firms in the EU-EFIGE Bruegel Dataset were asked for how many years the current main bank has been their main bank before: the mean answer was 22.7 years, with a median value of 17 years (EU-EFIGE, 2012). We are therefore confident that although we cannot observe bank-connections of firms at the starting year of our sample in 1998, bank connections in 2000 provide an accurate picture of the situation before the removal of the guarantee.

Table 4.1: Public bank firms and private bank firms in the sample

Group	**No. of firms**	**Share**	**No. of obs.**	**Observations/firm**
Non-public bank firms	1,815	41.2 %	11,958	6.59
Public bank firms	2,589	58.8 %	16,661	6.44
Total	4,404	100 %	28,619	6.5

Notes: Groups defined based on bank connection data for the year 2000. Share indicates the share of firms in total firms by group. The last column reports the average number of observations by firm by group.

As previously indicated, we also have information on the bank connections on the firms in our sample for the year 2006, the year after the end of the transition period. Comparing the information allows us to identify firms that switched groups over time. Table 4.2 shows developments in the data between 2000 and 2006. As we can see in part B of the table, the average number of banks that firms report changed over time. For the public bank firms, it decreased from 1.97 to 1.45, for the public bank firms, it increased from 3.01 to 3.19. In our empirical analysis, we will include a control variable to pick up this differences in the number of banks across groups.

Part C of Table 4.2 shows the switchers that we can identify, because we have information on the bank connections of those firms in both years. As we can see, from 2000 to 2006 there was a net flow towards public banks. More firms switched from private to public banks (or took up an additional public bank connection) than the other way around. This hints at the fact that public banks actually used the four-year grandfathering period to attract corporate customers. We will account for this by reporting results in two specifications, including all firms and using a sample that excludes all switchers. The results for the regressions on the sample that excludes group switching firms will be reported in the Section discussing robustness tests.

Table 4.2: Changes in bank connections over time

A: Number of firms	**Non-public bank firms**	**Public bank firms**
...in 2000	1,815	2,589
...in 2006	1,691	2,713
B: Number of banks		
...in 2000	1.97	3.01
...in 2006	1.45	3.19
C: Switchers	**2000 to 2006**	**2006 to 2010**
...private to public	371	171
...public to private	254	203
D: Non-Switchers	3,718	3,291

Table 4.3 provides summary statistics on the firms in the two groups from the ifo investment survey. Additional summary statistics on balance-sheet variables obtained from the BvD Amadeus database can be found in the Appendix in Table 4.A. Table 4.3 shows that non-public bank firms are larger in terms of total employees and revenue, on average. The mean number of employees in the public bank group of firms is 567, while it is 748 in the non-public bank group. Public bank firms are older with an average age of 65.61 years. The difference in age between the two groups is around 16 years. Non-public bank firms invest more in absolute terms but when accounting for the differences in firm size, both groups show a mean of similar magnitude.

The survey question on the perceived financing situation (*Financing_perception*) is our main dependent variable in the empirical analysis. Answers to this question are scaled from 1 to 5. An answer of 1 represents the financing situation being perceived as strongly animating while an answer of 5 represents a strong negative influence. Figure D4 in the Appendix shows the exact wording and graphical presentation of the question in the questionnaire. Across all years in the sample, public bank firms are more optimistic regarding their financing situation with a mean value of 3.05 compared to 3.13 of non-public bank firms as Table 4.3 indicates. The variables policy, return and sales perception are survey questions using the same scale from 1 to 5 as the question on the financing perception with higher values indicating worse perceptions. Both groups show very similar means regarding their perceptions of the sales situation this year. Non-public bank firms are, on average, a

bit more optimistic with regard to returns and perceptions of the general economic policy situation. An interesting number from the summary statistics on balance-sheet variables is the share of bank debt in total debt. Public bank firms have a bank debt share of 39 percent on average, non-public bank firms show a slightly lower value of 35 percent, on average. This shows that firms in both groups depend on external finance provided by banks and that their dependency is of similar magnitude, on average. Table D6 in the Appendix summarizes changes in investment, employment and bank debt for the two groups as well as the whole sample. Table D6 differentiates three periods: before the change (1998-2000), during the transition period (2001-2005) and after the change (2006-2007). We see that there are basically no changes with regard to employment in the two groups and only a slight reduction from the share of bank debt in total debt for the group of public bank firms in the after-change period. From the descriptive statistics, there is no evidence with regard to a negative trend in terms of total investment.

4.5 Empirical strategy

We employ a difference-in-differences analysis to identify the effect of the removal of the guarantor liability on the perceived financing situation. We also check for effects regarding total investment and employment. The group of public bank firms comprises firms that are affiliated with at least one public bank (savings bank and/or Landesbank) in 2000. Our non-public bank group contains firms that are solely affiliated with non-public banks in the year 2000. We differentiate the time period before the removal (before 2001 and 2005 respectively) and after the removal. The removal of the guarantor liability offers a natural setting for a difference-in-differences analysis as the group of public bank firms is exposed to the policy change in the after-removal period while the group of non-public bank firms is not. Regarding the period before the removal, the two groups are not exposed to differing shocks or policy changes that could influence their perception of the financing situation.
In order for a difference-in-differences estimation to identify the average effect of the removal of the guarantor liability on firms being customers of public banks, several statistical assumptions have to be met. The common trend assumption is of central importance: In the absence of treatment, firms in the treatment and control group are assumed to follow a parallel trend. We check for a parallel pretend between the two groups of firms comparing the mean answers of our main survey question of interest on the influence of the financing situation on investment activities this year. It should be kept in mind, that firms answer this question on a scale from 1 to 5 with the answer categories having the following meaning:

Table 4.3: Summary statistics by group and for the full sample

	Mean	Std. Deviation	Obs.
Full sample			
total revenue	200.17	1833.82	15,987
total investment	8.14	80.33	16,937
employees	641	4664	17,256
firm age (in 2007)	58.65	60.40	15,752
financing perception	3.08	0.88	13,137
policy perception	3.39	0.93	11,127
return perception	2.87	1.24	10,189
sales perception	2.78	1.28	10,305
Public bank firms			
total revenue	170.07	1979.68	9,686
total investment	6.94	87.75	9,922
employees	567.40	5305.01	10,228
firm age (in 2007)	65.61	63.67	9,011
financing perception	3.05	0.89	7,962
policy perception	3.41	0.94	7,053
return perception	2.88	1.26	6,764
sales perception	2.78	1.29	6,855
Non – public bank firms			
total revenue	246.44	1582.65	6,301
total investment	9.85	68.44	7,015
employees	748.11	3527.32	7,028
firm age (in 2007)	49.35	54.37	6,741
financing perception	3.13	0.87	5,175
policy perception	3.35	0.89	4,074
return perception	2.84	1.22	3,425
sales perception	2.77	1.25	3,450

Notes: Due to restrictive data policies for EBDC survey data obtained from the ifo Institute, it is not possible to report minimum and maximum values or percentiles on the respective variables.

1: strong inducement, 2: slight inducement, 3: no influence, 4: slight negative influence, 5: strong negative influence. Figure D3 in the Appendix indicates a stable parallel trend

for most years in the sample.[2] The parallel trend ends after 2005. As previously indicated, 2005 is the main year of interest, as the Brussels accord did not lead to immediate changes due to the agreed grandfathering period. The importance of the end of the transition period has also been recognized in the paper by Körner and Schnabel (2014), who use the same event for identification of effects on bank risk-taking. We do report regression results for both points in time, 2001 and 2005. In the discussion section, we furthermore check for effects around the time of the filing of the complaint in 1999.
Employing a difference-in-differences analysis, our main specification for the perceived financing situation is of the following form:

$$Financing\_perception_{i,t} = \alpha + \beta\_publicbank_i + \gamma\_time_t + \delta\_interaction_{i,t} + \psi X_{i,t} + \phi_t + \epsilon_{i,t} \quad (4.1)$$

The perception of the financing situation of firm i in year t is explained by a set of factors. Firstly, *publicbank* is the dummy variable that takes the value of one if the firm reports a bank connection to a public bank in 2000 and zero otherwise. *time* is the dummy that splits our sample into a pre- and post-change period, using either the year 2001 or 2005. *interaction* is the interaction term between *publicbank* and *time* and takes the value of one if the observations stems from a public bank firm in the post-change period.[3] The coefficient δ is therefore our main coefficient of interest: it indicates whether there is an additional effect from belonging to the public bank group in the post-change period on the perceived financing situation of firm i. We also include a varying set of control variables of interest, among others to see whether the number of banks the firm is affiliated with or the level of bank competition in the firm's postal code makes a difference. We also include fixed effects at the industry and federal state level to account for potential differences in the effects across industries and/or federal states. We will discuss the included controls in the results section.

We run the regressions using different specifications of the model. In a first step, we estimate the model using the OLS estimator. We then apply a panel data estimation strategy by using a fixed effects estimator. Pischke (2005) suggests the inclusion of fixed effects in difference-in-differences settings when the treatment was not randomly assigned. In our case, firms are free to choose their bank connections. It might be the case, that based on some (unobserved) firm characteristics, some

[2]The parallel trend is broken for one year in the sample, the year 2000. When checking other variables of the survey, we see stable parallel trends with exception for the same year as well. One potential reason could be that the composition of firms in the non-public bank group for that year was different for some reason.

[3]When reporting the results, we differentiate between time_2001 and time_2005 as well as interaction_2001 and interaction_2005 to avoid confusion on the applied pre- and post-change period.

firms might be more likely to be treated, meaning choosing a public bank. Körner and Schnabel (2013) also use a fixed effects estimator in their analysis of effects of the removal of the guarantee on bank risk-taking. Especially given that the parallel trend assumption is not fulfilled in one year of our covered period, we add robustness to obtained results by replicating them with the more restrictive fixed effects model. We therefore report estimation results obtained from both, the pooled OLS and fixed-effects estimations.

4.6 Results

In this section we report the regression results for our main dependent variables of interest: the perceived financing situation of firms. Furthermore, we check for effects on total investment and employment. We report both, results from pooled OLS and firm fixed effects estimations. We will first report results on the effect on the perceived financing situation from the announcement of the removal of the public guarantee in 2001 and the actual removal in 2005. This will be followed by a presentation of results with regard to total investment of employment. In the robustness section, we rerun the main specifications while excluding firms that switched groups during the transition period. Furthermore, we take a closer look at the exact timing of events by checking for a potential effect of the public discussions towards the end of the 1990s as well as for an effect when including both relevant points in time 2001 and 2005, in the regressions.

4.6.1 Effects on the perceived financing situation

Table 4.4 shows the estimation results for the pooled OLS and firm fixed effects regressions on the perceived financing situation of firms for 2001. Columns (1),(3), (5) and (6) report results from pooled OLS specifications, columns (2) and (4) report results from the fixed effects estimations. Year fixed effects are included in all regressions. Dummies at the industry and federal state level are included in all pooled OLS estimations. They are not included in the fixed effects estimations, as characteristics such as the industry classification and location of the firm are time invariant and would therefore be dropped in the estimations. Our main coefficient of interest is the interaction term, as it captures the effect for the removal of the public guarantee on firms being customers of savings banks and/or Landesbanken. The coefficient on the interaction term is statistically insignificant in all six specifications. This is in line with our first hypothesis, that the announcement of the removal of the public guarantee is likely to not have any effect on public bank firms due to the agreed transition period.

Next, we test whether our second hypothesis holds. We check for an effect of the actual removal of the public guarantee that set in with the end of the transition period in 2005. Table 4.5 summarizes results of the pooled OLS and fixed effects estimations now using a time dummy

that is one if the observations is from the years 2006 or 2007 and zero otherwise. The interaction term between the time dummy and the dummy indicating whether the firm is indicated with a public bank now shows a significant coefficient in columns (3) to (6). Given the scaling of the question from 1 (strongly inducing) to 5 (strong negative influence) a positive value means, that there is a negative effect of the removal of the public guarantee on the perceived financing situation for public bank firms. Also the fixed-effects estimation in column (4) results in a positive and significant coefficient for the interaction term, yet here the coefficient is a bit smaller in magnitude. Columns (5) and (6) show that the negative effect of the removal is less pronounced, the more banks the firm is affiliated with. Firstly, it is likely that firms with more banks are larger in size and therefore less likely to be credit restricted. Secondly, for firms with multiple bank connections, it might be easier to substitute away from a bank that restricts its loan supply.[4] show that the negative effect is less pronounced in areas with a higher level of bank competition, measured in the number of banks in the zip code of the firm. Coefficients of sales and revenue expectations are significant and positive. Like our dependent variable, sales and revenue expectations are scaled from 1 to 5 with higher values indicating worse expectations. Firms that are pessimistic about their business performance are also less optimistic about their financing situation, which reflects that firms are aware that banks might classify them as risky borrowers.

4.6.2 Effects on total investment and employment

Tables 4.6 and 4.7 show results for an effect on total investment and employment. The coefficients of the interaction terms are insignificant in all specifications. The lack of an effect with regard to total investment and employment could be due to several reasons: Firstly, the period covered in our data set is relatively short. The transition period ended in 2005, which leaves only two years of data after the effective removal of the government guarantee. However, among others Acharya et al. (2018) have shown, that restrictions in the access to external financing lead to negative effects on investment and employment in the short run (within two years after the experienced credit crunch). From the descriptive statistics in Table D6, there was already indicatory evidence that no changes occurred with regard to employment across the firms in our sample. Also, no negative trend in terms of total investment occurred. Therefore, the main explanatory factor for the lack of real effects of the removal at the firm level might be the particular setting of the removal of the guarantee. We will discuss this as well as incentive effects of the generous transition period more in section 4.6.3.

[4] At this point, it should be recalled that it is sufficient to be affiliated with one public bank in order to be classified into the public banks group. Public bank firms might therefore also be affiliated with private banks or cooperative banks. This is more likely, the larger the number of stated bank connections of the firm is.

Table 4.4: Estimation results on the perceived financing situation in 2001

	(1) OLS	(2) FE	(3) OLS	(4) FE	(5) OLS	(6) OLS
time_2001	0.172***	0.138***	0.226***	0.184***	0.232***	0.233***
	(0.0409)	(0.0398)	(0.0394)	(0.0388)	(0.0445)	(0.0446)
publicbank	-0.0678*	0	-0.0926***	0	-0.0887**	-0.0885**
	(0.0351)	(.)	(0.0339)	(.)	(0.0392)	(0.0397)
interaction_2001	0.0203	0.0270	0.0580	0.0598	0.0593	0.0593
	(0.0379)	(0.0371)	(0.0376)	(0.0374)	(0.0427)	(0.0427)
employees			0.0000255	0.0000192	0.0000179	0.0000188
			(0.0000255)	(0.0000135)	(0.0000500)	(0.0000510)
revenue_percept.			0.209***	0.187***	0.203***	0.202***
			(0.0137)	(0.0120)	(0.0146)	(0.0144)
sales_percept.			0.0862***	0.0744***	0.0984***	0.0991***
			(0.0121)	(0.0104)	(0.0129)	(0.0129)
total_revenue			-1.38e-08	-2.05e-08**	-0.000000122	-0.000000117
			(4.41e-08)	(9.19e-09)	(0.000000168)	(0.000000170)
total_investment			-0.000000917	-0.000000305*	0.00000260	0.00000237
			(0.00000207)	(0.000000182)	(0.00000243)	(0.00000247)
number_of_banks					-0.0324***	-0.0304***
					(0.00975)	(0.0102)
banks_zipcode					-0.00245	-0.00326*
					(0.00164)	(0.00166)
_cons	3.021***	2.849***	2.080***	2.108***	2.178***	2.195***
	(0.114)	(0.0216)	(0.111)	(0.0373)	(0.118)	(0.123)
LB Dummies	NO	NO	NO	NO	NO	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO	YES	YES
Federal State FE	YES	NO	YES	NO	YES	YES
N	12,167	13,137	8,944	9,825	7,277	7,277
R^2	0.054	0.039	0.208	0.176	0.223	0.225

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.6.3 Robustness and discussion

Firstly, Table4.8 reports results for the sample of firms that did not switch group during the transition period. Secondly, Table 4.6.3 checks for a joint effect of the announcement of the removal in 2001 and the actual removal in 2005, following the specification of Körner and Schnabel (2013). Furthermore, we check for a potential effect at the time the official complaint was filed in 1999 in Table 4.6.3. Lastly, we discuss induced behavioral changes among public banks during the transition period and assess the external validity of results obtained.

Table 4.5: Estimation results on the perceived financing situation in 2005

	(1) OLS	(2) FE	(3) OLS	(4) FE	(5) OLS	(6) OLS
time_2005	0.142***	0.131***	0.203***	0.180***	0.197***	0.198***
	(0.0421)	(0.0414)	(0.0419)	(0.0414)	(0.0467)	(0.0468)
publicbank	-0.0681**	0	-0.0758***	0	-0.0748**	-0.0748**
	(0.0292)	(.)	(0.0275)	(.)	(0.0316)	(0.0320)
interaction_2005	0.0655	0.0371	0.0930**	0.0668*	0.110**	0.111**
	(0.0403)	(0.0395)	(0.0403)	(0.0396)	(0.0446)	(0.0446)
employees			0.0000256	0.0000204	0.0000192	0.0000200
			(0.0000254)	(0.0000136)	(0.0000497)	(0.0000507)
revenue_percept.			0.209***	0.187***	0.204***	0.203***
			(0.0137)	(0.0120)	(0.0146)	(0.0145)
sales_percept.			0.0858***	0.0740***	0.0979***	0.0986***
			(0.0121)	(0.0105)	(0.0130)	(0.0129)
total_revenue			-1.33e-08	-2.09e-08**	-0.000000123	-0.000000118
			(4.41e-08)	(9.30e-09)	(0.000000168)	(0.000000170)
total_investment			-0.000000906	-0.000000319*	0.00000253	0.00000230
			(0.00000207)	(0.000000182)	(0.00000243)	(0.00000247)
number_of_banks					-0.0324***	-0.0304***
					(0.00975)	(0.0102)
banks_zipcode					-0.00249	-0.00330**
					(0.00164)	(0.00166)
_cons	3.020***	2.849***	2.065***	2.106***	2.165***	2.182***
	(0.114)	(0.0216)	(0.111)	(0.0374)	(0.118)	(0.122)
LB Dummies	NO	NO	NO	NO	NO	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO	YES	YES
Federal State FE	YES	NO	YES	NO	YES	YES
N	12,167	13,137	8,944	9,825	7,277	7,277
R^2	0.054	0.039	0.208	0.176	0.223	0.225

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Excluding switchers

As described in Table 4.2 in the Data section, there are some firms in the sample that switched groups during the transition period. To make sure that our results are not driven by those firms, we run the main regressions using a sample that excludes the switching firms. Table 4.8 reports results from pooled OLS and fixed effects estimations for the perceived financing situation on the sample of firms, that did not switch groups during the transition period. Once we include the previously discussed firm level controls, pooled OLS regressions show a positive and statistically significant

Table 4.6: Effects on investment

	(1) OLS	(2) FE	(3) OLS	(4) FE
time_2005	-0.0374	0.0289	0.0447	0.103*
	(0.0589)	(0.0447)	(0.0905)	(0.0621)
publicbank	-0.211**	0	-0.154*	0
	(0.0850)	(.)	(0.0899)	(.)
interaction_2005	0.0881	0.0160	-0.0589	-0.0393
	(0.0598)	(0.0441)	(0.0813)	(0.0588)
_cons	7.333***	6.429***	7.130***	6.706***
	(0.325)	(0.0239)	(0.282)	(0.149)
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
Federal State FE	YES	NO	YES	NO
N	15,097	16,237	7,259	8,933
R^2	0.160	0.035	0.484	0.096

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.7: Effects on employment

	(1) OLS	(2) FE	(3) OLS	(4) FE
time_2005	-0.0658**	-0.0188	-0.225***	-0.124***
	(0.0325)	(0.0148)	(0.0504)	(0.0199)
publicbank	-0.126**	0	-0.0230	0
	(0.0603)	(.)	(0.0657)	(.)
interaction_2005	0.0508	-0.0189	-0.0144	0.0130
	(0.0323)	(0.0139)	(0.0474)	(0.0178)
_cons	5.135***	4.881***	4.362***	5.635***
	(0.235)	(0.00760)	(0.204)	(0.255)
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
Federal State FE	YES	NO	YES	NO
N	16,074	17,255	7,496	9,199
R^2	0.211	0.010	0.516	0.132

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

coefficient of the interaction term. It is of similar magnitude than before. However, in the fixed effects specification, the interaction term does not show a significant coefficient anymore.

A closer look at the timing of events

Reviewing news paper articles from the late 1990s (see for example Der Spiegel, 1997; Die Welt, 2000) indicates that the potential removal of the public bank guarantee was a publicly discussed topic at that time. However, given that German politicians supported the stand of the public banking lobby at the time, it is questionable whether the removal was perceived to be a likely event to occur and induced any measurable changes at the firm level. Nevertheless, we check for an effect around the time the official complaint was handed in in 1999. To check for an effect in 1999, we split the sample into a period before 1999 and after 1999, indicated by the time dummy (time_1999). The interaction term is the interaction between the public bank dummy, defined as before, and the time_1999 dummy. Once firm level controls are included, the coefficient of the interaction term is insignificant. Therefore, there is no evidence for a statistically significant effect on firms from public discussions during the late 1990s.

Following Körner and Schnabel (2013), we include both decisive dates of the policy change, 2001 and 2005 in the regressions, to see if our obtained results for the actual removal in 2005 still hold. Table 4.6.3 summarizes the results. As before, the coefficient of the interaction term for 2001 (interaction_2001) is insignificant in all specifications. The coefficient of the interaction term for 2005 (interaction_2005) is significant at the 10 percent level once firm controls are included. It is of very similar magnitude than before and therefore confirms our results of a perceived deterioration in the financing situation of public bank firms in 2005.

Induced behavioral changes

The transition period is likely to have induced behavioral changes among public banks, especially the Landesbanken. Anticipating potential rating downgrades after 18 July 2005 and a subsequent increase in funding costs, Landesbanken used the transition period to issue substantial amounts of bonds. Fischer et al. (2014) show that the volume of unsecured bond issuances increased markedly from around 3 billion in 1998 to 95 billion in the first half of 2005. For example, the Bavarian Landesbank Bayern LB increased its issuance behavior by a factor of 14 compared with the value in the year 1999. These behavioral changes during the transition period are likely to influence our results. The transition period prevented a shock in funding costs for public banks after its announcement in 2001. During the transition period, public banks are likely to even have expanded their credit supply due to the large amount of liquidity they took up during the four years between 2001 and 2005. It is likely that behavioral changes only have occurred among Landesbanken and not among savings banks, whose business model mainly depends on consumer deposits and does typically not involve trading activities in financial markets. Nevertheless, it is plausible that also savings banks profited from the increase in liquidity of the Landesbanken via spillover effects within the public banking network.

Table 4.8: Estimation results for the perceived financing situation in 2005 (switchers excluded)

	(1) OLS	(2) FE	(3) OLS	(4) FE	(5) OLS	(6) OLS
time_2005	0.163***	0.149***	0.214***	0.193***	0.211***	0.211***
	(0.0460)	(0.0451)	(0.0459)	(0.0450)	(0.0509)	(0.0510)
publicbank	-0.0602*	0	-0.0812**	0	-0.0779**	-0.0800**
	(0.0328)	(.)	(0.0321)	(.)	(0.0385)	(0.0388)
interaction_2005	0.0561	0.0263	0.101**	0.0690	0.115**	0.118**
	(0.0450)	(0.0438)	(0.0448)	(0.0438)	(0.0491)	(0.0491)
employees			0.0000339	0.0000197	0.0000141	0.0000114
			(0.0000288)	(0.0000144)	(0.0000573)	(0.0000588)
revenue_percept.			0.210***	0.188***	0.207***	0.206***
			(0.0152)	(0.0130)	(0.0159)	(0.0157)
sales_percept.			0.0884***	0.0792***	0.0993***	0.0999***
			(0.0135)	(0.0114)	(0.0141)	(0.0140)
total_revenue			-7.00e-09	-2.89e-08**	-0.000000109	-8.91e-08
			(4.95e-08)	(1.16e-08)	(0.000000188)	(0.000000191)
total_investment			-0.00000160	-0.000000375*	0.00000380	0.00000374
			(0.00000244)	(0.000000224)	(0.00000272)	(0.00000276)
number_of_banks					-0.0279**	-0.0250**
					(0.0113)	(0.0118)
banks_zipcode					-0.00256	-0.00334*
					(0.00174)	(0.00177)
_cons	3.055***	2.838***	2.095***	2.082***	2.173***	2.193***
	(0.129)	(0.0238)	(0.128)	(0.0406)	(0.132)	(0.137)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO	YES	YES
Federal State FE	YES	NO	YES	NO	YES	YES
N	10,342	11,131	7,608	8,321	6,298	6,298
R^2	0.053	0.037	0.209	0.182	0.225	0.227

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

These developments do not contradict our obtained results with regard to the survey question on the perceived financing situation. The lack of an effect on the perceived financing situation in 2001 shows, that firms were aware of the existence of the transition period, that secured refinancing conditions for their banks for the next four years. Our results with regard to 2005 show, that firms did expect to see a deterioration in their financing situation after the end of the transition period. This hints at the fact that firms were aware of the rating downgrade that happened towards the end of the transition period and the likely consequences for lending behavior of public banks. In July

Table 4.9: Checking for an effect in the year 1999

	(1) OLS	(2) FE	(3) OLS	(4) FE	(5) OLS	(6) OLS
time_1999	0.131***	0.0996**	0.223***	0.177***	0.225***	0.226***
	(0.0456)	(0.0422)	(0.0456)	(0.0420)	(0.0527)	(0.0527)
publicbank	-0.135***	0	-0.113**	0	-0.114*	-0.114*
	(0.0522)	(.)	(0.0519)	(.)	(0.0587)	(0.0592)
interaction_1999	0.0878*	0.0909*	0.0625	0.0716	0.0689	0.0694
	(0.0513)	(0.0474)	(0.0513)	(0.0471)	(0.0590)	(0.0590)
_cons	3.062***	2.849***	2.092***	2.107***	2.194***	2.211***
	(0.117)	(0.0216)	(0.114)	(0.0373)	(0.122)	(0.127)
Firm Controls	NO	NO	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO	YES	YES
Federal State FE	YES	NO	YES	NO	YES	YES
N	12,167	13,137	8,944	9,825	7,277	7,277
R^2	0.054	0.039	0.208	0.176	0.223	0.225

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.10: Checking for a joint effect of 2001 and 2005

	(1) OLS	(2) FE	(3) OLS	(4) FE	(5) OLS	(6) OLS
time_2001	0.328***	0.281***	0.205***	0.159***	0.218***	0.218***
	(0.0418)	(0.0391)	(0.0416)	(0.0394)	(0.0477)	(0.0477)
publicbank	-0.0680*	0	-0.0927***	0	-0.0890**	-0.0888**
	(0.0352)	(.)	(0.0339)	(.)	(0.0392)	(0.0397)
time_2005	-0.186***	-0.157***	-0.0138	0.00310	-0.0306	-0.0298
	(0.0420)	(0.0399)	(0.0426)	(0.0399)	(0.0476)	(0.0476)
interaction_2005	0.0656	0.0287	0.0773*	0.0471	0.0974*	0.0987**
	(0.0441)	(0.0423)	(0.0445)	(0.0425)	(0.0497)	(0.0497)
interaction_2001	-0.000151	0.0191	0.0327	0.0463	0.0272	0.0268
	(0.0414)	(0.0397)	(0.0414)	(0.0400)	(0.0472)	(0.0473)
_cons	3.020***	2.849***	2.078***	2.107***	2.176***	2.193***
	(0.114)	(0.0216)	(0.111)	(0.0373)	(0.119)	(0.123)
Firm Controls	NO	NO	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO	YES	YES
Federal State FE	YES	NO	YES	NO	YES	YES
N	12,167	13,137	8,944	9,825	7,277	7,277
R^2	0.054	0.039	0.208	0.176	0.223	0.225

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

2004, Fitch Ratings downgraded all Landesbanken by 4 to 7 notches. (Senkarcin, 2016) Given that most bank-firm loan contracts are medium-to long-term contracts and that the transition period entailed a clause that also secured all debt of public banks that matured before 1 January 2016, our sample period is simply too short to capture any negative real effects. However, given that the financial crisis set in shortly afterwards and that it heavily affected most Landesbanken, an identification of effects would be difficult, even if our dataset had covered more years after the removal of the guarantee.

Regarding the external validity of the results obtained from the analysis of the removal of the guarantor liability and maintenance obligations, a distinction has to be made. We feel confident that results with regard to the perception of the financing situation of firms are valid for the removal of public guarantees in the banking sector in other settings, too. However, results with regard to effects on total investment and employment are likely to be blurred by the transition period, that is unique to the analyzed case. The policy design of the transition period prevented a shock in funding costs for banks in 2001, that would have potentially translated into negative real effects at the firm level. Therefore, we do not find any effects in terms of employment and investment that might have been found in other settings.

With regard to policy implications from the analysis, the lack of negative real effects at the firm level does not imply that the policy design of the removal of the public guarantee should be assessed positively. The incentive effects of the transition period led to severe consequences that enfolded during the financial crisis from 2008 onward. Senkarcin (2016) discusses the failed policy design of the removal of the guarantee with regard to bank risk taking in detail. He finds, that the long transition period of four years caused Landesbanken to take on hazardous strategies. Next to investing in mortgage derivatives, excess funds were passed on to risky borrowers. Both Landesbanken and savings banks failed to take the chance to adapt their business model during the transition period (Senkarcin, 2016). In turn, the subsequent severe problems of public banks during the financial crisis are likely to have entailed negative real effects on the corporate sector. However, a quantification of these effects is beyond the scope of our paper.

4.7 Conclusion

This paper assesses firm level effects of the removal of a long-standing government guarantee in the German banking sector. As only public banks were affected by the removal while non-public banks remained unaffected by the policy change, the setting allows for a difference-in-differences analysis. We find that firms being affiliated with public banks perceived a deterioration in their financing situation after the end of the transition period in 2005, compared to firms being solely affiliated with non-public banks. We do not find any evidence for effects in terms of employment and total investment. Regarding the lack of real effects, the particular setting of the removal of the

guarantor liability and maintenance obligation has to be taken into account. Several lessons can be drawn from the analysis: the transition period is likely to have prevented a shock in refinancing costs for public banks (Landesbanken) in 2001. Considering that previous research has shown that shocks in the banking sector get passed on to the corporate sector (Acharya et al., 2018), it is possible that there would have been negative effects from the removal of the guarantee on public bank firms in the absence of the transition period. Overall, evidence from our survey data analysis shows, that firms are sensible to changes in the banking sector, given that they largely depend on external finance. Next to the incentive effects of the policy design on bank risk taking, this should be kept in mind when announcing the removal of public guarantees.

Appendix

4.A Additional tables

Table D1: Additional information on the data set

Variable Name	Description	Scale/Unit
ifo Investment Survey		
total investment	gross fixed capital formation (equipment and buildings) in the business year x	in Mio. Euro
employees	number of employees last year (overall company)	
total revenue	total revenue (overall company) last year	in Mio. Euro
financing situation	factors influencing investment activities: influence of financing situation this year	1 - 5
sales expectations	factors influencing investment activities: influence of turnover situation/expectation this year	1 - 5
return expectations	factors influencing investment activities: influence of expected return this year	1 - 5
policy expectations	factors influencing investment activities: influence of economic policy parameters this year	1 - 5
BvD Amadeus		
age	computed as 2007 minus year of incorporation of company	in years
total assets	total assets of the company	in 1000 Euro
financial assets	financial assets of the company	in 1000 Euro
total debt	debt in total	in 1000 Euro
total equity	total equity/shareholders' funds	in 1000 Euro
sales	total sales of the company	in 1000 Euro
profit loss for period	profit/loss for period	in 1000 Euro
bank debt ratio	computed as debt to financial institutions divided by total debt	
debt ratio	computed as the ratio of total debt to total assets	
BvD Markus		
bank connection	name of banks the company is associated to in year x (available for 2000, 2006 and 2010)	
number of bank connections	number of different banks the company is associated to in year x (available for 2000, 2006 and 2010)	
number of bank types	number of different types of banks the company is associated to in year x (available for 2000, 2006 and 2010)	

Notes: For variables from the ifo Investment survey, monetary values prior to 2002 were reported in DM; corresponding Euro values were computed using an exchange rate of .... Regarding the number of employees, the wording of the question does not differentiate between full time/part time employees. Information on the bank connections of firms is available for three distinct years.

Table D2: Number of firms by group and year

Year	Private bank firms	Public bank firms	Total
1998	824	1,159	1,983
1999	828	1,166	1,994
2000	840	1,173	2,013
2001	966	1,310	2,276
2002	1,070	1,443	2,513
2003	1,239	1,678	2,917
2004	1,338	1,806	3,144
2005	1,584	2,251	3,835
2006	1,703	2,438	4,141
2007	1,566	2,237	3,803

Table D3: Bank types: Classification of banks in the sample

Bank type code	Description
1	Big commercial bank (Deutsche Bank, Commerzbank, Postbank, UniCredit, Dresdner Bank)
2	Regional banks and other commercial banks
3	Savings bank
4	Landesbank
5	Cooperative bank (Volksbank, Raiffeisenbank and others)
6	Central cooperative bank (DZ Bank, DG Bank, WGZ Bank)
7	Foreign bank in Germany
8	Bank in a foreign country
9	Others (special purpose banks etc.)

Notes: Banks were classified following the bank categories of Deutsche Bundesbank in their official Banking statistics. For more information see: `https://www.bundesbank.de/Navigation/EN/Statistics/Banks_and_other_financial_institutions/Banks/banks.html` (last access 25/06/18)

Table D4: Information on ifo Industry Classification and Distribution of Firms

ifo Industry Code	Description	N.P. firms	P. firms	Total share
210	Manufacture of mining products	3.86	5.76	4.98
222	Drawing plants, cold rolling mills	1.14	1.45	1.32
223	Foundry industry	2.19	2.48	2.36
230	Metal production	1.26	1.04	1.13
250	Chemical industry	6.39	2.88	4.32
260	Wood machining	1.44	3.13	2.43
270	Production of pulp, paper and paperboards	1.22	1.01	1.10
280	Manufacture of rubber	1.02	0.97	0.99
310	Steel and lightweight construction	2.72	2.34	2.50
320	Mechanical Engineering	15.77	12.51	13.85
331	Road vehicle production	4.18	1.87	2.82
340	Electrical engineering	7.78	4.92	6.10
350	Precision engineering, optics	3.02	3.65	3.40
370	Steel deformation	3.13	4.95	4.20
380	Manufacture of EBM equipment	6.19	7.27	6.82
411	Fine ceramics	0.56	1.01	0.83
412	Manufacture of glass	2.32	0.81	1.43
420	Wood processing	3.18	5.66	4.64
430	Manufacture of musical instruments, toys, jewelry, etc	1.50	1.41	1.45
441	Manufacture of paper and paperboards	3.12	3.48	3.33
442	Printing, copying	4.47	9.83	7.62
450	Production of plastics goods	4.71	5.58	5.22
462	Leather fabrication, without manufacture of shoes	0.76	0.56	0.64
463	Manufacture of shoes	0.70	0.53	0.60
471	Drapery	4.48	3.62	3.97
472	Clothing trade	1.46	1.71	1.61
510	Food industry	7.84	8.06	7.97
-	Others	3.59	1.51	2.37
Total		100	100	100

Table D5: Summary statistics on balance-sheet information

	Mean	Std. Deviation	Obs.
Full sample			
total_assets	210803.19	1841717.13	14,494
fixed_assets	117288.53	1179560.93	14,415
total_debt	119476.79	811214.17	9,009
short_term_debt	60414.38	547610.06	14,374
long_term_debt	21250.97	223469.81	14,485
bank_debt	28751.01	187833.91	5,239
sales	364752.32	2541471.83	9,455
financial_profit_loss	4609.19	108748.41	17,556
interest_expenses	4051.68	33963.49	10,387
operating_profit	23019.90	227863.41	12,311
debtratio	0.69	0.40	14,494
bankdebtfraction	0.38	0.26	5,239
Public bank firms			
total_assets	165039.28	2000135.30	8,170
fixed_assets	93167.03	1314757.92	8,117
total_debt	95280.57	842738.59	5,013
short_term_debt	48197.01	596936.11	8,109
long_term_debt	13639.99	133075.71	8,166
bank_debt	24893.72	218424.56	3,029
sales	332319.82	2764531.46	5,030
financial_profit_loss	3711.59	122497.76	9,980
interest_expenses	3141.18	33294.72	5,711
operating_profit	14037.88	195935.24	6,794
debtratio	0.71	0.43	8,170
bankdebtfraction	0.39	0.25	3,029
Non – public bank firms			
total_assets	269925.76	1612436.25	6,324
fixed_assets	148376.85	977359.02	6,298
total_debt	149831.05	768871.80	3,996
short_term_debt	76227.73	475821.22	6,265
long_term_debt	31086.59	302368.37	6,319
bank_debt	34037.76	134958.62	2,210
sales	401619.09	2261099.84	4,425
financial_profit_loss	5791.62	87388.75	7,576
interest_expenses	5163.71	34734.06	4,676
operating_profit	34080.96	261482.48	5,517
debtratio	0.66	0.39	6,324
bankdebtfraction	0.35	0.27	2,210

Table D6: Changes in debt, investment and employment over time

	Public banks		**Non-public banks**	
	Mean	Std.Dev.	Mean	Std.Dev.
1998 − 2000				
bank_debt	0.40	0.27	0.32	0.29
growth_bank_debt	-0.04	0.40	-0.12	0.50
growth_investments	0.21	1.00	0.19	0.99
growth_employees	0.00	0.12	0.01	0.13
financing_perception	2.90	0.88	3.00	0.83
2001 − 2005				
bank_debt	0.40	0.24	0.35	0.27
growth_bank_debt	-0.04	0.38	-0.09	0.42
growth_inv	0.17	1.03	0.18	1.02
growth_empl	-0.01	0.12	-0.00	0.12
financing_perception	3.17	0.91	3.25	0.90
2006 − 2007				
bank_debt	0.38	0.25	0.36	0.25
growth_bank_debt	-0.04	0.44	-0.04	0.45
growth_investments	0.32	1.01	0.26	0.92
growth_employees	-0.00	0.12	0.00	0.13
financing_perception	2.98	0.79	2.99	0.78

Table D7: Effects on employment (switchers excluded)

	(1) OLS	(2) OLS	(3) FE	(4) FE
time_2005	-0.0658**	-0.214***	-0.0279*	-0.138***
	(0.0325)	(0.0578)	(0.0152)	(0.0254)
publicbank	-0.126**	-0.0940	0	0
	(0.0603)	(0.0797)	(.)	(.)
interaction_2005	0.0508	-0.0192	-0.0202	0.0191
	(0.0323)	(0.0541)	(0.0146)	(0.0215)
_cons	5.135***	4.273***	5.801***	5.469***
Controls	NO	YES	NO	YES
	(0.235)	(0.209)	(0.263)	(0.0650)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	NO	NO
Federal State FE	YES	YES	NO	NO
N	16,074	6,555	16,074	6,555
R^2	0.211	0.523	0.056	0.202

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

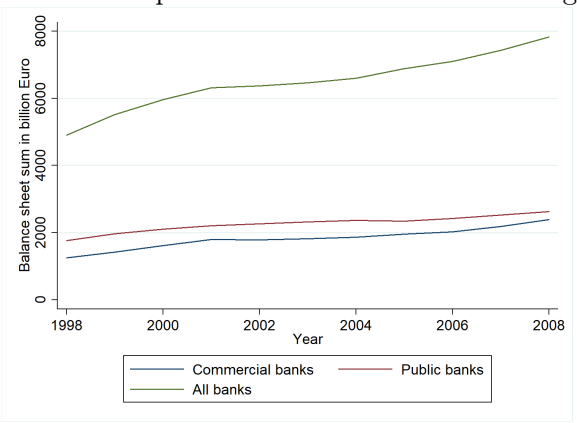
Table D8: Effects on total investment (switchers excluded)

	(1) OLS	(2) FE	(3) OLS	(4) FE
time_2005	-0.0890	0.00964	-0.00439	0.0776
	(0.0674)	(0.0510)	(0.103)	(0.0649)
publicbank	-0.250**	0	-0.237**	0
	(0.0971)	(.)	(0.110)	(.)
interaction_2005	0.127*	0.0281	-0.00476	-0.0221
	(0.0669)	(0.0493)	(0.0919)	(0.0619)
_cons	7.347***	6.390***	7.129***	7.037***
Controls	NO	NO	YES	YES
	(0.343)	(0.0258)	(0.286)	(0.0503)
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
Federal State FE	YES	NO	YES	NO
N	12,778	13,702	6,288	8,320
R^2	0.170	0.034	0.489	0.079

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

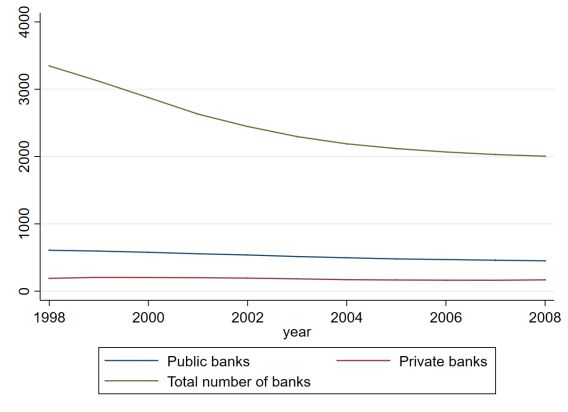
4.B Additional figures

Figure D1: Developments in the size of the banking sector



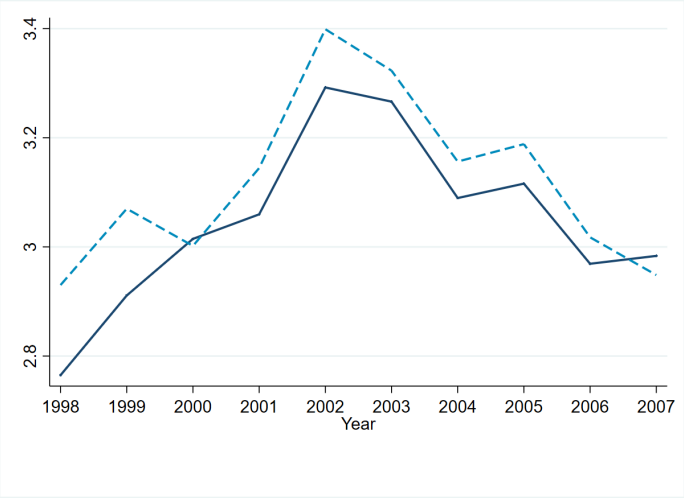
Notes: The figure shows the development of the balance sheet sum by bank type in billion Euro. Public banks comprise Landesbanken and savings banks; commercial banks comprise private banks and branches of foreign banks in Germany. Source: Time series data base of the Deutsche Bundesbank; `https://www.bundesbank.de/Navigation/EN/Statistics/Time_series_databases/time_series_databases.html?https=1` (last access 06/07/2018).

Figure D2: Developments in the number of credit institutions



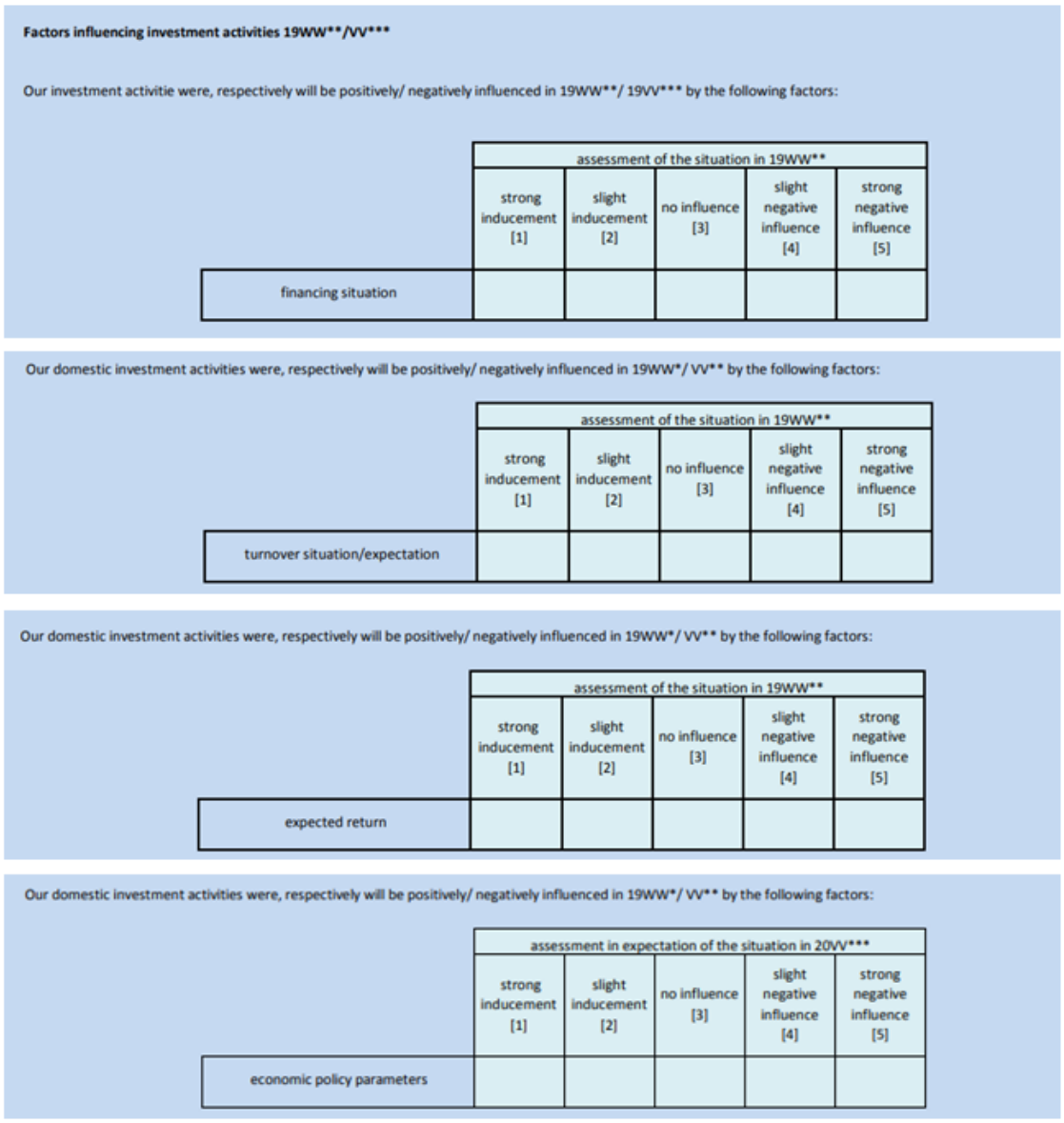
Notes: Public banks comprise Landesbanken and savings banks; private banks comprise big banks and regional and other credit banks. The reduction in the total number of banks over the period can largely be explained by mergers among cooperative banks with the number of credit cooperations falling from 2406 to 1197. The total number of savings banks declined from 595 to 438, the number of Landesbanken from 13 to 10. **Data source:**Time series data base of the Deutsche Bundesbank; `https://www.bundesbank.de/Navigation/EN/Statistics/Time_series_databases/time_series_databases.html?https=1` (last access 06/07/2018).

Figure D3: The influence of the financing situation of firms on investment decisions



Notes: The solid line shows the mean answer of firms in the public bank group by year, the dashed line shows the mean answers of firms, which are not affiliated with public banks.

Figure D4: Influencing factors of investment activities: exact phrasing of the questions



Notes: All questions were asked referring to last year, this year and next year: 19WW refers to this year, 19VV refers to next year. ifo differentiates between a western and eastern version of the survey. The questions were asked annually in the autumn version of the survey for the region west, gaps exist with regard to data from the region east

Bibliography

[1] Abramovsky, Laura, Alexander Klemm, and David Phillips. 2007. *Corporate Tax in Developing Countries: Current Trends and Design Issues*. Fiscal Studies, Vol. 35(4), pp. 559-588.

[2] Acharya, Viral V., Tim Eisert, Christian Eufinger, and Christian Hirsch. 2018. *Real effects of the Sovereign Debt Crisis in Europe: Evidence from Syndicated Loans*. The Review of Financial Studies, Vol. 31(8), pp. 2855-2896.

[3] Armstrong, Christopher, Jennifer Blouin, David Larcker. 2012. *The incentives for tax planning*. Journal of Accounting and Economics, 2012, Vol. 53(1-2), pp. 391-411.

[4] Auerbach, Alan. 2008. *Why Have Tax Revenues Declined? Another Look.*. CESifo Economic Studies, Vol. 53(2), pp. 153-171.

[5] Becker, Johannes, Clemens Fuest and Nadine Riedel. 2012. *Corporate tax effects on the quality and quantity of FDI*. European Economic Review, Vol. 56(8), pp. 1495-1511.

[6] Berger, Allen, Christa Bouwman, Thomas Kick, Thomas and Klaus Schaeck. 2016. *Bank Liquidity Creation Following Regulatory Interventions and Capital Support*. Journal of Financial Intermediation, Vol. 26, pp. 115-141.

[7] Blouin, Jennifer, Harry Huizinga, Luc Laeven and Gaetan Nicodeme. 2014. *Thin Capitalization Rules and Multinational Firm Capital Structure*. International Monetary Fund (IMF) Working Paper No. 14/12.

[8] Brill, Alex and Kevin A. Hassett. 2007. *Revenue-Maximizing Corporate Income Taxes: The Laffer Curve in OECD Countries*. American Enterprise Institute, Working Paper No. 137.

[9] Buca, Andra and Philip Vermeulen. 2017. *Corporate investment and bank-dependent borrowers during the recent financial crisis*. Journal of Banking and Finance, Vol. 78, pp. 164-180.

[10] Buch, Claudia and Katja Neugebauer. 2011. *Bank-Specific Shocks and the Real Economy*. Journal of Banking and Finance, Vol. 35(8), pp. 2179-2187.

[11] Bucovetsky, Sam. 1991. *Asymmetric tax competition*. Journal of Urban Economics, Vol. 30(2), pp. 167-181.

[12] Bureau van Dijk. 2011. *Orbis User Guide*. Available at `https://www.wu.ac.at/fileadmin/wu/s/library/databases_info_image/ugorbisneo.pdf` (last access: September 06, 2018).

[13] Campello, Murillo, John Graham and Campbell Harvey. 2010. *The real effects of financial constraints: Evidence from a financial crisis*. Journal of Financial Economics, Vol. 97(3), pp. 470-487.

[14] Chen, Yang, Juan Carlos Cuestas and Paulo Jose Regis. 2016. *Convergence in Corporate Statutory Tax Rates in the Asian and Pacific Economies*. International Journal of Finance and Economics, Vol. 21(3), pp. 266-278.

[15] Clausing, Kimberly. 2007. *Corporate tax revenues in OECD countries*. International Tax and Public Finance, Vol. 14(2), pp. 115-133.

[16] Clausing, Kimberly. 2016. *The Effect of Profit Shifting on the Corporate Tax Base in the United States and Beyond*. National Tax Journal, Vol. 69(4), pp. 905-934.

[17] Crass, Dirk, Georg Licht and Bettina Peters. 2014 *Intangible Assets and Investments at the Sector Level - Empirical Evidence for Germany*. ZEW Discussion Paper No. 14-049. Available at: `http://ftp.zew.de/pub/zew-docs/dp/dp14049.pdf` (last access: September 16, 2018).

[18] Curtis, Mark and Ryan Decker. 2018. *Entrepreneurship and State Taxation*. Finance and Economics Discussion Series 2018-003. Washington: Board of Governors of the Federal Reserve System, available at `https://doi.org/10.17016/FEDS.2018.003`. (last access: September 14, 2018).

[19] Dahlby, Bev and Ergete Ferede. 2018. *The Marginal Cost of Public Funds and the Laffer Curve: Evidence from the Canadian Provinces*. FinanzArchiv: Public Finance Analysis, Vol. 74(2), pp. 173-199.

[20] Dell'Ariccia, Giovanni, Enrica Detragiache and Raghuram Rajan. 2008. *The real effect of banking crises*. Journal of Financial Intermediation, Vol. 17(1), pp. 89-112.

[21] Der Spiegel. 1997. *VorstoÃŸ von Simonis*. Article published on 17/02/97. Available at `http://www.spiegel.de/spiegel/print/d-8670149.html` (last access: September 15, 2018).

[22] Detzer, Daniel, Nina Dodig, Trevor Evans, Eckhard Hein, Hansjörg Herr. 2013. *The German Financial System*. Studies in Financial Systems No 3., published as part of the research project Financialisation, Economy, Society and Sustainable Development (FESSUD).

[23] Detzer, Daniel, Nina Dodig, Trevor Evans, Eckhard Hein, Hansjörg Herr and Franz Prante. 2017. *The German Financial System and the Financial and Economic Crisis*. Financial and Monetary Policy Studies, Vol. 45., Springer International Publishing.

[24] Desai, Mihir and Dhammika Dharmapala. 2006. *Corporate tax avoidance and high-powered incentives*. Journal of Financial Economics, Vol. 79, pp. 145-179.

[25] Devereux, Michael and Rachel Griffith. 1999. *The taxation of discrete investment choices.* Institute for Fiscal Studies, Working paper 98/16 (Revision 2).

[26] Devereux, Michael, Rachel Griffith, and Alexander Klemm. 2002. *Corporate Income Tax Reforms and International Tax Competition.* Economic Policy, Vol. 17(35), pp. 449-495.

[27] Devereux, Michael and Rachel Griffith. 2003. *Evaluating tax policy for location decisions.* International Tax and Public Finance, Vol. 10, pp.107-126.

[28] Devereux, Michael, Rachel Griffith and Alexander Klemm. 2004. *Why Has the UK Corporation Tax Raised So Much Revenue?* Fiscal Studies, Vol. 25(4), pp. 367-388.

[29] Devereux, Michael. 2007. *Developments in the Taxation of Corporate Profit in the OECD since 1965: Rates, Bases and Revenues.* Oxford University Centre for Business Taxation Working Paper 7(4).

[30] Devereux, Michael, Ben Lockwood and Michaela Redoano. 2008. *Do countries compete over corporate tax rates?.* Journal of Public Economics, Vol. 92, pp. 1210-1235.

[31] Devereux, Michael, Christina Elschner, Dieter Endres, and Christoph Spengel.2011. *Effective Tax Levels Using the Devereux/Griffith Methodology.* Intermediate Report 2011, Project for the EU Commission TAXUD/2008/CC/099, Mannheim and Oxford.

[32] Dharmapala, Dhammika. 2014. *What Do We Know about Base Erosion and Profit Shifting? A Review of the Empirical Literature.* Fiscal Studies, Vol. 35(4), pp. 421-448.

[33] Die Welt. 2000. *Private Banken werfen Sparkassen Marktabschottung vor.* Article published on July 28, 2000. Available at `https://www.welt.de/print-welt/article525386/Private-Banken-werfen-Sparkassen-Marktabschottung-vor.html` (last access: September 17, 2018).

[34] Dischinger, Matthias. 2010. *Profit Shifting by Multinationals: Evidence from European Micro Panel Data.* Available at `https://www.ecpol.econ.uni-muenchen.de/downloads/publis/dischinger_publis/dischinger_ps_new1.pdf` (last access: September 04, 2018).

[35] Drake, Katherine, Russ Hamilton and Stephen Lusch. 2018. *The sources of declining effective tax rates: Insight from effective tax rate reconciliations.* Available at `https://ssrn.com/abstract=2974219` (last access: September 12, 2018).

[36] Dwenger, Nadja and Viktor Steiner. 2012. *Profit Taxation and the Elasticity of the Corporate Income Tax Base: Evidence from German Corporate Tax Return Data.* National Tax Journal, Vol. 65(1), pp. 117-150.

[37] Dyreng, Scott, Michelle Hanlon, Edward Maydew. 2010. *The Effects of Executives on Corporate Tax Avoidance.* The Accounting Review, Vol. 85(4), pp. 1163-1189.

[38] European Commission. 2015. *User Guide to the SME Definition.* Ref. Ares(2016)956541, Publications Office of the European Union.

[39] European Commission. 2016. *State aid: Ireland gave illegal tax benefits to Apple worth up to 13 billion*. Press release, IP/16/2923. Available at: `http://europa.eu/rapid/press-release_IP-16-2923_en.htm` (last access: September 14, 2018).

[40] European Commission. 2018. *Digital Taxation: Commission proposes new measures to ensure that all companies pay fair tax in the EU*. Press release, IP/18/2041. Available at: `http://europa.eu/rapid/press-release_IP-18-2041_en.htm` (last access: September 02, 2018).

[41] Evers, Lisa, Hellen Miller and Christoph Spengel. 2013. *Intellectual Property Box Regimes: Effective Tax Rates and Tax Policy Considerations*. ZEW Discussion Paper No.13-070. Available at: `http://ftp.zew.de/pub/zew-docs/dp/dp13070.pdf` (last access: September 13, 2018).

[42] Fernandez-Rodriguez, Elena and Antonio Martinez-Arias. 2014. *Determinants of the Effective Tax Rate in the BRIC Countries*. Emerging Markets Finance and Trade, Vol. 50(3), pp. 214-228.

[43] Fischer, Markus, Christa Hainz, Jörg Rocholl and Sascha Steffen. 2014. *Government Guarantees and Bank Risk Taking Incentives*. Working Paper 2014.

[44] Fuest, Clemens and Alfons Weichenrieder. 2002. *Tax Competition and Profit Shifting: On the Relationship between Personal and Corporate Tax Rates*. CESifo Economic Studies, Vol. 48(4), pp. 611-632.

[45] Fuest, Clemens, Giorgia Maffini and Nadine Riedel. 2010. *What determines corporate tax payments in developing countries? Evidence from firm panel data*. Available at `https://sbs.ox.ac.uk/sites/default/files/So-What-Statements/Docs/Maffini-countries-tax.pdf` (last access: August 06, 2018).

[46] Fuest, Clemens, Volker Meier, Florian Neumeier and Daniel Stoehlker. 2018. *Die ökonomischen und fiskalischen Auswirkungen der EU Digitalsteuer*. Unpublished study for IHK.

[47] Fullerton, Don. 1982. *On the Possibility of an Inverse Relationship Between Tax Rates and Government Revenues*. Journal of Public Economics, Vol. 19(1), pp. 03-22.

[48] Garrett, Geoffrey and Deborah. Mitchell. 2001. *Globalization, Government Spending and Taxation in the OECD*. European Journal of Political Research, Vol. 39(2), pp. 145-177.

[49] Giannetti, Mariassunta and Andrei Simonov. 2013. *On the Real Effects of Bank Bailouts: Micro Evidence from Japan*. American Economic Journal: Macroeconomics, Vol. 5(1), pp.135-167.

[50] Govindarajan, Vijay, Shivaram Rajgopal and Anup Srivastava. 2018. *Why Financial Statements Don't Work for Digital Companies*. Harvard Business Review, February 26, 2018. Available at `https://hbr.org/2018/02/why-financial-statements-dont-work-for-digital-companies` (last access: September 04, 2018).

[51] Graham, John, Jana Raedy, Douglas Shackelford. 2012. *Research in accounting for income taxes*. Journal of Accounting and Economics, Vol. 53(1-2), pp. 412-434.

[52] Greene, William. 2018. *Econometric Analysis*. Pearson, 8th Edition.

[53] Gropp, Reint, Christian Gruendl and Andre Guettler. 2014. *The Impact of Public Guarantees on Bank Risk-Taking: Evidence from a Natural Experiment*. Review of Finance, Vol. 18(2), pp. 457-488.

[54] Gropp, Reint, Andre Guettler and Vahid Saadi. 2018. *Public Bank Guarantees and Allocative Efficiency*. Updated version of IWH Discussion Paper 7/2015. Available at `https://ssrn.com/abstract=2889304` (last access: September 11, 2018).

[55] Gruber, Jon and Emmanuel Saez. 2002. *The Elasticity of Taxable Income: Evidence and Implications*. Journal of Public Economics, Vol. 84(1), pp. 01-32.

[56] Gruber, Jonathan and Joshua Rauh. 2007. *How Elastic is the Corporate Income Tax Base?*. In: edited by Alan Auerbach, James R. Hines and Joel Slemrod: *Taxing Corporate Income in the 21st Century*, Cambridge University Press, Cambridge.

[57] Hainz, Christa and Manuel Wiegand. 2013. *Financing Of The German Economy During The Financial Crisis*. Dice Report No. 1/2013, pp. 48-55.

[58] Hanlon, Michelle and Terry Shevlin. 2005. *Book-tax conformity for corporate income: An introduction to the issues*. Tax Policy and the Economy, Vol. 19, pp. 101-134.

[59] Hanlon, Michelle and Shane Heitzman. 2010. *A review of tax research*. Journal of Accounting and Economics, Vol. 50., pp. 127-178.

[60] Heckemeyer, Jost and Michael Overesch. 2017. *Multinationals' profit response to tax differentials: Effect size and shifting channels*. Canadian Journal of Economics , Vol. 50(4), pp. 965-994.

[61] Hines, James, Anna Gumpert and Monika Schnitzer. 2016. *Multinational Firms and Tax Havens*. The Review of Economics and Statistics, Vol. 98(4), pp. 713-727.

[62] Huizinga, Harry and Luc Laeven. 2008. *International profit shifting within multinationals: A multi-country perspective*. Journal of Public Economics, Vol. 92, pp. 1164-1182.

[63] Judson, Ruth and Ann Owen. 1999. *Estimating dynamic panel data models: a guide for macroeconomists*. Economic Letters, Vol. 65, pp. 09-15.

[64] Kalemli-Ozcan, Sebnem, Bent Sorensen, Carolina Villegas-Sanchez, Vadym Volosovych and Sevcan Yesiltas. 2015. *How to Construct Nationally Representative Firm Level Data from the Orbis Global Database*. National Bureau of Economic Research, NBER Working Paper No. 21558.

[65] Kawano, Laura and Joel Slemrod. 2012. *The Effect of Tax Rates and Tax Bases on Corporate Tax Revenues: Estimates with New Measures of the Corporate Tax Base*. NBER Working Paper No. 18440.

[66] Keeley, Michael. 1990. *Deposit Insurance, Risk, and Market Power in Banking*. American Economic Review, Vol. 80(5), pp. 1183-1200.

[67] Kiviet, Jan. 1995. *On bias, inconsistency, and efficiency of various estimators in dynamic panel data models*. Journal of Econometrics, Vol. 68, pp.53-78.

[68] Koerner, Tobias; Schnabel, Isabel. 2013. *Abolishing Public Guarantees in the Absence of Market Discipline*. Ruhr Economic Papers No. 437.

[69] Kraft, Anastasia. 2014. *What Really Affects German Firms' Effective Tax Rate?*. International Journal of Financial Research, Vol. 5(3), pp.1-19.

[70] Laeven, Luc and Fabian Valencia. 2013. *The Real Effects of Financial Sector Interventions During Crises*. Journal of Money, Credit and Banking, Vol. 45(1), pp. 147-177.

[71] Levintal, Oren. 2013. *The real effects of banking shocks: Evidence from OECD countries*. Journal of International Money and Finance, Vol. 32(C), pp. 556-578.

[72] Liu, Xing and Shujun Cao. 2007. *Determinants of Corporate Effective Tax Rates: Evidence from Listed Companies in China*. The Chinese Economy, Vol. 40(6), pp. 49-67.

[73] Mahenthrian, Sakthi and Jeyapalan Kasipillai. 2011. *Influence of Ownership Structure, Corporate Governance, and Culture on Tax Policy: Evidence from Malaysia*. Available at `https://hbr.org/2018/02/why-financial-statements-dont-work-for-digital-companies` (last access: September 12, 2018).

[74] Markle, Kevin S. and Douglas A. Shackelford. 2012. *Cross-Country Comparisons of Corporate Income Taxes*. National Tax Journal, Vol. 65, pp. 493-528.

[75] Markle, Kevin S. and Douglas A. Shackelford. 2014. *The Impact of Headquarter and Subsidiary Locations on Multinationals' Effective Tax Rates*. Tax Policy and the Economy, Vol. 28(1), pp. 33-62.

[76] Mintz, Jack. (1995). *The corporation tax: A survey*. Fiscal Studies, Vol. 16(4), pp. 23-68.

[77] Mooij, Ruud and Gaetan Nicodeme. 2008. *Corporate tax policy and incorporation in the EU*. International Tax and Public Finance, Vol. 15, pp. 478-498.

[78] Moser, Stefan, Nicola Pesaresi and Karl Soukup. 2002. *State guarantees to German public banks: a new step in the enforcement of State aid discipline to financial services in the Community*. Competition Policy Newsletter No.2, European Commission.

[79] New York Times. 2017. *Arthur Laffer's Theory on Tax Cuts Comes to Life Once More*. New York Times, April 25, 2017. Available at: `https://www.nytimes.com/2017/04/25/us/politics/white-house-economic-policy-arthur-laffer.html` (last access: September 4, 2018).

[80] Nickell, Stephen. 1981. *Biases in Dynamic Models with Fixed Effects*. Econometrica, Vol. 49(6), pp. 1417-1426.

[81] Nicodeme, Gaetan. 2007a. *Comparing Effective Corporate Tax Rates*. Frontiers in Finance and Economics, Vol. 4(2), pp. 102-131.

[82] Nicodeme, Gaetan. 2007b. *Do Larger Companies Have Lower Effective Corporate Tax Rates? A European Survey*. Centre Emile Bernheim, UniversitÃ© Libre de Bruxelles, CEB Working Paper No 07/001.

[83] Nicodeme, Gaetan, Antonella Caiumi and Ina Majewski. 2018. *What Happened to CIT collection? Solving the Rates-Revenues Puzzle*. Unpublished working paper.

[84] OECD. 2006. *Sustaining Economic Growth: Outlook and Challenges*. Presentation at the Bank of Greece by Angel Gurria, OECD Secretary-General, June 2006. Available at `http://www.oecd.org/health/37007533.pdf` (last access: August 16, 2018).

[85] OECD. 2010a. *Tax Policy Reform and Economic Growth*. OECD Tax Policy Studies, published on 03/11/10. Available at `http://www.oecd.org/ctp/tax-policy/tax-policy-reform-and-economic-growth-9789264091085-en.htm` (last access: September 16, 2018).

[86] OECD. 2010b. *OECD Economic Surveys: Germany 2010*. OECD Economic Surveys, Volume 2010/9. Available at `http://www.oecd.org/germany/economicsurveyofgermany2010.htm` (last access: August 12, 2018).

[87] OECD. 2013. *Action Plan on Base Erosion and Profit Shifting*. OECD Publishing, Paris. `Availableathttps://doi.org/10.1787/9789264202719-en` (last access: September 16, 2018).

[88] OECD. 2017. *OECD Revenue Statistics*. Available at `https://stats.oecd.org/index.aspx?DataSetCode=REV` (last access: August 16, 2018).

[89] Pischke, Joern Steffen. 2005. *Empirical Methods in Applied Economics - Lecture Notes*. London School of Economics, October 2005. Available at `http://econ.lse.ac.uk/staff/spischke/ec524/evaluation3.pdf` (last access: August 18, 2018).

[90] Phillips, Peter and Donggyu Sul. 2007. *Transition Modeling and Econometric Convergence Tests*. Econometrica, Vol. 75(6), pp. 1771-1855.

[91] Phillips, Peter and Donggyu Sul. 2009. *Economic transition and growth*. Journal of Applied Econometrics, Vol. 24(7), pp. 1153-1185.

[92] Piotrowska, Joanna and Werner Vanborren. 2008. *The Corporate Income Tax-rate-revenue Paradox: Evidence in the EU*. European Commission - Taxation and Customs Union.

[93] PwC. 2018. *21st CEO Survey: The Anxious Optimist in the Corner Office*. Available at: `https://www.pwc.com/gx/en/ceo-survey/2018/pwc-ceo-survey-report-2018.pdf` (last access: September 15, 2018).

[94] Regis, Paulo Jose, Juan Carlos Cuestas and Yang Chen. 2015. *Corporate Tax in Europe: Towards convergence?*. Economic Letters, Vol. 134, pp. 09-12.

[95] Rego, Sonja. 2003. *Tax Avoidance Activities of U.S. Multinational Corporations*. Contemporary Accounting Research, Vol. 20(4), pp. 805-833.

[96] Rego, Sonja and Ryan Wilson. 2012. *Executive compensation, equity risk incentives, and corporate tax aggressiveness*. Journal of Accounting Research, Vol. 50(3), pp. 775-810.

[97] Richardson, Grant and Roman Lanis. 2007. *Determinants of the variability in corporate effective tax rates and tax reform: Evidence from Australia*. Journal of Accounting and Public Policy, Vol. 26(6), pp. 689-704.

[98] Riedel, Nadine. 2018. *Quantifying International Tax Avoidance: A Review of the Academic Literature*. Review of Economics, Vol. 69(2), pp. 169-181.

[99] Saez, Emmanuel, Joel Slemrod, Seth Giertz. 2012. *The Elasticity of Taxable Income with Respect to Marginal Tax Rates: A Critical Review*. Journal of Economic Literature, Vol. 50(1), pp. 03-50.

[100] Schreiber, Ulrich. 2000. *German Tax Reform: An International Perspective*. Finanz-Archiv, Vol. 57(4), pp. 525-541.

[101] Senkarcin, Matej. 2016. *German Landesbanks in the post-guarantee reality*. University of Pennsylvania, The Wharton School, Master Thesis.

[102] Siegfried, John. 1972. *The relationship between economic structure and the effect of political influence: Empirical evidence from the Federal Corporation Income Tax Program*. PhD. Dissertation, University of Wisconsin, reported in Nicodeme (2007b).

[103] Slemrod, Joel. 2004. *Are corporate tax rates, or countries, converging?*. Journal of Public Economics, Vol. 88(6), pp. 1169-1186.

[104] Sœrensen, Peter B. 2006. *Can capital income taxes survive?*. CESifo Economic studies, Vol. 53(2), pp. 172-228.

[105] Spengel, Christoph, Frank Schmidt, Jost Heckemeyer, Katharina Nicolay. 2016. *Effective tax levels using the Devereux/Griffith Methodology*. Project for the EU Commission TAXUD/2013/CC/120, Final Report 2016.

[106] Steinmueller, Elias, Georg U. Thunecke, and Georg Wamser. 2018. *Corporate Income Taxes Around the World. A Survey on Forward-looking Tax Measures and Two Applications*. CESifo Working Paper No. 7050.

[107] Stimmelmayr, Michael. 2015. *Investors' Portfolio Choice and Tax Reforms: The 2008 German Corporate Tax Reform Reconsidered*. CESifo Working Paper No. 5311.

[108] Tax Justice Network. 2017. *Tax avoidance and evasion - The scale of the problem* . Briefing. Available at: `https://www.taxjustice.net/wp-content/uploads/2017/11/Tax-dodging-the-scale-of-the-problem-TJN-Briefing.pdf` (last access: September 14, 2018).

[109] United Nations, 2008. *International Standard Industrial Classification of All Economic Activities - Revision 4*. United Nations Statistical Papers, Series M No. 4/Rev.4.

[110] Zodrow, George R. and Peter Mieszkowski. 1986. *Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods*. Journal of Urban Economics, Vol. 19(3), pp. 356-370.